Appendix M
Surface Geophysics Technical Memorandum

NOTE: Attachments including data profiles and magnetic contour maps are not included. They are available upon request through CH2M HILL.

TECHNICAL MEMORANDUM CH2M HILL

PREPARED FOR: Jeffrey Gratz/USEPA, Region II

PREPARED BY: Mary Kate Dwyer/CH2M HILL

COPIES: Jeffrey Bartlett/Stepan Company
Roger Julian/Stepan Company
Ted Kielbasa/Stepan Company
Rick Ramuglia/Alliance

DATE: March 4, 1992

SUBJECT: Surface Geophysics Investigation--SWS Realty Property

PROJECT: NJO22948.FH.GP

1.0 Introduction

1.1 Purpose and Scope

A surface geophysical investigation was conducted at the SWS Realty property (Lot 4, Block 124; former Hunter-Douglas property) in Maywood, New Jersey, on December 31, 1991 and January 3, 1992. The survey, performed as part of the Remedial Investigation at the site, was conducted over approximately 2.5 acres of open area around the facility. The remaining 2 acres of the site was not investigated because it was occupied by the site building and tall brush on the eastern boundary of the site. The survey was conducted by CH2M HILL personnel Mary Kate Dwyer, Joe Merchak, and Bob Jackson.

The objectives of the geophysical investigation are to identify potential sources of chemical contamination. Specifically, the geophysical investigation was performed in an effort to locate and define abandoned ferromagnetic containers in the overburden of the SWS Realty property. Due to the nature of deposits in the Maywood area, a magnetic survey was determined to be the most effective geophysical method available. The magnetometer can identify areas of buried metal but cannot distinguish drums from other ferrous materials or determine whether there is chemical contamination present. Therefore, the results of the magnetometer investigation were used to select locations for test pits that will be used to characterize the buried material.

The geophysical investigation was performed in several steps. First a grid was established in the survey areas. A magnetometer was then used to collect and store the geophysical data along the survey lines. The raw data was transferred from the magnetometer to the computer and the data was then arranged in spreadsheet form.

The data were graphed and anomalies were identified. The locations of the source of the anomalies were interpreted and put on the base map. The anomalies that could not be explained by cultural features were evaluated to identify possible areas of buried metal.

This technical memorandum (TM) is organized into six sections and supplemented with three attachments. The remainder of this introduction presents an overview of the report organization. The magnetometer selected and the theory of magnetics is described in Section 2.0. Section 3.0 describes the procedures employed in the collection of the data. Section 4.0 describes the methods used to interpret the data. Section 5.0 presents the results of the survey, the interpretation of the data, and the limitations of the results. A map showing the location of buried metal is included as part of this interpretation. Finally, Section 6.0 discusses recommendations for use of the data. Attachment A contains letters from CH2M HILL to the United States Environmental Protection Agency (EPA) regarding the change in the magnetometer used for the survey. Attachment B contains profile plots of the data collected during the investigation. Attachment C contains letters from CH2M HILL and EPA regarding a change in interpretation procedures for the anomalous areas.

2.0 Magnetometer and Theory of Magnetics

2.1 Magnetometer

A GEM GSM-19G overhauser gradiometer was used for the magnetic investigation. This magnetometer is different from the Geometrics G866 originally proposed in the workplan. The change in method was presented to the EPA before the survey was performed. The change in method was approved by the EPA. The letters documenting the change in method, the technical rationale for the change, and the advantages of the GEM magnetometer are presented in Attachment A.

2.2 Theory of Magnetics

The GEM is a proton precession magnetometer that measures the magnitude of the earth's magnetic field and vertical magnetic gradient. The magnetic field measured by the magnetometer is the sum of the earth's field, fields due to geologic formations, and fields due to cultural features such as buildings, cars, and other ferrous metal. The vertical magnetic gradient is the difference between two simultaneous total field measurements made at different heights above the ground. The gradiometer sensor supplied with the GEM magnetometer consists of two sensors about 2 feet apart. The vertical gradient often provides higher resolution of magnetic anomalies and may allow the collection of useful data closer to buildings than do total field measurements.

The magnetometer sensor consists of a small container filled with an organic, hydrogen-rich fluid, such as kerosene. A current is passed through a coil wrapped around the container, causing the molecules of the liquid to orient themselves with the inducing magnetic field produced by the coil. When the current to the coil is stopped, the molecules realign (precess) themselves with the earth's magnetic field. A small electric field, produced by the molecules as they realign themselves, is measured by the coil around the container and amplified. The strength of this field is proportional to the strength of the earth's magnetic field. The electronic circuitry of the magnetometer converts the measured field to a digital display of the magnetic field strength.

The earth's field varies during the day due to solar activity, and these variations are called diurnal drift. Diurnal drift is measured by periodic readings at a base station and removed from the data if necessary. Diurnal drift is usually negligible compared to anomalies caused by the presence of buried metal. The vertical gradient is not subject to diurnal drift.

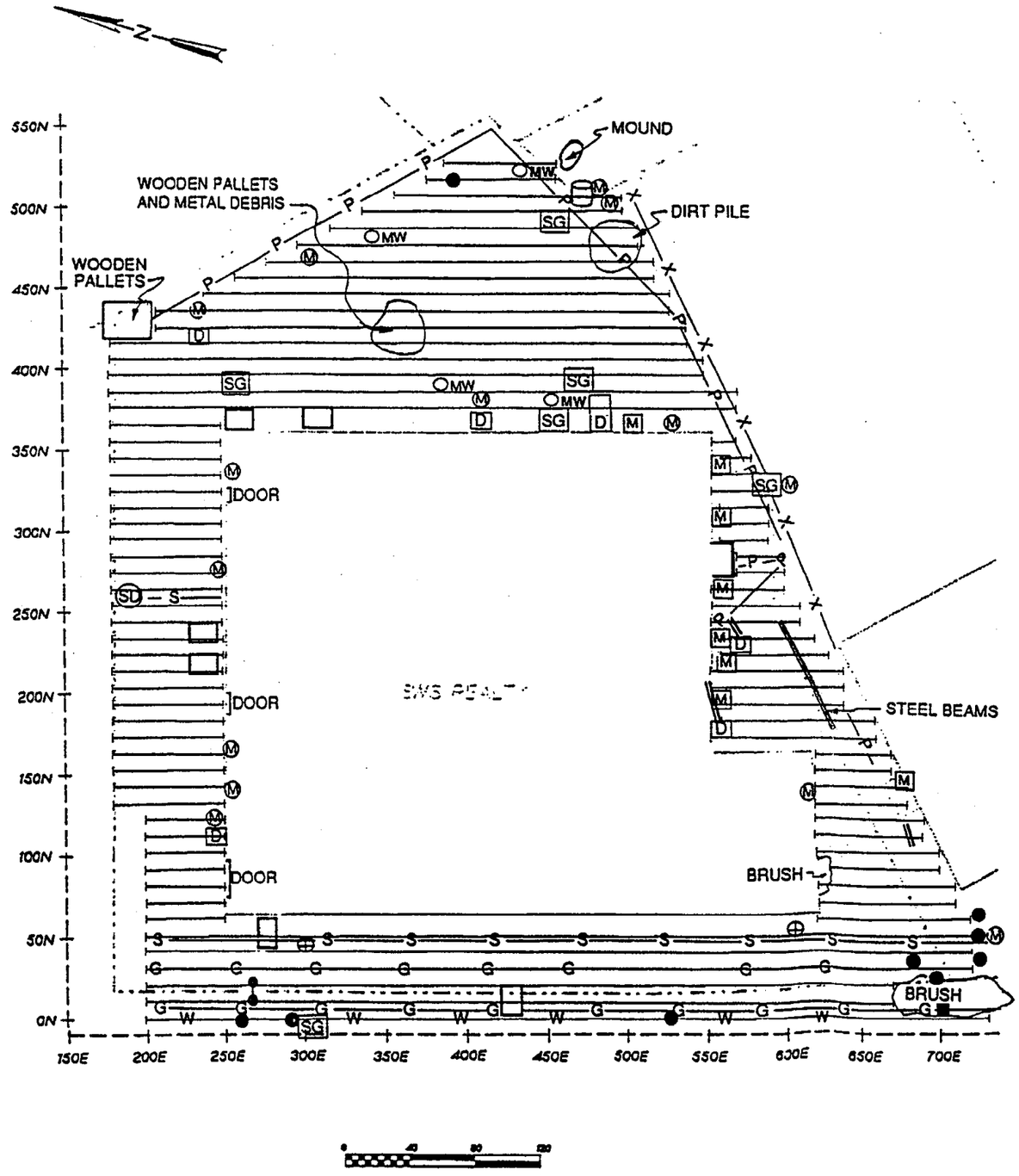
Anomalies due to geologic formations can be and often are negligible, depending on the nature of the formation and its depth. Geologic anomalies are usually related to igneous or metamorphic rock formations. These rock types are not present near the surface at the Maywood site. Therefore, the anomalies at SWS Realty property are not thought to be geologic.

3.0 Field Procedures

3.1 Establishing the Grid

Survey grids were established over the SWS Realty property before geophysical data was collected. The grids were placed to allow accurate and systematic sampling and to cite the positions of anomalies in the field. The grids were based on two perpendicular base lines formed by placing markers (pin flags or spray paint) at regular intervals across the site by using a compass and measuring tape. Grid north was oriented approximately 80 degrees east of true north.

Figure 1 shows the extent of the survey and the grid coordinates. East-west base lines were marked at 20-foot intervals. The east-west base lines corresponded with the 100-foot intervals along the north-south grid lines. East-west base lines were parallel to the front edge of the SWS Realty building. East-west grid coordinates were labeled continuously from the AMP Realty property to the SWS Realty property, so that data could be combined and graphed between the two site buildings. The location of metal objects and other sources of interference at the site are also shown in Figure 1.



LEGEND:

- = SURVEY LINE
- = PROPERTY LINE
- X = FENCE LINE
- = RUBBLE
- M / Ⓜ = METAL OBJECTS OR DEBRIS
- ■ = HYDRANT
- = DRUM
- P = POWERLINE
- G = GAS LINE
- W = WATERLINE
- MC = REINFORCED CONCRETE (REBAR)
- = CAR,TRUCK, VAN OR RV
- ○ = TELEPHONE POLE
- ● = POLE
- MW = MONITORING WELL
- SD = STORM DRAIN
- D = DUMPSTER
- = PIPE
- ⊕ = MANHOLE
- ● = SIGN
- S = SEWER LINE
- SG = SEWER GRATE

Figure 1
SURVEY GRID AND EXTENT OF MAGNETOMETER INVESTIGATION
CULTURAL FEATURES MAP
SWS REALTY PROPERTY
MAYWOOD, NJ

3.2 Base Station

A base station was established to determine the amount of diurnal (daily) drift in the earth's magnetic field. The station was located in an area free from magnetic anomalies and away from any detectable sources of interference. Readings were taken throughout the day in the morning, midday, and late afternoon and were entered into the field notes. On all days, the drift was less than 100 gammas. No drift correction was performed because the maximum observed drift of 100 gammas is small compared to the anomalies recorded over the site, which typically measured from greater than 200 gammas up to 5,000 gammas.

3.3 Magnetometer Survey

Data were systematically collected at 10-foot intervals along the east-west grid lines, since these lines corresponded closely with the true north direction. The line number and direction, station number, and the station spacing were programmed into the magnetometer at the start of each grid line. Data were collected and stored in the internal memory of the instrument. Measurements were also recorded in the field logbook at regular intervals. Locations of features such as fences, power lines, utilities, buildings, and scrap metal that may have affected the readings were recorded. Data from the digital logger were transferred to a computer on a daily basis, and the data were reviewed to determine if they were properly recorded and were checked for consistency with the data manually recorded in the logbook. Data were then processed as described in Section 4.0.

No functional checks are prescribed in the operator's manual for the magnetometer. Initial readings were compared against the total magnetic intensity predicted for the area, as shown on a map that was provided with the equipment. Equipment was determined to be responsive by taking measurements at different locations and noting that the measurements did not remain constant.

4.0 Interpretation Procedures

4.1 Magnetic Data

Preparation and plotting of the magnetometer data consisted of the following steps. The data were received in XYZ format, imported into a spreadsheet, and rearranged into a spreadsheet format with the columns representing survey lines and the rows representing station positions along the line. Profile plots of magnetic intensity and vertical magnetic gradient were prepared (Attachment B). The profile plots were used to interpret the location of the source of each anomaly.

A magnetic anomaly normally consists of both a magnetic high and a magnetic low. The pair of high and low values is due to the magnetic field induced in the buried

metal by the earth's field. The magnetic field induced in the buried object has both a north and south magnetic pole, which results in a net increase and decrease, respectively, in the measured total field. In the northern hemisphere, the magnetic high is on the south side of the source and the low is on the north side. The source of the anomaly is interpreted as extending from the peak of the magnetic high to the lowest value north of the high. The high/low pairs are not always well-defined due to nearby interferences and grid line orientation. Professional judgement is required in delineating magnetic sources. An anomaly was chosen if it was recognizable over the same station interval on both the total field and the vertical gradient profiles. Once an anomaly was identified, the interpreted location of the source of the anomaly was transferred to the base map.

5.0 Results of Investigation

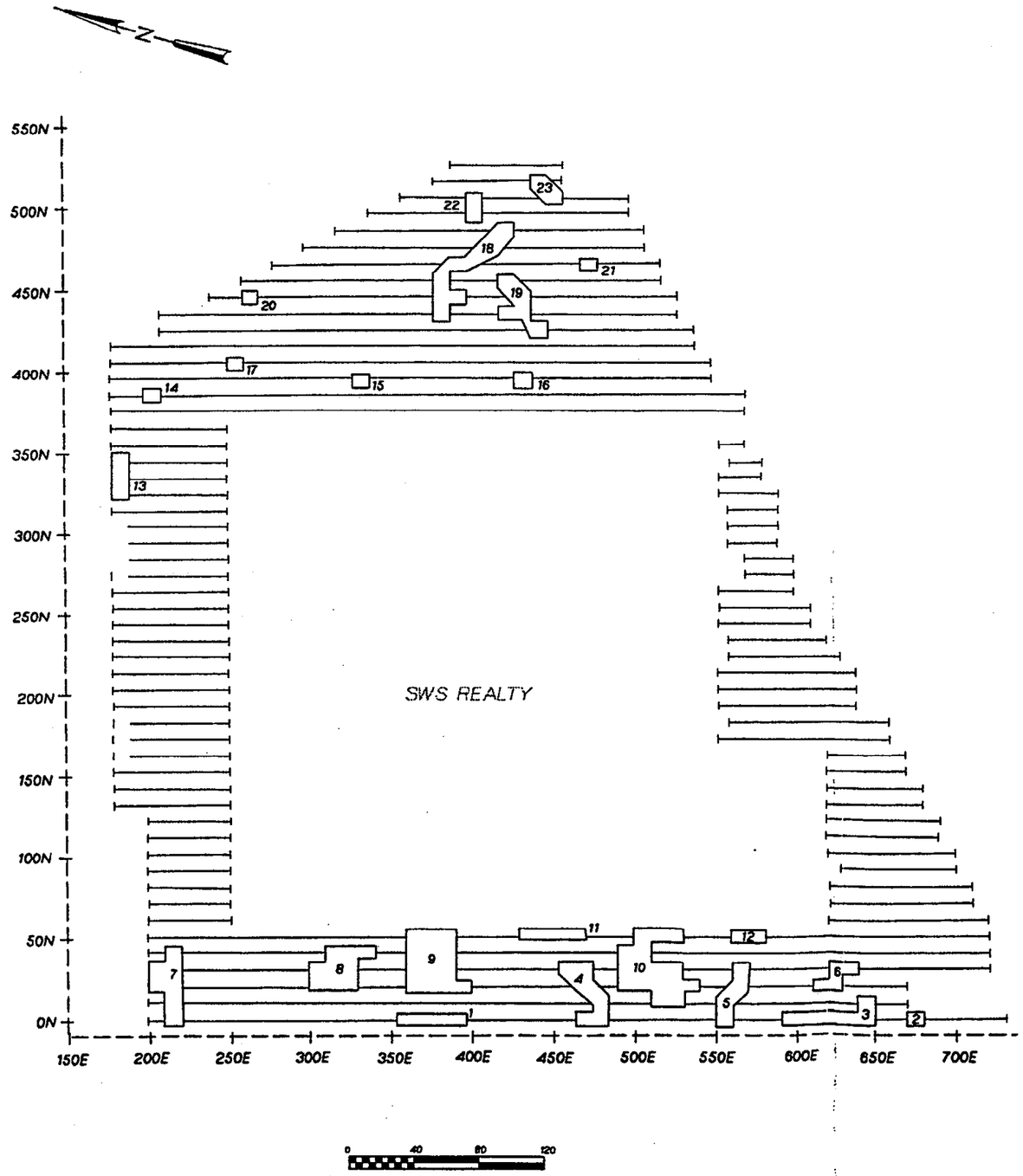
5.1 Buried Metal

The extent of the magnetometer survey conducted on the SWS Realty property is shown in Figure 1. Magnetic data are presented in Attachment B. Figure 2 presents the locations that are interpreted to contain buried metal.

Twenty-three areas of buried metal have been identified at the site (Figure 2). The areas shown on the map have been identified based on magnetic anomalies that are not a result of known sources. Anomalies resulting from known sources, such as power lines, surface metal, or buildings have not been shown unless other buried material is suspected based upon the amplitude of the anomaly. The location of metal objects and other sources of interference encountered at the site are shown in Figure 1. The areas are numbered from west to east across the property. These areas are listed in Table 5-1, along with their strength, nearby cultural features, and potential test-pit locations.

5.2 Limitation of Results

Prioritization for followup investigations of the interpreted areas of buried metal should not be based only on geophysical data. Other factors, such as site history and visual observations, should also be considered. The instrument is sensitive enough to see the anomaly associated with several drums to a depth of 20 feet. This depth is greater than the thickness of the overburden at the site. Because of the existence of many cultural sources of interference on the site, anomalies that were identified in some cases may not contain buried metal or appear to be as extensive as they are shown on the map. Other locations that may contain minor amounts of buried metal may have been missed due to magnetic interferences from known or unknown sources.



LEGEND

SURVEY LINE

PROPERTY LINE

2 BOUNDARIES OF INTERPRETED METAL

FIGURE 2
Interpreted Areas of Buried Metal
SWS REALTY PROPERTY
MAYWOOD, NJ

CH2M HILL

Table 5-1
Interpreted Areas of Buried Metal
SWS Realty Property

Area	Strength of Anomalies (gammas)	Cultural Feature	Potential Test-Pit Location
1	250-1200	Water line	0 N, 350-370 E
2	470	Water line	0 N, 670-680 E
3	1000-1750	Water line	0 N, 600-610 E
4	560-1250	Water line, 2 gas lines	30 N, 450-470 E
5	120-700	Water line, 2 gas lines	10 N, 550-560 E
6	500-1200	Gas line	30 N, 620-640 E
7	640-3600	Water line, 2 gas lines, sewer line	30 N, 200-220 E
8	1500-2350	Gas line, sewer line	30 N, 310-330 E
9	1300-4000	Sewer line, 2 gas lines	50 N, 370-390 E
10	630-5400	Sewer line, 2 gas lines	50 N, 510-520 E
11	1250	Sewer line, water line	50 N, 450-470 E
12	1050	Sewer line	50 N, 560-580 E
13	200	None	320 N, 220-230 E
14	180	None	380 N, 200-210 E
15	240	None	390 N, 330-340 E
16	170	None	390 N, 430-440 E
17	550	Sewer grate?	400 N, 250-260 E
18	150-325	None	460 N, 390-400 E
19	225-825	None	450 N, 420-430 E
20	275	Power line	440 N, 260-270 E
21	275	Dirt pile	460 N, 470-480 E
22	150-250	None	490 N, 400-410 E
23	2000-2400	Power line	500 N, 450-460 E

6.0 Discussion and Recommendations

Buried metal has been identified in 23 areas distributed around the site. Some of the anomalies are thought to be due to underground utilities and other sources of interference.

The following 12 areas are recommended for the test-pit program on the SWS Realty property: Areas 9, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, and 23. Areas 1 through 12 on the western side of the property adjacent to Route 17, are generally not recommended for test-pit activities. Two gas lines, a water line, and a sewer line, are located beneath these areas. The strong anomalies in this area appear to be due to these utility lines. However, some anomalies over the utility lines appear to line up on adjacent lines, perpendicular to the direction of the utility lines. This suggests that there may be additional sources causing the anomalies. Area 9 exhibits the strongest anomalies on adjacent lines and is recommended for the test-pit investigation. Careful excavation adjacent to the utility lines may reveal additional buried metal or waste material. Investigation of this area is considered sufficient to characterize the type of materials that may be present in other anomalous areas west of the SWS Realty building. All other anomalies located on the site are recommended for test-pitting.

The nature of the buried metal cannot be determined from the data and further investigations will be necessary. All anomalies proposed for test-pitting will be field screened with a metal detector before digging to correctly locate their position and extent. If metal is not detected in areas where a cultural feature is present, the cultural feature will be determined to be the source of the anomaly and the anomaly will not be test-pitted. All anomalies greater than 100 gammas have been identified.

Priority of the follow-up investigations (i.e., test-pitting) should be based on the areal extent of the buried metal (an indication of volume), the strength of the magnetic anomalies, site history, and field observations. The test-pit program should concentrate on the strongest anomalies within the recommended test-pit areas, in order to characterize the type of materials producing the largest anomalies. The investigation should progress from those areas consisting of multiple-line anomalies to the areas defined by single-line anomalies. Single-line anomalies may be less significant as potential sources.

The extent of the test pit will be sufficient to characterize the source of the magnetic anomaly. The test pit will target the strongest part of the anomaly. A test pit excavated within the locations provided in Table 5-1 should be sufficient to characterize the anomaly.

CH2M HILL
Engineers
Planners
Economists
Scientists

April 27, 1992

Mr. Jeffrey Gratz, Project Manager
United States Environmental Protection Agency
Special Programs Branch, Room 2930
26 Federal Plaza
New York, New York 10278

Dear Mr. Gratz:

Subject: Maywood Chemical Company Site, Maywood, Bergen County, New Jersey, Administrative Order on Consent (Index No. II-CERCLA-70104): Surface Geophysics Report, Sears Property

Enclosed please find one (1) copy of the above. By copy of this letter, we are also forwarding a copy to Rick Ramuglia/Alliance.

Please give me a call with any comments or questions.

Sincerely,

Mary S. Manto /MKJ

Mary S. Manto
Project Manager

mtc/NJC9/061C9.51
cc: R. Ramuglia/Alliance
J. Bartlett/Stepan Co.
R. Julian/Stepan Co.

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Parsippany, NJ 07054-1102
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TECHNICAL MEMORANDUM CH2MHILL

PREPARED FOR: Jeffrey Gratz/USEPA, Region II

PREPARED BY: Don Johnson/CH2M HILL

COPIES: Jeffrey Bartlett/Stepan Company
Rodger Julian/Stepan Company
Rick Ramuglia/Alliance

DATE: April 27, 1992

SUBJECT: Surface Geophysics Investigation--Sears Property

PROJECT: NJO22948.SR.GP

1.0 Introduction

1.1 Purpose and Scope

A surface geophysical investigation was conducted at the Sears Logistical Services Property (Sears) in Maywood, New Jersey, from March 2 to March 17, 1992. The survey, performed as part of the Remedial Investigation at the site, was conducted over approximately 15 acres of open area around the facility. The remaining 10 acres were occupied by buildings, reinforced concrete surfaces, railroad tracks, or open water which prohibited the execution of the geophysical investigation. The survey was conducted by CH2M HILL personnel Don Johnson, Mary Kate Dwyer, Mike Snype and Joe Merchak.

The objectives of the geophysical investigation are to identify potential sources of chemical contamination. Specifically, the geophysical investigation was performed in an effort to locate and define abandoned ferromagnetic containers in the overburden of the Sears property. Due to the nature of deposits at the Sears site, a magnetic survey was determined to be the most effective geophysical method available. The magnetometer can identify areas of buried metal but cannot distinguish drums from other ferrous materials or determine whether there is chemical contamination present. Therefore, the results of the magnetometer investigation were used to select locations for test pits that will be used to characterize the buried material.

The geophysical investigation was performed in several steps. First a grid was established in the survey areas. A magnetometer was then used to collect and store the geophysical data along the survey lines. The raw data was transferred from the magnetometer to the computer and the data was then arranged in spreadsheet form.

The data were graphed and anomalies were identified. The locations of the sources of the anomalies were interpreted and put on the base map. The anomalies that could not be explained by cultural features were evaluated to identify possible areas of buried metal.

This technical memorandum (TM) is organized into six sections and supplemented with two attachments. The remainder of this introduction presents an overview of the report organization. The magnetometer selected and the theory of magnetics is described in Section 2.0. Section 3.0 describes the procedures employed in the collection of the data. Section 4.0 describes the methods used to interpret the data. Section 5.0 presents the results of the survey, the interpretation of the data, and the limitations of the results. A map showing the location of buried metal is included as part of this interpretation. Finally, Section 6.0 discusses recommendations for use of the data. Attachment A contains letters from CH2M HILL to the United States Environmental Protection Agency (EPA) regarding the change in the magnetometer used for the survey. Attachment B contains profile plots of the data collected during the investigation.

2.0 Magnetometer and Theory of Magnetics

2.1 Magnetometer

A GEM GSM-19G overhauser gradiometer was used for the magnetic investigation. This magnetometer is different from the Geometrics G866 originally proposed in the work plan. The change in method was presented to the EPA before the survey was performed. The change in method was approved by the EPA. The letters documenting the change in method, the technical rationale for the change, and the advantages of the GEM magnetometer are presented in Attachment A.

2.2 Theory of Magnetics

The GEM is a proton precession magnetometer that measures the magnitude of the earth's magnetic field and vertical magnetic gradient. The magnetic field measured by the magnetometer is the sum of the earth's field, fields due to geologic formations, and fields due to cultural features such as buildings, cars, and other ferrous metal. The vertical magnetic gradient is the difference between two simultaneous total field measurements made at different heights above the ground. The gradiometer sensor supplied with the GEM magnetometer consists of two sensors about 2 feet apart. The vertical gradient often provides higher resolution of magnetic anomalies and may allow the collection of useful data closer to buildings than do total field measurements.

The magnetometer sensor consists of a small container filled with an organic, hydrogen- rich fluid, such as kerosene. A current is passed through a coil wrapped around the container, causing the molecules of the liquid to orient themselves with the inducing magnetic field produced by the coil. When the current to the coil is

stopped, the molecules realign (precess) themselves with the earth's magnetic field. A small electric field, produced by the molecules as they realign themselves, is measured by the coil around the container and amplified. The strength of this field is proportional to the strength of the earth's magnetic field. The electronic circuitry of the magnetometer converts the measured field to a digital display of the magnetic field strength.

The earth's field varies during the day due to solar activity, and these variations are called diurnal drift. Diurnal drift is measured by periodic readings at a base station and removed from the data if necessary. Diurnal drift is usually negligible compared to anomalies caused by the presence of buried metal. The vertical gradient is not subject to diurnal drift.

Anomalies due to geologic formations can be and often are negligible, depending on the nature of the formation and its depth. Geologic anomalies are usually related to igneous or metamorphic rock formations. These rock types are not present near the surface at the Maywood site. Therefore, the anomalies at Sears are not thought to be geologic.

3.0 Field Procedures

3.1 Establishing the Grid

Survey grids were established in areas clear of mature vegetation and building structures over the Sears property before geophysical data was collected. A single grid was established over the entire site, with the exception of a portion of the access road to the site. Since the access road crossed the primary grid at an angle and was bounded by a fence on either side, this area was gridded parallel to the road to facilitate data collection.

Subsequent references to compass directions in this technical memorandum refer to grid directions. Grid north is approximately 45 degrees west of true north.

The primary grid was based on the west and south sides of the Sears building. The east-west base lines for the survey grid were parallel to the south side of the building. The south-west corner of the building was arbitrarily assigned grid coordinates 1000 E and 1000 N. Figure 1 shows the extent of the survey and the grid coordinates. East-west base lines were marked at 20-foot intervals. The east-west base lines corresponded with the 100- foot intervals along the north-south grid lines.

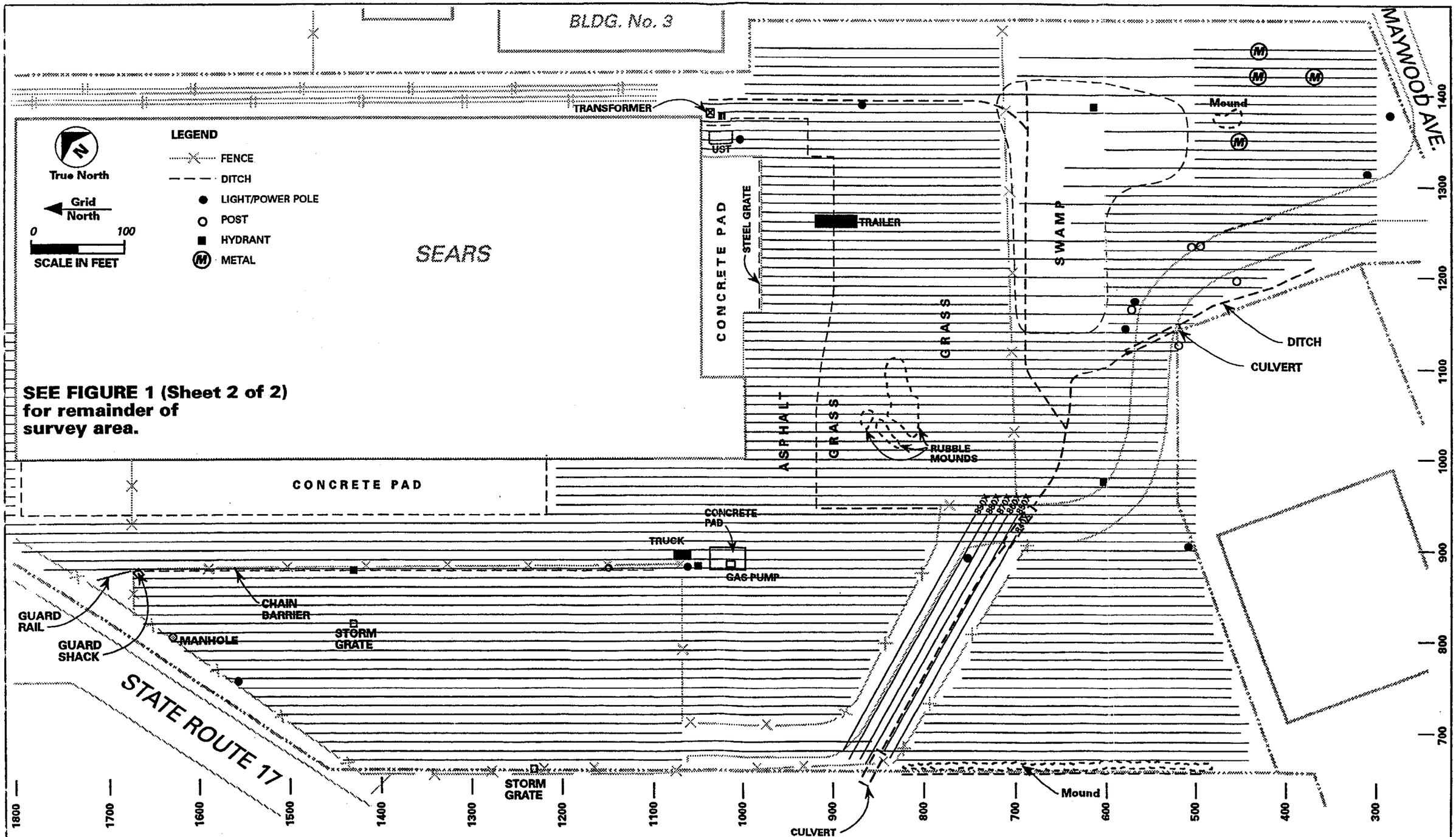

FIGURE 1 (Sheet 1 of 2)
Extent of Magnetometer Investigation
SEARS LOGISTICAL SERVICES
MAYWOOD, NJ

CRAHILL

N:\02048.88.GP_MAG SURVEY 1 4-20-92mms

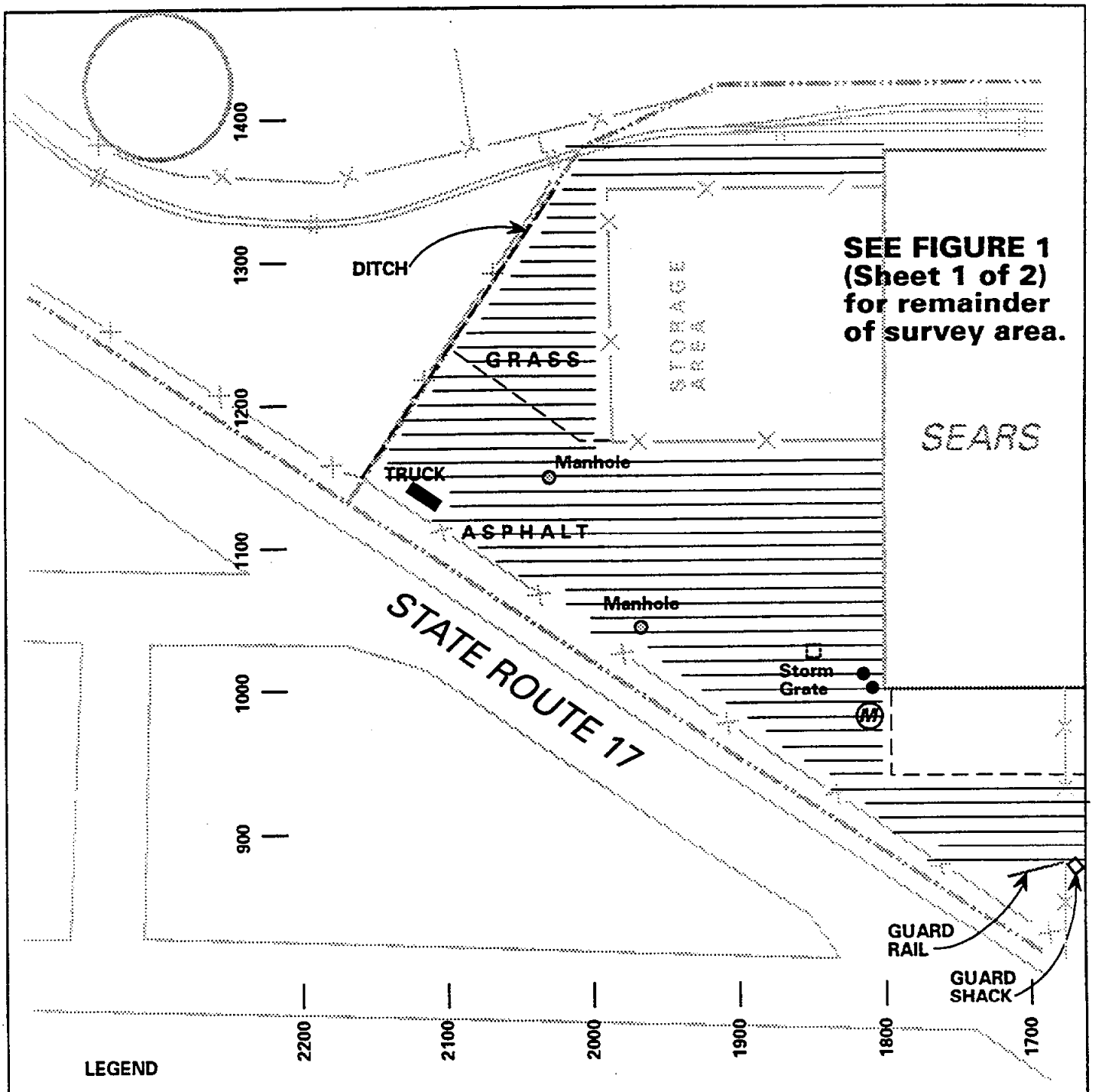

FIGURE 1 (Sheet 2 of 2)
Extent of
Magnetometer Investigation
SEARS LOGISTICAL SERVICES
MAYWOOD, NJ

CH2MHILL

NJO22948.SR.GP 2 Ext of MAG Survey 4-20-92mms

3.2 Base Station

A base station was established to determine the amount of diurnal (daily) drift in the earth's magnetic field. The station was located in an area free from magnetic anomalies and away from any detectable sources of interference (in the grassy area south of the building). Readings were taken throughout the day in the morning, midday, and late afternoon and were entered into the field notes. On all days, the drift was less than about 50 gammas. No drift correction was performed because the maximum observed drift was small compared to the anomalies recorded over the site, which typically measured from greater than 200 gammas up to 3,000 gammas.

3.3 Magnetometer Survey

Data were systematically collected at 10-foot intervals along the north-south grid lines across most of the site. The swampy area south of the building was surveyed at 20-foot line intervals because the swamp was impassible without considerable brushing. In some areas of the swamp, no data could be collected because perched water and marsh deposits were too deep. The situation was discussed with EPA and they verbally approved of our plan for this area.

The line number and direction, station number, and the station spacing were programmed into the magnetometer at the start of each grid line. Data were collected and stored in the internal memory of the instrument. Measurements were also recorded in the field logbook at regular intervals. Locations of features such as roads, fences, power lines, utilities, buildings, and scrap metal that may have affected the readings were recorded. Data from the digital logger were transferred to a computer on a daily basis, and the data were reviewed to determine if they were properly recorded and were checked for consistency with the data manually recorded in the logbook. Data were then processed as described in Section 4.0.

No functional checks are prescribed in the operator's manual for the magnetometer. Initial readings were compared against the total magnetic intensity predicted for the area, as shown on a map that was provided with the equipment. Equipment was determined to be responsive by taking measurements at different locations and noting that the measurements did not remain constant.

4.0 Interpretation Procedures

4.1 Magnetic Data

Preparation and plotting of the magnetometer data consisted of the following steps. The data were received in XYZ format, imported into a spreadsheet, and rearranged into a spreadsheet format with the columns representing survey lines and the rows representing station positions along the line. Profile plots of magnetic intensity and vertical magnetic gradient were prepared (Attachment B). The profile plots were used to interpret the location of the source of each anomaly.

A magnetic anomaly normally consists of both a magnetic high and a magnetic low. The pair of high and low values is due to the magnetic field induced in the buried metal by the earth's field. The magnetic field induced in the buried object has both a north and south magnetic pole, which results in a net increase and decrease, respectively, in the measured total field. In the northern hemisphere, the magnetic high is on the south side of the source and the low is on the north side. The source of the anomaly is interpreted as extending from the peak of the magnetic high to the lowest value north of the high. The high/low pairs are not always well-defined due to nearby interferences and grid line orientation. Professional judgement is required in delineating magnetic sources. An anomaly was chosen if it was recognizable over the same station interval on both the total field and the vertical gradient profiles.

Once an anomaly was identified, the interpreted location of the source of the anomaly was transferred to the base map. Anomalies that corresponded to anomalies on adjacent lines were grouped together as an anomalous area.

5.0 Results of Investigation

5.1 Buried Metal

The extent of the magnetometer survey conducted at Sears is shown in Figure 1. The site has been subdivided into 4 separate areas to facilitate the discussion of results and is shown in Figure 2. Magnetic data are presented in Attachment B. Figure 3 presents the locations that are interpreted to contain buried metal.

A total of 183 areas of buried metal have been identified at the site. Eighty three of the areas are based on anomalies on two or more adjacent lines (Table 5-1). The remaining 101 areas are based on anomalies observed on single lines (Table 5-2). The areas shown on the map have been identified based on magnetic anomalies that are not a result of known sources. Anomalies resulting from known sources, such as power lines, surface metal, or buildings have not been shown unless other buried material is suspected based upon the amplitude of the anomaly. The location of metal objects and other sources of interference encountered at the site is shown in Figure 1.

5.2 Distribution of Anomalous Areas

A brief description of the site with respect to the areas of buried metal is given in the following summary.

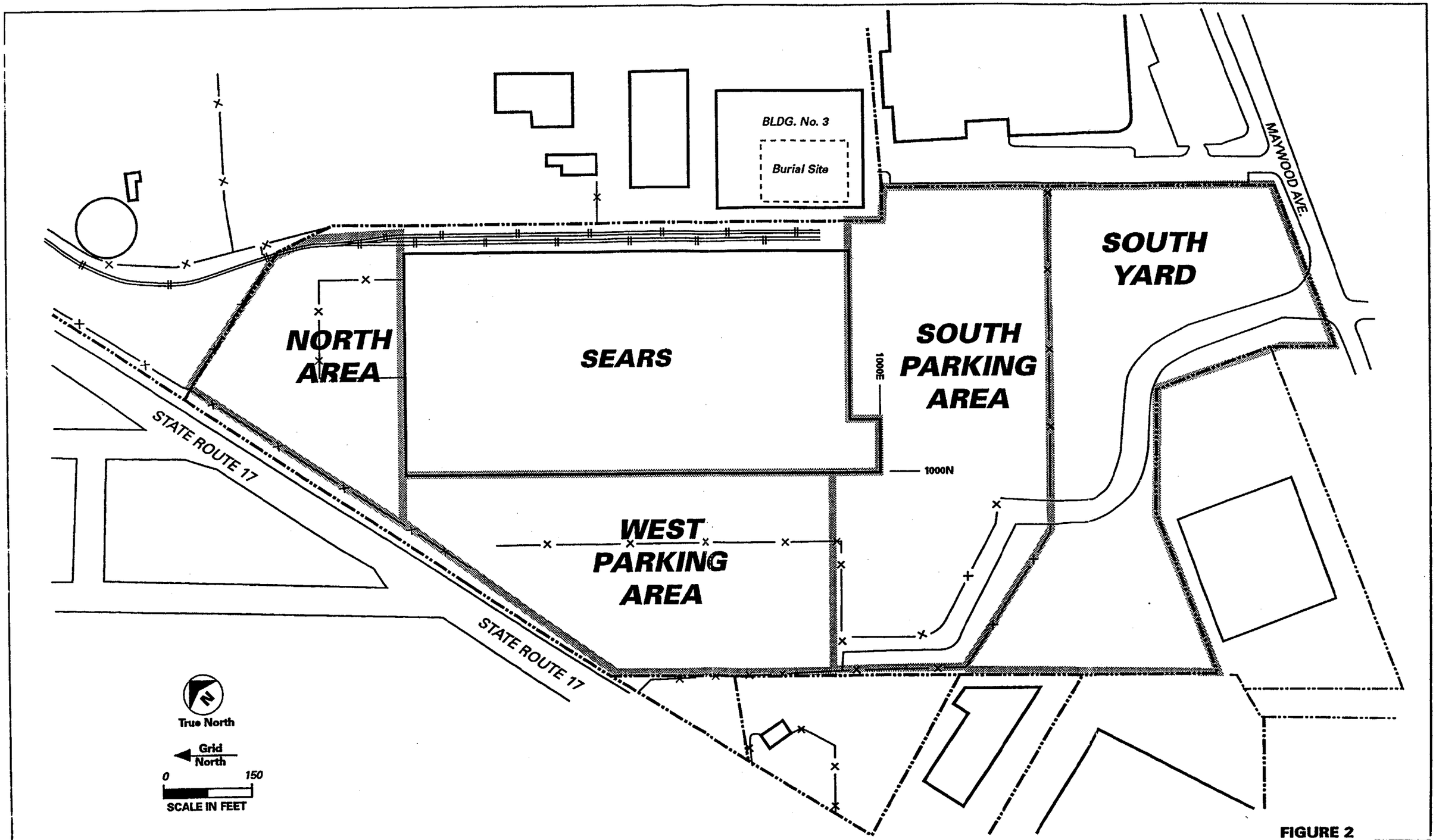

FIGURE 2
Site Map
SEARS LOGISTICAL SERVICES
MAYWOOD, NJ

CH2MHILL

NJ022948.8R.GP Vicinity Map 4-20-92mms

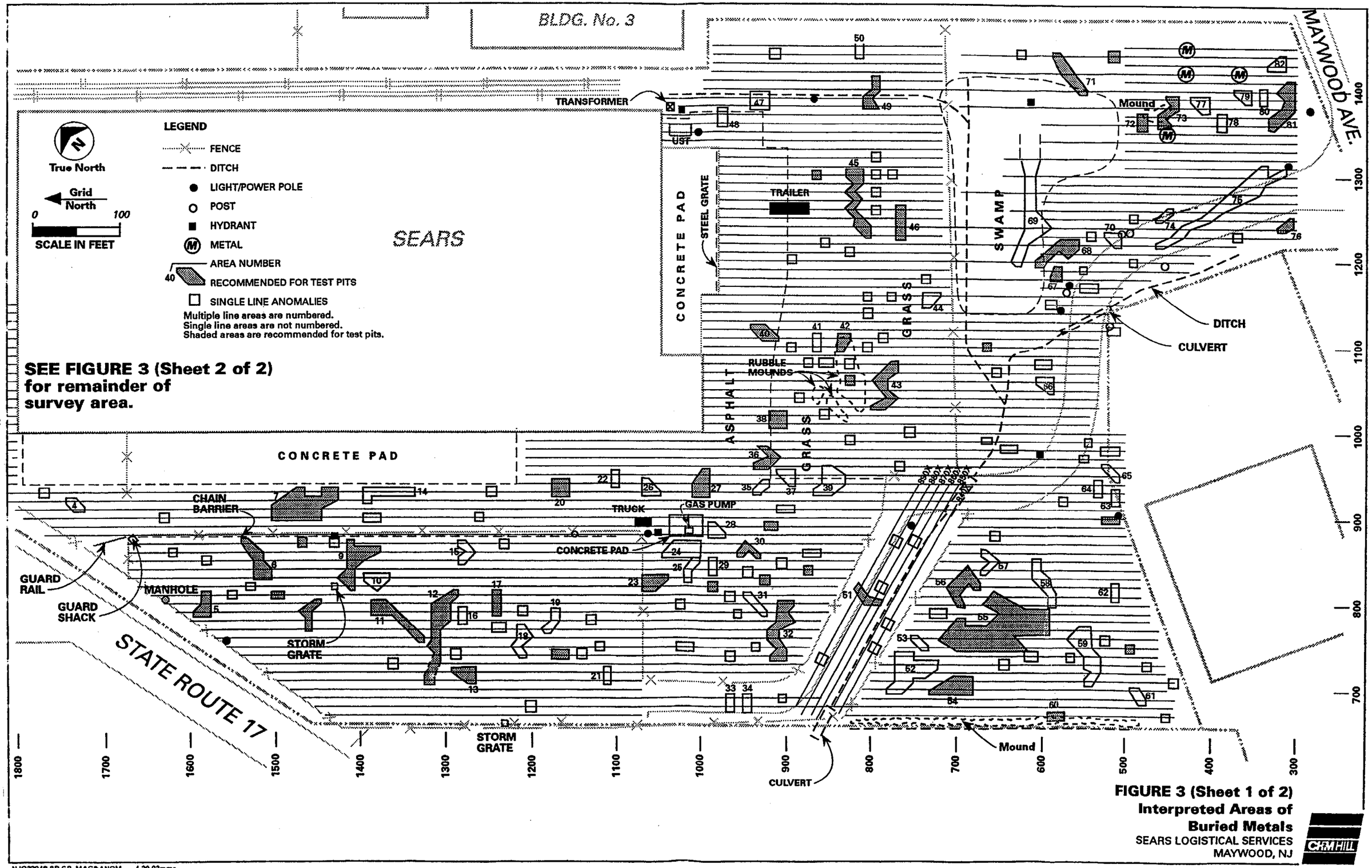

FIGURE 3 (Sheet 1 of 2)
Interpreted Areas of Buried Metals
SEARS LOGISTICAL SERVICES
MAYWOOD, NJ

CH2MHILL

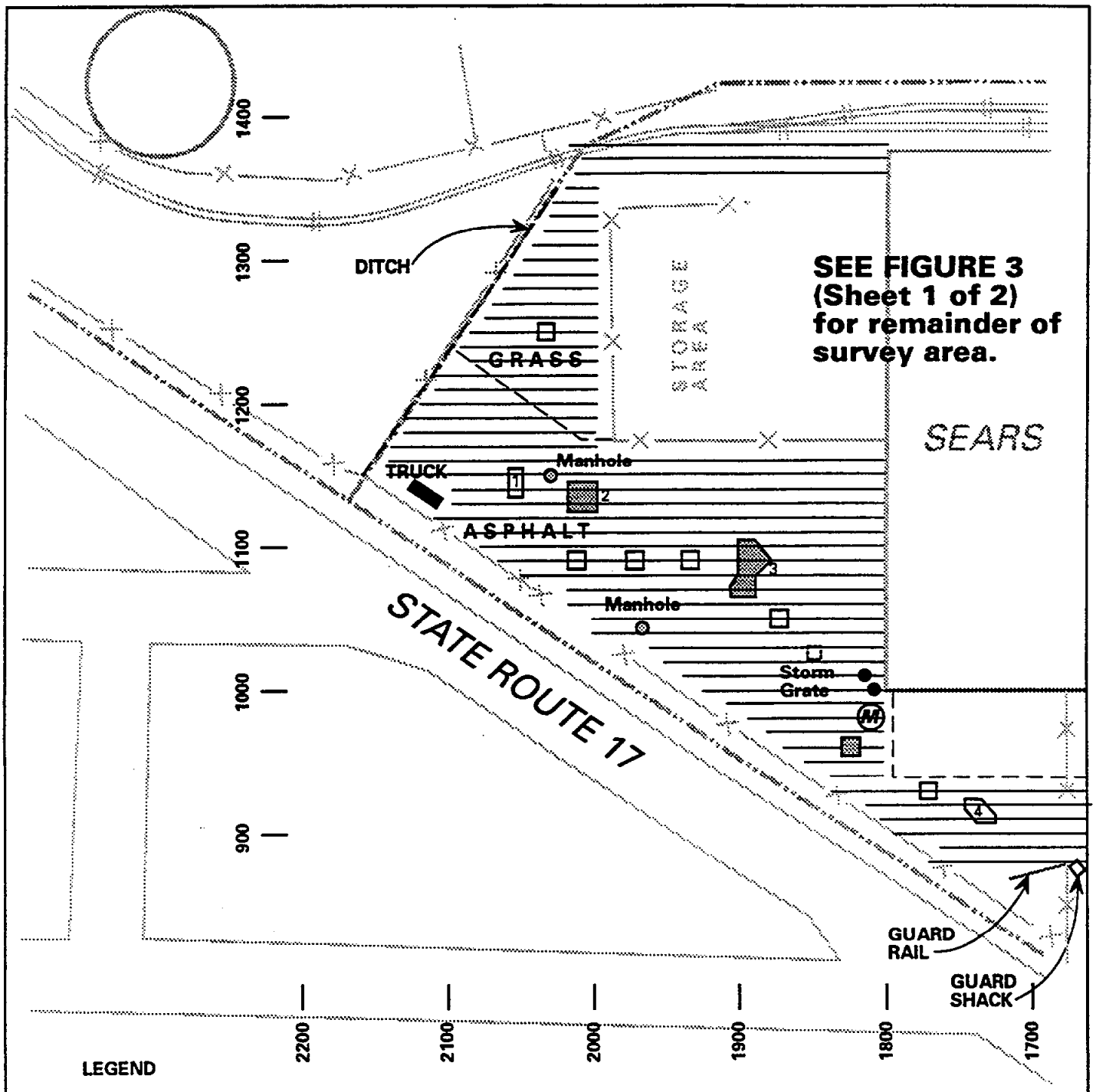

FIGURE 3 (Sheet 2 of 2)
Interpreted Areas of Buried Metals
SEARS LOGISTICAL SERVICES
MAYWOOD, NJ

NJO22948.SR.GP 2 Mag & Anom 4-20-92mms

Table 5-1			Page 1 of 7
MULTIPLE LINE AREAS			
Area Number	**Maximum Anomaly Strength (Gammas)**	**Potential Test-Pit Location**	**Comments**
1	130	1140 E, 2050-2060 N	Weak
2*	1200	1140 E, 2000-2010 N	10 feet from manhole.
3*	1300	1090 E, 1880-1890 N	Much weaker on adjacent lines.
4	170	920 E, 1740-1750 N	The anomalies are affected by their proximity to the building.
5*	350	800 E, 1580-1590 N	Western 2 anomalies affected by fence.
6*	700	850 E, 1520-1530 N	About 25 feet west of storm sewer.
7*	1400	910 E, 1450-1480 N	West side not well defined because of interpreted utility along grid line 880 E (appx.)
8*	1000	790 E, 1460-1470 N	Well defined anomalies.
9*	1200	830 E, 1410-1430 N	West end merges with storm sewer anomalies. Additional interference with Area 10 anomalies. Near DOE drum site.
10	550	830 E, 1380-1400 N	Considerably weaker on adjacent lines.
11*	900	800 E, 1370-1390 N	Most other anomalies in this zone are weak. Linearity of this area suggests a utility line.
12*	1300	750 E, 1310-1320 N	Most anomalies are greater than 500 gammas. Area crosses storm sewer.

Table 5-1			Page 2 of 7
MULTIPLE LINE AREAS			
Area Number	**Maximum Anomaly Strength (Gammas)**	**Potential Test-Pit Location**	**Comments**
13*	1100	720 E, 1270-1290 N	Although anomaly on line 710 appears stronger, it is distorted by storm sewer anomaly and does not provide a good target. Near DOE drum site.
14	1600	930 E, 1340-1370 N	Not seen at all on 920 E. Near edge of concrete pad in front of building.
15	200	850 E, 1280-1290 N	Weak, poorly defined anomalies.
16	250	780 E, 1280-1290 N	Weak.
17*	550	790 E, 1240-1250 N	Other anomalies in area are less than 200 gammas.
18	250	770 E, 1210-1220 N	Weak, poorly formed anomalies.
19	200	790 E, 1170-1180 N	Weak, poorly formed anomalies.
20*	550	930 E, 1160-1180 N	Possibly affected by proximity to building.
21	150	710 E, 1110-1120 N	Weak. Distorted by response to fence at 1070 N.
22	170	950 E, 1100-1110 N	Weak. Both anomalies less than 200 gammas.
23*	3000	820 E, 1050-1070 N	Partially affected by fence at 1070 N. Similar in appearance to Area 24, which is probably a UST.
24	4000	870 E, 1000-1040 N	Adjacent to a gas pump and presumably an underground tank.
25	350	840 E, 1010-1020 N	Distorted by Area 24 anomalies.

Table 5-1			Page 3 of 7
MULTIPLE LINE AREAS			
Area Number	**Maximum Anomaly Strength (Gammas)**	**Potential Test-Pit Location**	**Comments**
26	250	930 E, 1050-1070 N	Weak. Affected by proximity to building.
27*	400	930 E, 990-1010 N	Anomalies not well shaped. Affected by nearby building.
28	300	880 E, 970-990 N	Anomalies not well shaped. Weak on other line.
29	250	840 E, 980-990 N	Weak.
30*	350	860 E, 930-940 N	
31	200	790 E, 920-930 N	Weak. Anomaly on line 800 E is less than 100 gammas.
32*	300	780 E, 890-910 N	West end affected by proximity to fence.
33	400	690 E, 960-970 N	Beneath access road. Full extent of area may not be defined because of fence.
34	220	690 E, 940-950 N	Beneath access road. Full extent of area may not be defined because of fence.
35	240	930 E, 925-940 N	
36*	2000	970 E, 910-920 N	Edge of asphalt.
37	600	950 E, 890-910 N	Adjacent lines are much weaker.
38*	600	1020 E, 900-910 N	Metal can observed at this location.

Table 5-1			Page 4 of 7
MULTIPLE LINE AREAS			
Area Number	**Maximum Anomaly Strength (Gammas)**	**Potential Test-Pit Location**	**Comments**
39	300	940 E, 830-850 N	Poorly formed anomalies.
40*	280	1120 E, 920-930 N	Distinct anomalies. Near edge of asphalt.
41	120	1110 E, 860-870 N	Weak, poorly formed anomalies.
42*	400	1110 E, 830-840 N	Concrete and other rubble present.
43*	400	1050 E, 780-790 N	Grassy area.
44	200	1160 E, 720-740 N	Somewhat distorted by fence at 700 N.
45*	400	1300 E, 810-820 N	Other weak single line anomalies in vicinity.
46*	1100	1240 E, 760-770 N	Other anomalies in this area 200 gammas or less.
47	1000	1390 E, 920-940 N	A suspected underground utility line is beneath grid line 1380 or 1390 E. It may be a power line servicing the light pole at 1390 E, 870 N.
48	300	1370 E, 970-980 N	Noisy data due to proximity to transformer and suspected underground utility.
49*	1700	1390 E, 800-810 N	A suspected underground utility line is beneath grid line 1380 or 1390 E. It may be a power line servicing the light pole at 1390 E, 870 N.
50	220	1450 E, 810-820 N	Eastern extent not defined because of proximity to power line.

Table 5-1			Page 5 of 7
MULTIPLE LINE AREAS			
Area Number	**Maximum Anomaly Strength (Gammas)**	**Potential Test-Pit Location**	**Comments**
51*	700	860x N, 810-820 E	Data are noisy and interpretation is less certain.
52	700	740 E, 750-770 N	Fence crosses east end of area. Most anomalies are relatively wide, poorly formed and with multiple peaks.
53	400	750 E, 730-740 N	Possible distortion of anomalies by nearby fence.
54*	500	710 E, 700-710 N	Multiple peaks along each of the two lines of this area. Near DOE drum site.
55*	700	770 E, 660-670 N 780 E, 600-610 N	Multiple peaks along each of the lines. Two test pit locations are proposed because of the size of the area.
56*	1000	800 E, 690-700 N	Possible connected to Area 55.
57	250	850 E, 650-660 N	Weak.
58	190	820 E, 600-610 N	All anomalies less than 200 gammas.
59	250	760 E, 550-570 N	Mostly weak, poorly shaped anomalies.
60*	600	670 E, 580-600 N	Western extent not covered by survey. May originate in dirt/rubble pile beside ditch.
61	230	690 E, 480-490 N	Weak.
62	200	820 E, 510-520 N	Weak.

Table 5-1			Page 6 of 7
MULTIPLE LINE AREAS			
Area Number	**Maximum Anomaly Strength (Gammas)**	**Potential Test-Pit Location**	**Comments**
63	250	920 E, 510-520 N	Power line is nearby.
64	110	940 E, 530-540 N	Weak.
65	200	960 E, 520-530 N	Weak.
66	200	1060 E, 590-600 N	Weak.
67*	400	1180 E, 580-590 N	
68*	260	1210 E, 590-600 N	No data on line 1220.
69	300	1240 E, 600-620 N	Weak anomalies. Underground water line is suspected.
70	190	1220 E, 510-520 N	Weak, poorly shaped anomalies.
71*	1300	1440 E, 580-590 N	East end of area not defined.
72*	500	1370 E, 480-490 N	Possibly related to Area 73 and utility line.
73*	500	1370 E, 460-470 N	Corresponds in part to a dirt mound. Possibly related to Area 72. East end not well defined because of effect of presumed underground utility along grid line 1380 or 1390 E.
74	200	1260 E, 450-460 N	Along edge of access road.
75	400	1290 E, 350-360 N	Beneath access road. Length vs. width suggests underground utility line.

Table 5-1			Page 7 of 7
MULTIPLE LINE AREAS			
Area Number	**Maximum Anomaly Strength (Gammas)**	**Potential Test-Pit Location**	**Comments**
76*	600	1250 E, 310-320 N	Beside access road.
77	500	1390 E, 410-430 N	Anomalies may be due to assumed underground utility along grid line 1380 or 1390 E.
78	130	1370 E, 390-400 N	Weak.
79	130	1400 E, 360-370 N	Weak, poorly shaped anomalies. May be due to assumed underground utility along grid line 1380 or 1390 E.
80	150	1390 E, 340-350 N	Weak, poorly shaped anomalies. May be due to assumed underground utility along grid line 1380 or 1390 E.
81*	500	1380 E, 310-320 N	May be related to assumed underground utility along grid line 1380 or 1390 E.
82	200	1440 E, 320-330 N	Weak.

*Areas recommended for test pits.

Table 5-2			Page 1 of 4
SINGLE LINE AREAS			
Location of Anomaly Peak	**Anomaly Strength (Gammas)**	**Recommended for Test Pit (Y/N)**	**Comments**
900 E, 510 N	1400	Y	Possibly due to power line noise.
810 E, 1500 N	660	Y	In line with Area 6.
870 E, 1470 N	460	Y	Might be part of Area 7.
890 E, 910 N	400	Y	Corresponding low seen on Line 900 E.
960 E, 1820 N	380	Y	
1100 E, 660 N	310	Y	
1300 E, 860 N	300	Y	
740 E, 1170 N	300	Y	
820 E, 980 N	260	Y	Corresponding low seen on Line 830 E. Near DOE drum site.
830 E, 920 N	260	Y	
750 E, 490 N	250	Y	Corresponding low seen on adjacent line.
840 E, 870 N	240	Y	
1060 E, 820 N	210	Y	Corresponding low seen on Line 1070 E. Located on rubble pile.
1440 E, 520 N	-400	Y	Only anomalous low seen.
740 E, 610 N	440	N	Might be part of Area 55.
1190 E, 550 N	400	N	Near pole and near Areas 67 and 68.
1020 E, 850 N	380	N	Metal poles.
870 E, 1430 N	310	N	Near Area 9.
1080 E, 820 N	260	N	
1080 E, 870 N	260	N	
1160 E, 770 N	250	N	
850 E, 1580 N	250	N	
980 E, 630 N	240	N	
900 E, 1630 N	240	N	
730 E, 640 N	230	N	
1110 E, 780 N	230	N	

Table 5-2			Page 2 of 4
SINGLE LINE AREAS			
Location of Anomaly Peak	**Anomaly Strength (Gammas)**	**Recommended for Test Pit (Y/N)**	**Comments**
850 E, 900 N	220	N	
1220 E, 850 N	220	N	
930 E, 1770 N	220	N	Entire line is noisy.
750 E, 1120 N	210	N	
770 E, 1240 N	210	N	
1170 E, 540 N	200	N	In line with possible utility (Area 75).
800 E, 1020 N	200	N	
810 E, 960 N	200	N	
1300 E, 770 N	200	N	
840 N, 800 E	200	N	Skewed grid.
860 E, 1620 N	200	N	
750 E, 1010 N	190	N	
790 E, 710 N	190	N	
880 E, 650 N	180	N	
910 E, 890 N	180	N	
1000 E. 750 N	180	N	
930 E, 1250 N	180	N	
890 N, 720 E	180	N	Skewed grid.
860 N, 900 E	180	N	Skewed grid.
740 E, 560 N	170	N	
790 E, 950 N	170	N	
1080 E, 850 N	170	N	
1100 E, 890 N	170	N	
1180 E, 730 N	170	N	
900 E, 1260 N	170	N	
990 E, 540 N	160	N	
730 E, 470 N	150	N	
970 E, 550 N	150	N	

Table 5-2			Page 3 of 4
SINGLE LINE AREAS			
Location of Anomaly Peak	**Anomaly Strength (Gammas)**	**Recommended for Test Pit (Y/N)**	**Comments**
980 E, 510 N	150	N	
1200 E, 490 N	150	N	
750 E, 930 N	150	N	
900 E, 1380 N	150	N	
1090 E, 1930 N	150	N	
1230 E, 540 N	140	N	
990 E, 660 N	140	N	
990 E, 820 N	140	N	
1160 E, 800 N	140	N	
1440 E, 620 N	140	N	
680 E, 1200 N	140	N	
790 E, 1210 N	140	N	
820 E, 1530 N	140	N	
880 N, 880 E	140	N	Skewed grid.
1250 E, 490 N	130	N	
840 E, 940 N	130	N	
960 E, 760 N	130	N	
740 E, 1140 N	130	N	
740 E, 1290 N	130	N	
780 E, 1130 N	130	N	
860 N, 830 E	130	N	Skewed grid.
870 E, 1230 N	130	N	
860 E, 860 N	120	N	
1070 E, 650 N	120	N	
1140 E, 800 N	120	N	
1200 E, 890 N	120	N	
1210 E, 820 N	120	N	
1300 E, 790 N	120	N	
1440 E, 910 N	120	N	

Table 5-2			Page 4 of 4
SINGLE LINE AREAS			
Location of Anomaly Peak	**Anomaly Strength (Gammas)**	**Recommended for Test Pit (Y/N)**	**Comments**
730 E, 1360 N	120	N	
1050 E, 1870 N	120	N	
1090 E, 1970 N	120	N	
840 N, 760 E	120	N	Skewed grid.
670 E, 450 N	110	N	
760 E, 520 N	110	N	
740 E, 960 N	110	N	
1100 E, 800 N	110	N	
1260 E, 790 N	110	N	
1280 E, 790 N	110	N	
1320 E, 790 N	110	N	
810 E, 1550 N	110	N	
1090 E, 2010 N	110	N	
1250 E, 2030 N	110	N	
710 E, 440 N	100	N	
920 E, 570 N	100	N	
1040 E, 880 N	100	N	
1230 E, 320 N	-100	N	No corresponding high was observed.

5.2.1 North Area

The north area consists of a section of lawn as well as an asphalt parking area. A fenced storage area adjacent to the north side of the building was not investigated. A test line within the storage area indicated excessive interferences from an extensive reinforced concrete pad and a steel roof. A fence is present between the site and Highway 17. A truck was located at the north end of the area.

Three multiple-line areas have been identified, with 2 of them recommended for test pits. Both are within 20 feet of a manhole and the location of the underground utility should be confirmed.

5.2.2 West Parking Area

This entire area is asphalt covered. It is bounded on the east by the Sears building and the concrete parking area in front of the building. A chain barrier present along grid Line 880 east separates automobile parking from the truck access to the loading docks. Data suggests an underground utility (such as a water line) is present beneath the chain barrier. There is a fence along the south and west sides of this area. A storm sewer also crosses this area. Anomalies due to the storm sewer are not shown in the figures.

Nineteen multiple-line areas of buried metal have been interpreted beneath the west parking area. An underground utility line (in addition to the storm sewer) is suspected as causing some of the anomalies in Areas 9, 10, 11, 12 and 13. These areas, along with Area 7, also correspond closely with the location of a former drainage channel. Previous DOE investigations encountered drums in the vicinity of Areas 13 and 9.

Areas 17, 18, 19 and 21, along with several one-line anomalies fall within a relatively isolated grouping. This suggests that the buried material within the cluster might be related.

Area 14 is one of the strongest detected at the site but is not recommended for test pitting because of the likelihood that the anomaly is related to either the building or concrete pad in front of the loading docks.

5.2.3 South Parking Area

About two-thirds of this area is asphalt covered and the remainder is grass. A gas pump is present in the west portion of this area and large anomalies attributed to underground storage tanks were detected at either side of the pump. A power transformer and a fuel oil UST near the southeast corner of the building interfered with data in that area. Noisy data along grid lines 1380 and 1390 E indicate the presence of a buried utility there.

A large number of anomalies were detected beneath the asphalt in the west portion of this area (west of grid line 950 E). Many were single line anomalies and less than 300 gammas, indicating a scattering or relatively small amounts of metal. Area 23 anomalies are similar in strength and extent to Area 24 anomalies (probably an UST) and the anomalies over the concrete pad at the gas pump (assumed to be another UST and/or reinforcing bars in the concrete and not shown in the figure). Previous DOE investigations encountered a drum near a single line area recommended for follow-up at 820 E, 980 N (adjacent to Area 29).

Another grouping of anomalies, including Areas 41, 42 and 43, is located in an area of dirt piles and concrete and asphalt pieces. A similar grouping is centered around Area 45, except no rubble is present on the surface.

5.2.4 South Yard

The south yard consists of grassy areas, wooded areas and a swamp. The access road crosses this area. The survey over the swampy area was conducted with 20-foot line spacing in order to minimize the number of lines cut through the weeds and because it was difficult to survey this area. A part of the swamp (about 1 acre) could not be investigated at all because of deep perched water and relatively thick (3 feet) marsh deposits.

The portion of the south yard west of the access road contains the most extensive areas of buried metal on the Sears property. Area 55 is the single most extensive area of buried metal and covers an area about 100 feet by 40 feet. The nature of the anomalies indicate that metal is not evenly distributed throughout Area 55. DOE investigations encountered a drum in the vicinity of Area 54.

The grouping of anomalies around Areas 63, 64 and 65 are weak, with the exception of the single line anomaly recommended for further investigation (900 E, 510 N). They may be due to interferences from the nearby power line. Several anomalies are related to cultural features including light poles, hydrants, culverts and reflector poles. Underground utilities cross the area, but their locations are not well known. Areas 69 and 75 are suspected of being due to utilities. A suspected underground utility beneath grid line 1380 or 1390 may be the source of anomalies at Areas 72, 73, 77, 78, 79, 81 and 82. A gas and water line exist in this area.

5.3 Limitation of Results

Prioritization for follow-up investigations of the interpreted areas of buried metal should not be based only on geophysical data. Other factors, such as site history and visual observations, should also be considered. The magnetometer is sensitive enough to detect the anomaly associated with several drums to a depth of 20 feet. This depth is greater than the thickness of the overburden at the site. Because of the complex nature of the site and the existence of many cultural sources of interference, anomalies that were identified in some cases may not contain buried metal or appear

to be as extensive as shown on the map. Other locations that may contain minor amounts of buried metal may have been missed due to magnetic interferences from other nearby metal.

6.0 Discussion and Recommendations

Buried metal has been identified in 183 areas distributed around the site. The nature of the buried metal cannot be determined from the data and further investigations will be necessary. All of the interpreted areas shown in Figure 3 are believed to have buried metal present. Test pits are not recommended for follow-up at all locations because it is not necessary or practical to perform such a large number of test pits to adequately characterize the buried materials. Each area within a clustered group of anomalies should not require further investigation. Excavation of a limited number of areas within each cluster should be adequate to characterize the group as a whole.

Areas recommended for test pits have been selected based on several criteria:

- They are the most extensive areas.
- They contain the largest amplitude anomalies.
- Cultural features do not appear to significantly contribute to the anomalies in the area.
- Previous DOE investigations encountered one or more containers in the vicinity.

Areas that were not recommended for follow-up were generally not selected because:

- Other areas selected for follow-up were nearby.
- The anomalies were small, indicating only small amounts of metal are present.

The following approach is recommended for the test-pit program. All anomalies proposed for test pitting will be field screened with a metal detector before digging to correctly locate their position and extent and to help establish the presence of buried utilities. Anomalies that cannot be located with the metal detector will not be investigated further.

6.1 Test-Pit Program

Thirty six multiple-line areas and 14 single-line areas for a total of 50 areas, are recommended for the test-pit program on the Sears property. The areas are identified in Tables 5-1 and 5-2. Test pit locations to investigate the areas defined by multiple line anomalies are described in Table 5-1. Test pits to investigate the areas defined by single lines should start at the location given in Table 5-2 and extend north about 10 feet.

Excavation of the selected test pits should provide a representative characterization of the type of ferromagnetic materials buried at the site. If drums are found in any of the test pits, it will be assumed that drums may exist in the other nearby anomalous areas and further investigations in these areas will not be necessary. If drums are found, the need for additional monitoring well coverage will be evaluated based on analytical results from the test-pit program. If no drums are found, the possibility that this area is still a source of contamination will be evaluated by using groundwater quality data obtained from the existing and proposed monitoring wells located downgradient of this area.

If test pits in addition to the ones recommended above are required, then priority of the follow-up investigations should be based on the areal extent of the buried metal (an indication of volume), the strength of the magnetic anomalies, site history, and field observations. The test-pit program should concentrate on the strongest anomalies within the recommended test-pit areas, in order to characterize the type of materials that are producing the largest anomalies. The investigation should progress from those areas consisting of multiple-line anomalies to the areas defined by single-line anomalies. Single-line anomalies may be less significant as potential sources. The extent of the test pit will be sufficient to characterize the source of the magnetic anomaly. The test pit will target the strongest part of the anomaly.

TECHNICAL MEMORANDUM CH2M HILL

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PREPARED BY: Mary Kate Dwyer/CH2M HILL

COPIES: Jeffrey Bartlett/Stepan Company
Rick Ramuglia/Alliance

DATE: November 8, 1991

SUBJECT: Surface Geophysics Investigation--Stepan Property

PROJECT: NJO22948.ST.GP

1.0 Introduction

1.1 Purpose and Scope

A surface geophysical investigation was conducted at the Stepan Company (Stepan) in Maywood, New Jersey, from September 3 to September 12, 1991. The survey, performed as part of the Remedial Investigation at the site, was conducted over approximately 8.6 acres of open area around the facility. The remaining 10 acres were occupied by buildings, reinforced concrete surfaces, railroad tracks, or radiation restricted areas which prohibited the execution of the geophysical investigation. The survey was conducted by CH2M HILL personnel Don Johnson, Mary Kate Dwyer, Bob Jackson, and Joe Merchak.

The objectives of the geophysical investigation are to identify potential sources of chemical contamination. Specifically, the geophysical investigation was performed in an effort to locate and define abandoned ferromagnetic containers in the overburden of the Stepan property. Due to the nature of deposits at the Stepan site, a magnetic survey was determined to be the most effective geophysical method available. The magnetometer can identify areas of buried metal but cannot distinguish drums from other ferrous materials or determine whether there is chemical contamination present. Therefore, the results of the magnetometer investigation were used to select locations for test pits that will be used to characterize the buried material. The Stepan site has been filled with approximately 10 feet of material, and it is likely that other types of non-hazardous metal debris and old building material may be the cause of a significant number of anomalies identified at the site.

The geophysical investigation was performed in several steps. First a grid was established in the survey areas. A magnetometer was then used to collect and store the geophysical data along the survey lines. The raw data was transferred from the magnetometer to the computer and the data was then arranged in spreadsheet form.

The data were graphed and anomalies were identified. The locations of the source of the anomalies were interpreted and put on the base map. The anomalies that could not be explained by cultural features were evaluated to identify possible areas of buried metal.

This technical memorandum (TM) is organized into six sections and supplemented with five attachments. The remainder of this introduction presents an overview of the report organization. The magnetometer selected and the theory of magnetics is described in Section 2.0. Section 3.0 describes the procedures employed in the collection of the data. Section 4.0 describes the methods used to interpret the data. Section 5.0 presents the results of the survey, the interpretation of the data, and the limitations of the results. A map showing the location of buried metal is included as part of this interpretation. Finally, Section 6.0 discusses recommendations for use of the data. Attachment A contains letters from CH2M HILL to the United States Environmental Protection Agency (EPA) regarding the change in the magnetometer used for the survey. Attachment B contains profile plots of the data collected during the investigation. Attachment C contains letters from CH2M HILL and EPA regarding a change in interpretation procedures for the anomalous areas. Attachment D is a contour map of the total magnetic field that was prepared for the southwest portion of the site. Also provided in this attachment is the map superimposed with the outlined areas and explanations for all other anomalies not included within the areas. Attachment E is a cultural features map that shows the location of metal objects and other sources of interference at the site.

2.0 Magnetometer and Theory of Magnetics

2.1 Magnetometer

A GEM GSM-19G overhauser gradiometer was used for the magnetic investigation. This magnetometer is different from the Geometrics G866 originally proposed in the workplan. The change in method was presented to the EPA before the survey was performed. The change in method was approved by the EPA. The letters documenting the change in method, the technical rationale for the change, and the advantages of the GEM magnetometer are presented in Attachment A.

2.2 Theory of Magnetics

The GEM is a proton precession magnetometer that measures the magnitude of the earth's magnetic field and vertical magnetic gradient. The magnetic field measured by the magnetometer is the sum of the earth's field, fields due to geologic formations, and fields due to cultural features such as buildings, cars, and other ferrous metal. The vertical magnetic gradient is the difference between two simultaneous total field measurements made at different heights above the ground. The gradiometer sensor supplied with the GEM magnetometer consists of two sensors about 2 feet apart. The vertical gradient often provides higher resolution of magnetic anomalies and may allow the collection of useful data closer to buildings than do total field measurements.

The magnetometer sensor consists of a small container filled with an organic, hydrogen-rich fluid, such as kerosene. A current is passed through a coil wrapped around the container, causing the molecules of the liquid to orient themselves with the inducing magnetic field produced by the coil. When the current to the coil is stopped, the molecules realign (precess) themselves with the earth's magnetic field. A small electric field, produced by the molecules as they realign themselves, is measured by the coil around the container and amplified. The strength of this field is proportional to the strength of the earth's magnetic field. The electronic circuitry of the magnetometer converts the measured field to a digital display of the magnetic field strength.

The earth's field varies during the day due to solar activity, and these variations are called diurnal drift. Diurnal drift is measured by periodic readings at a base station and removed from the data if necessary. Diurnal drift is usually negligible compared to anomalies caused by the presence of buried metal. The vertical gradient is not subject to diurnal drift.

Anomalies due to geologic formations can be and often are negligible, depending on the nature of the formation and its depth. Geologic anomalies are usually related to igneous or metamorphic rock formations. These rock types are not present near the surface at the Maywood site. Therefore, the anomalies at Stepan are not thought to be geologic.

3.0 Field Procedures

3.1 Establishing the Grid

Survey grids were established over the Stepan property before geophysical data was collected in areas clear of mature vegetation and building structures. Four separate grids were established over various portions of the site to facilitate data collection over the site. This was necessary because the buildings prevented a continuous grid to be established easily. The grids were placed to allow accurate and systematic sampling and to cite the positions of anomalies in the field. The grids were based on two perpendicular base lines formed by placing markers (pin flags or spray paint) at regular intervals across the site by using a compass and measuring tape. The east-west base lines for the major survey grid were parallel to the southern property fenceline. The east-west base lines for the northeast and eastern part of the property were parallel to West Hunter Avenue. The east-west lines for the two smaller grid areas were established over minor localized areas, as shown in Figure 1. Grid north was oriented approximately 50 degrees east of true north for the major site grid and varied by several degrees for the other grids.

Figure 1 shows the extent of the survey and the grid coordinates. East-west base lines were marked at 20-foot intervals. The east-west base lines corresponded with the 100-foot intervals along the north-south grid lines.

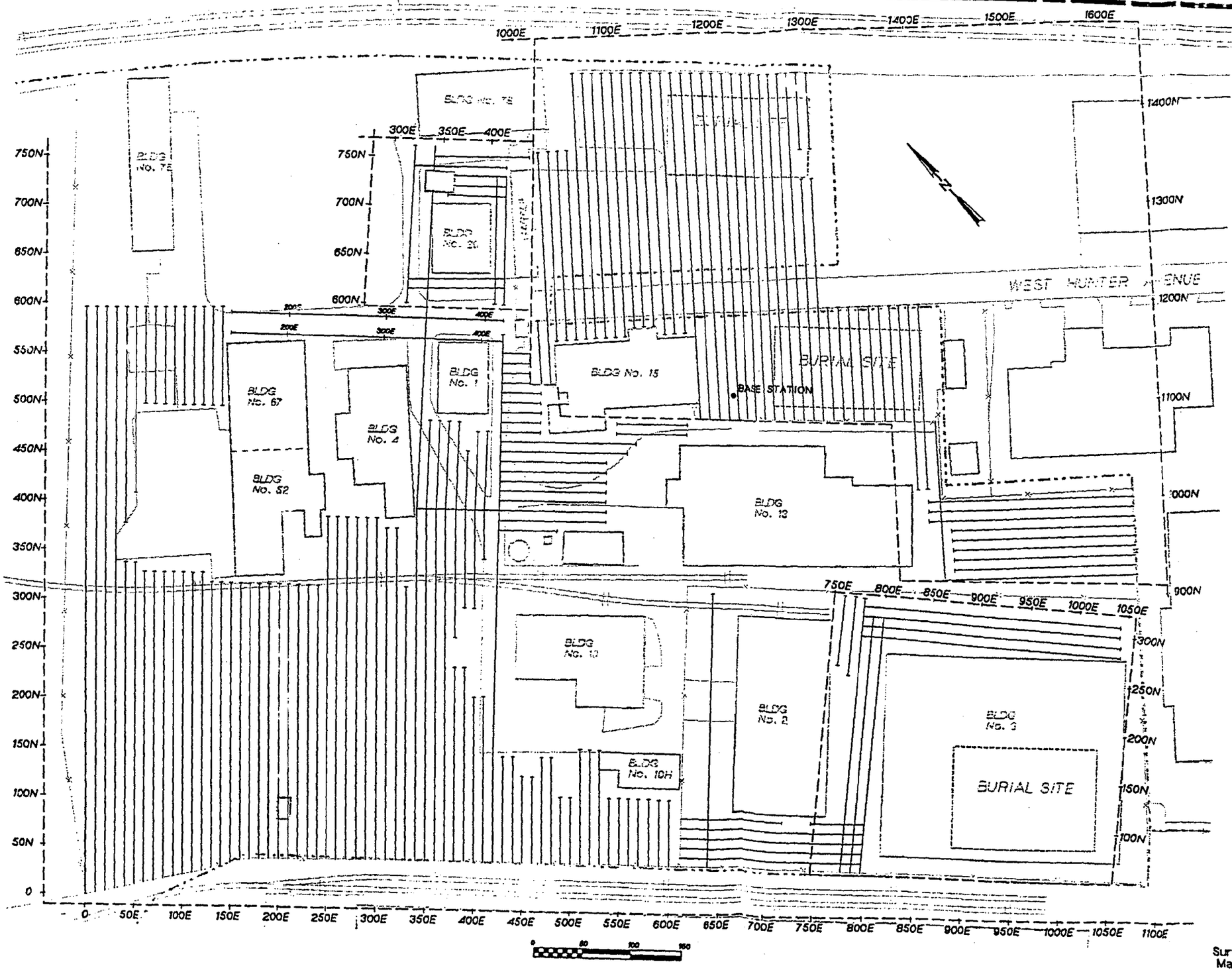

FIGURE 1
Survey Grid And Extent Of Magnetometer Investigation
STEPAN COMPANY
MAYWOOD, NJ

CH2MHILL

2848c010.dgn 31-Oct-1991

3.2 Base Station

A base station was established to determine the amount of diurnal (daily) drift in the earth's magnetic field. The station was located in an area free from magnetic anomalies and away from any detectable sources of interference (Figure 1). Readings were taken throughout the day in the morning, midday, and late afternoon and were entered into the field notes. On all days, the drift was less than 100 gammas. No drift correction was performed because the maximum observed drift of 100 gammas is small compared to the anomalies recorded over the site, which typically measured from greater than 500 gammas up to 5,000 gammas.

3.3 Magnetometer Survey

Data were systematically collected at 10-foot intervals along the north-south grid lines across most of the site. In areas that could not be surveyed in the north-south direction, data was collected at 10-foot intervals along east-west lines. The line number and direction, station number, and the station spacing were programmed into the magnetometer at the start of each grid line. Data were collected and stored in the internal memory of the instrument. Measurements were also recorded in the field logbook at regular intervals. Locations of features such as roads, fences, power lines, utilities, buildings, and scrap metal that may have affected the readings were recorded. Data from the digital logger were transferred to a computer on a daily basis, and the data were reviewed to determine if they were properly recorded and were checked for consistency with the data manually recorded in the logbook. Data were then processed as described in Section 4.0.

No functional checks are prescribed in the operator's manual for the magnetometer. Initial readings were compared against the total magnetic intensity predicted for the area, as shown on a map that was provided with the equipment. Equipment was determined to be responsive by taking measurements at different locations and noting that the measurements did not remain constant.

4.0 Interpretation Procedures

4.1 Magnetic Data

Preparation and plotting of the magnetometer data consisted of the following steps. The data were received in XYZ format, imported into a spreadsheet, and rearranged into a spreadsheet format with the columns representing survey lines and the rows representing station positions along the line. Profile plots of magnetic intensity and vertical magnetic gradient were prepared (Attachment B). The profile plots were used to interpret the location of the source of each anomaly.

A magnetic anomaly normally consists of both a magnetic high and a magnetic low. The pair of high and low values is due to the magnetic field induced in the buried metal by the earth's field. The magnetic field induced in the buried object has both a north and south magnetic pole, which results in a net increase and decrease, respectively, in the measured total field. In the northern hemisphere, the magnetic high is on the south side of the source and the low is on the north side. The source of the anomaly is interpreted as extending from the peak of the magnetic high to the lowest value north of the high. The high/low pairs are not always well-defined due to nearby interferences and grid line orientation. Professional judgement is required in delineating magnetic sources. An anomaly was chosen if it was recognizable over the same station interval on both the total field and the vertical gradient profiles.

Once an anomaly was identified, the interpreted location of the source of the anomaly was transferred to the base map. A contour map of total magnetic field was generated for the southwest corner of the site, because of the large number of anomalies in this area. The contour map illustrates the relationship between anomalies on adjacent lines and also shows which anomalies should be grouped together.

Many geophysical constraints and potential magnetic interferences are present on the Stepan property and were described in the workplan. As was stated in the workplan, the combined effect of magnetic interferences from buildings, utilities, and other features present at the Stepan site could not be predicted before the survey. These combined interferences affect the anomaly amplitude required before an anomaly is recognizable. After the data were reviewed on the profiles and anomalies plotted on the base map, it was determined that a different approach (i.e., anomaly amplitude) would be necessary for interpretation of the data. This approach was brought to the EPA's attention. The letters included in Attachment C document the correspondence between CH2M HILL and EPA.

Ordinarily at a site free of buildings and other cultural features, a 100 gamma anomaly, as stated in the workplan, would be recognizable and considered significant. However, because of the large amount of anomalies with large amplitude and areal extent identified at the site, this approach is no longer practical for the Stepan property. With respect to the anomalies encountered and the geophysical constraints present at the site, only anomalies greater than 500 gammas have been identified as anomalous areas. However, anomalies less than 500 gammas were plotted on the base map, as was stated in the workplan.

5.0 Results of Investigation

5.1 Buried Metal

The extent of the magnetometer survey conducted at Stepan is shown in Figure 1. Magnetic data are presented in Attachment B. Figure 2 presents the locations that are interpreted to contain buried metal. Attachment D is the contour map of total magnetic field intensity for the particularly complicated southwest area of the site. Attachment D-1 illustrates how the anomalies on the contour map were used to define the location and shape of anomalous areas.

Ninety-two areas of buried metal have been identified at the site (Figure 2). The areas shown on the map have been identified based on magnetic anomalies that are not a result of known sources. Anomalies resulting from known sources, such as power lines, surface metal, or buildings have not been shown unless other buried material is suspected based upon the amplitude of the anomaly. The location of metal objects and other sources of interference encountered at the site are shown in the cultural features map (Attachment E). Note that a qualitative attempt was made to prioritize the anomalies by numerical order based on the areal extent of the interpreted location of the source and the amplitude of magnetic anomalies within the area.

5.2 Distribution of Anomalous Areas

A brief description of the site with respect to the areas of buried metal is given in the following summary. Figure 3 shows where the anomalous areas are located.

5.2.1 Southwest Site

The southwest portion of the site contains a majority of the interpreted areas. Approximately 51 areas of buried metal have been located. Anomalies in this area range from less than 500 gammas to greater than 5000 gammas. One of the strongest magnetic anomalies in this areas is located directly south of the railroad tracks (Area 2). It appears to be related to Area 28. The anomalies in both of these areas are located on the same magnetic high seen on the total field contour map (Attachment D). Steel tanks and other metal structures near the eastern portion of the southwest area may be affecting the strong anomalies that define the delineated areas located here.

5.2.2 Northwest Site

The northwest portion of the site contains 16 areas of buried metal. Magnetic anomalies in this portion of the site range from less than 500 to 2000 gammas. The large reinforced concrete pad located in the central portion of this area may be affecting the amplitude of nearby anomalies.

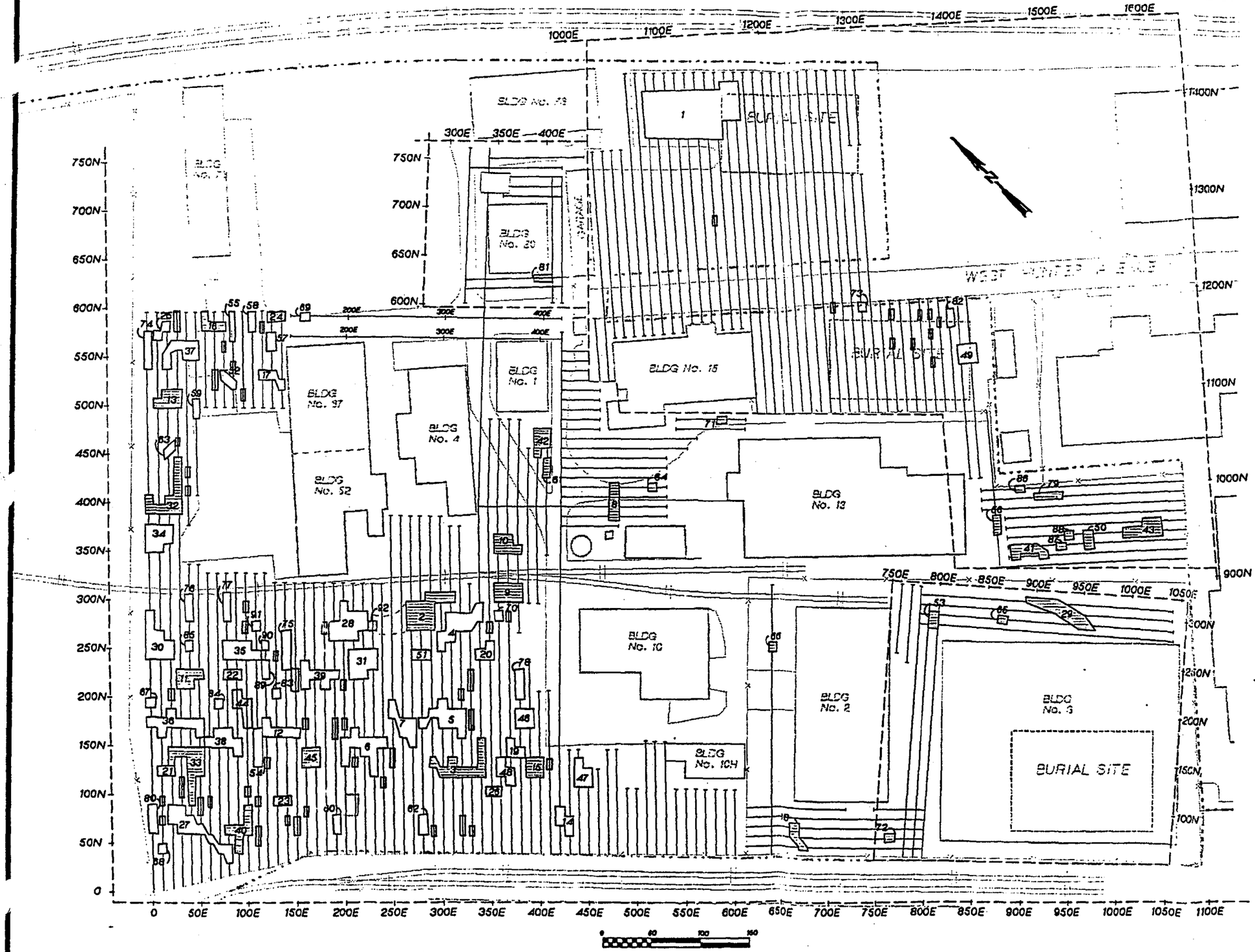

FIGURE 2
Interpreted Areas Of Buried Metal
STEPAN COMPANY
MAYWOOD, NJ

CH2M HILL

2948c012.dgn 31-Oct-1991

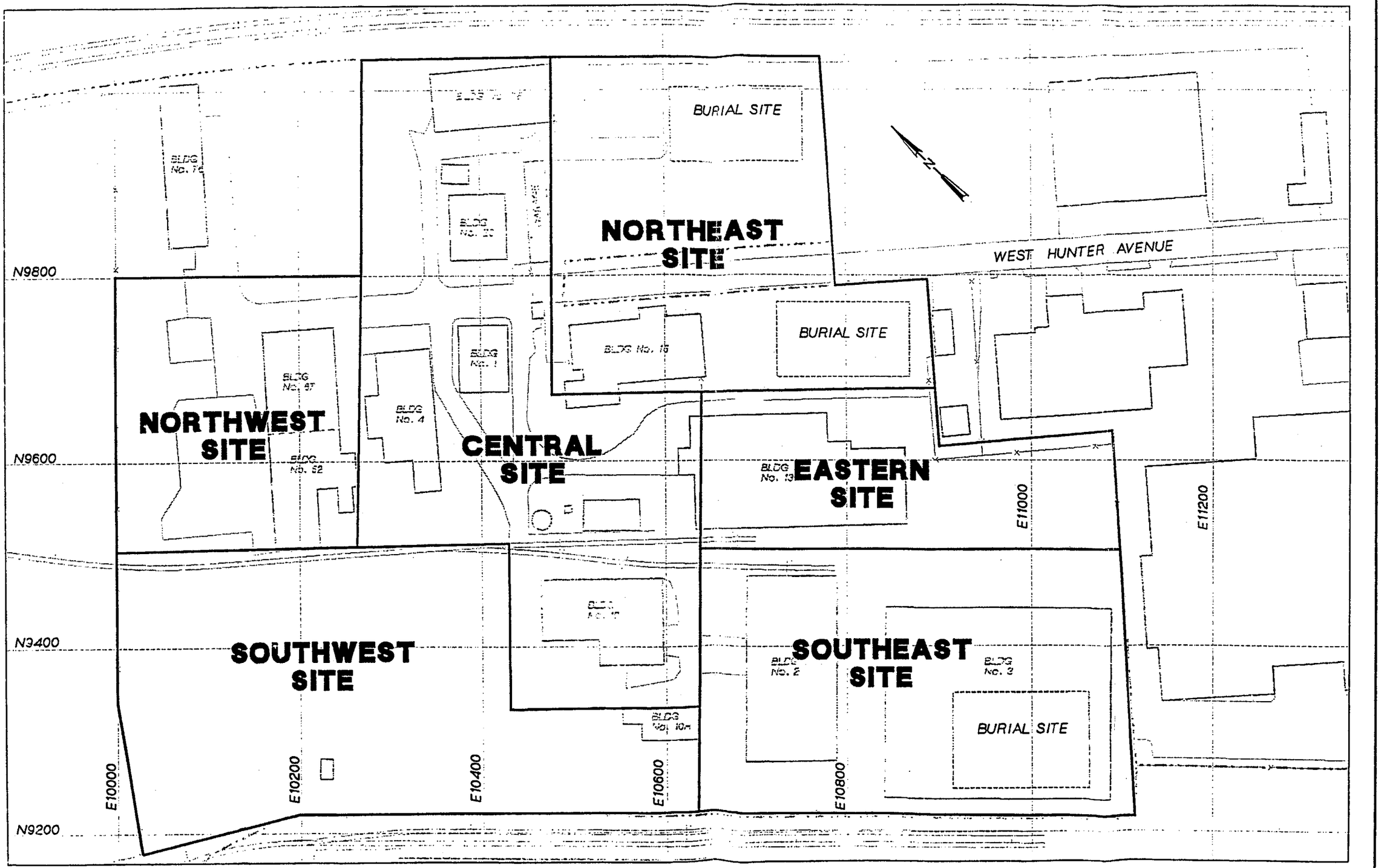

FIGURE 3
Site Location Index
STEPAN COMPANY
MAYWOOD, NJ

CH2M HILL

2948c009.dgn 24-Oct-1991

5.2.3 Central Site

The central portion of the site contains seven areas of buried metal. Anomalies range from less than 500 to 4000 gammas. Large interferences (i.e., buildings) and metal objects prevented collection of usable data over a large portion of this area.

5.2.4 Northeast Site

The northeast portion of the site contains the largest and one of the strongest anomalies found at the site (Area 1). Area 1 is thought to be the burial site in the north parking lot, because of its shape and extensive area. Three smaller anomalous areas in the eastern part of the front lawn, and a number of weaker anomalies, were observed and appear to be related to the burial site located below this area.

5.2.5 Eastern Site

The eastern portion of the site contains 8 areas of buried metal. Anomalies range from 500 to 5,000 gammas in this area. Most of the areas are believed to be located over a portion of the railroad that used to exist in this area that is now covered with asphalt.

5.2.6 Southeast Site

The southeast portion of the site contains six areas of buried metal. Anomalies in this area range from 500 to 2,000 gammas. The smaller anomalies may be related to utility lines that run through the area. Area 29 is believed to be located over a portion of the railroad line that used to exist in this area that is now covered with asphalt.

5.3 Categories of Buried Metal

The areas of buried metal were divided into four different categories, based on their overall extent, magnetic amplitude, and whether there were cultural features that may have contributed to the anomaly at the surface.

5.3.1 Category 1 Areas

Category 1 areas are characterized by multiple-line anomalies that are greater than 500 gammas and are not influenced by any observed surface or subsurface source of interference. These areas are listed in Table 5-1 along with their site location, their strength, and test-pit locations. Potential test-pit locations given in these tables indicate the strongest source of the anomaly and the location to begin digging if the source is investigated.

Table 5-1 Category 1 Areas*				
Area	Site Location	Strength of Anomalies (gammas)	Potential Test-Pit Location	Justification for Not Recommending Area As a Test-Pit Location**
1	NE Site	>500-5,000	1170 E, 1420-1430 N	Related to Radiation Burial site.
2***	SW Site	>1,000-5,000	280-290 E, 280-300 N	Recommended test-pit location.
3***	SW Site	>1,000-2,000	320-330 E, 120-130 N	Recommended test-pit location.
4	SW Site	>1,000-2,000	310-330 E, 270-290 N	Between Area 2 and Area 9.
5	SW Site	>500-1,000	310 E, 170-180 N	Close to Area 3.
6	SW Site	>500-2,000	240 E, 150-160 N; 210 E, 150 N	Anomaly not well-defined. May be several smaller sources. Close to Area 45.
7	SW Site	>1,000-5,000	250 E, 180-200 N	Area adjacent to transformer pad. Close to Area 3.
8	Central Site	>2,000-5,000	410 N, 470-480 E	Suspected location of abandoned underground storage tank.
9***	SW Site	>2,000	360 E, 300-320 N	Recommended test-pit location.
10***	Central Site	<500-2,000	360 E, 350-370 N	Recommended test-pit location.
11***	SW Site	>500-1,500	40-50 E, 210-220 N	Recommended test-pit location.
12	SW Site	<500-1,500	130 E, 160-170 N	Close to Area 45.
13***	NW Site	>500-2,000	10 E, 500-510 N	Recommended test-pit location.
14	SW Site	>1,000-2,000	430 E, 60-70 N	Possible powerline/rubble interference. Close to Area 15.
15***	SW Site	>2,000	390-400 E, 120-130 N	Recommended test-pit location.
16***	NW Site	>500-2,000	580 N, 50-60 E	Recommended test-pit location.
17	NW Site	<500-1,000	140 E, 520-530 N	Adjacent to building structure. Weak response. Close to Area 16.
18***	SE Site	>500	60 N, 660-670 E	Recommended test-pit location.
19	SW Site	>2,000	370 E, 140-150 N	Adjacent to Area 15.

Table 5-1
Category 1 Areas*

Area	Site Location	Strength of Anomalies (gammas)	Potential Test-Pit Location	Justification for Not Recommending Area As a Test-Pit Location**
20	SW Site	>500	340 E, 240-250 N	Weak response. Close to Area 9.
21	SW Site	1,000-1,500	10 E, 120-130 N	Adjacent to Area 33.
22	SW Site	500-1,000	80 E, 220-230 N	Weak response. Limited extent. Close to Area 11.
23	SW Site	>500	130-140 E, 90-100 N	Weak response. Limited extent. Close to Area 40.
24	NW Site	>500	130 E, 590-600 N	Weak response. Close to Area 16.
25	NW Site	>500	10 E, 570-580 N	Weak response. Close to Area 16.
26	SW Site	>1,000	350 E, 100-110 N	Between Area 3 and Area 15.

*Multiple-line anomalies greater than 500 gammas not influenced by cultural sources.
**Recommendations based on amplitude of anomalies, areal extent and location of areas, and the nature of magnetic high and low pairs on magnetic contour map.
***Recommended test-pit location.

5.3.2 Category 2 Areas

Category 2 areas consist of multiple-line anomalies that are greater than 500 gammas and may be influenced by a source of interference at the surface. These areas are shown in Table 5-2. The cultural feature that may have contributed to the magnetic field is also listed.

5.3.3 Category 3 Areas

Category 3 areas are classified as single-line anomalies greater than 500 gammas that are located in an area where no source of interference is present. These areas are listed in Table 5-3.

5.3.4 Category 4 Areas

Category 4 areas are described as single line anomalies greater than 500 gammas that may be influenced by the presence of a cultural feature. These areas are shown in Table 5-4. The cultural feature that may have contributed to the magnetic field is also listed.

5.4 Limitation of Results

Prioritization for followup investigations of the interpreted areas of buried metal should not be based only on geophysical data. Other factors, such as site history and visual observations, should also be considered. The instrument is sensitive enough to see the anomaly associated with several drums to a depth of 20 feet. This depth is greater than the thickness of the overburden at the site. Because of the complex nature of the site and the existence of many cultural sources of interference, anomalies that were identified in some cases may not contain buried metal or appear to be as extensive as they are shown on the map. Other locations that may contain minor amounts of buried metal may have been missed due to magnetic interferences from known or unknown sources.

6.0 Discussion and Recommendations

Buried metal has been identified in 92 areas distributed around the site. The largest concentration of areas is in the western portion of the site, particularly in the south. The nature of the buried metal cannot be determined from the data and further investigations will be necessary. Only anomalies that exceeded 500 gammas were identified as anomalous areas. Even though there were many sources of interference at the site, a large number of anomalies were identified and comprise the interpreted areas of buried metal. Anomalies less than 500 gammas were insignificant in comparison to the selected areas and many may be caused by surface features or related to the larger anomalies.

Table 5-2
Category 2 Areas*

Area	Site Location	Strength of Anomalies (gammas)	Cultural Feature	Test-Pit Location	Justification for Not Recommending Area As a Test-Pit Location**
27	SW Site	<500-1,000	rubble, scrap metal	20 E, 70-90 N; 70 E, 40-50 N	Anomaly not well-defined. Adjacent to Area 40 and Area 33.
28	SW Site	1,000-2,000	building foundation	220 E, 270-280 N	Close to Area 2. May be related to same source as Area 2.
29***	SE Site	3,000-4,000	RR tracks, drums	300 N, 920-930 E	Recommended test-pit location.
30	SW Site	>500-1,500	monitoring well, fence	10 E, 250-270 N	Close to Area 11.
31	SW Site	>500-1,000	foundation edge, scrap metal	210 E, 240-250 N	Close to Area 2.
32***	NW Site	>1,000-2,000	reinforced concrete	10-20 E, 390-410 N	Recommended test-pit location.
33***	SW Site	>1,000-2,000	rubble	30-40 E, 140-150 N	Recommended test-pit location.
34	NW Site	>1,000	fence, metal plate	20 E, 360-380 N	Adjacent to Area 32.
35	SW Site	>1,000-2,000	foundation, drum	100 E, 240-260 N	Close to Area 11.
36	SW Site	>500-1,000	rubble	30 E, 170-180 N	Between Area 11 and Area 33.
37	NW Site	>500-2,000	reinforced concrete	40 E, 550-570 N	Between Area 13 and Area 16.
38	SW Site	>500-1,000	rubble	60-70 E, 150-160 N	Adjacent to Area 33.
39	SW Site	>1,000-2,000	rubble	180 E, 210-230 N	Close to Area 45.
40***	SW Site	>500-1,000	scrap metal, rubble	90-100 E, 60 N	Recommended test-pit location.
41***	Eastern Site	>2,000	RR tracks	940 N, 1,440-1,450 E	Recommended test-pit location.
42***	Central Site	>2,000	loading ramp	400-410 E, 460-470 N	Recommended test-pit location.
43***	Eastern Site	>5,000	RR tracks	960 N, 1,560-1,580 E	Recommended test-pit location.
44	SW Site	>500-2,000	rubble, metal pipe	100 E, 170-180 N	Weak response. Between Area 11 and Area 45.

Table 5-2
Category 2 Areas*

Area	Site Location	Strength of Anomalies (gammas)	Cultural Feature	Test-Pit Location	Justification for Not Recommending Area As a Test-Pit Location**
45***	SW Site	>2,000-3,000	rebar, metal	160 E, 130-140 N	Recommended test-pit location.
46	SW Site	>2,000-3,000	near tanks	390 E, 170-190 N	Close to Area 15.
47	SW Site	>1,000-2,000	near fence; tank	440 E, 110-130 N	Weak response. Close to Area 15.
48	SW Site	>1,000-2,000	dumpster	360 E, 120-130 N	Adjacent to Area 3 and Area 15.
49	NE Site	>500	edge of burial site	1390-1400 E, 1,120-1,140 N	Related to Radiation Burial site.
50***	Eastern Site	>500-2,000	RR tracks	940 N, 1,500-1,510 E	Recommended test-pit location.
51	SW Site	>500-1,000	monitor well	280 E, 240-250 N	Anomaly not well-defined. Close to Area 2.
52	NW Site	<500-500	reinforced concrete	80 E, 530-540 N	Weak response. Between Area 13 and Area 16.
53***	SE Site	undetermined	building	280-290 N, 790-800 E	Recommended test-pit location.

*Multiple-line anomalies greater than 500 gammas not influenced by cultural sources.
**Recommendations based on amplitude of anomalies, areal extent and location of areas, observed cultural features, and the nature of magnetic high and low pairs on magnetic contour map.
***Recommended test-pit location.

Table 5-3 Category 3 Areas*			
Area	Site Location	Strength of Anomalies (gammas)	Test-Pit Location
54	SW Site	>500	110 E, 130-150 N
55	NW Site	>500	90 E, 590-600 N
56**	Eastern Site	1500	1410 E, 950-970 N
57	NW Site	>1000	130 E, 560-580 N
58	NW Site	>1000	110 E, 580-590 N
59	NW Site	>1000	50 E, 490-500 N
60	SW Site	>500	not recommended
61**	Central Site	>500	410 E, 430-440 N
62	SW Site	>500	not recommended
63	NW Site	>500	20 E, 450-460 N
64**	Central Site	>1000	420 N, 510-520 E
65**	SE Site	>1000	290 N, 860-870 E
66**	SE Site	>1000	640 E, 250-260 N
67	SW Site	>500	0 E, 190-200 N
68	SW Site	>500	not recommended
69	NW Site	>500	590 N, 150-160 E
70	SW Site	>500	360 E, 280-290 N
71**	NE Site	>500	490 N, 580-590 E
72**	SE Site	>500	60 N, 760-770 E
73**	NE Site	>500	1,290, 1,190-1,200 N

*Single-line anomalies greater than 500 gammas not influenced by a cultural source
**Recommended test-pit location

Table 5-4 Category 4 Areas*				
Area	Site Location	Strength of Anomalies (gamma)	Cultural Feature	Test Pit Location
74	NW Site	>1000	fenceline	OE, 540-550 N
75	SW Site	>1000	foundation, rebar	140 E, 230-260 N
76	SW Site	>2000	foundation	40 E, 280-290 N
77	SW Site	>1000	foundation	80 E, 280-290 N
78	SW Site	>2000	tank farm	380 E, 200-210 N
79**	Eastern Site	>1000	fenceline	990 N, 1,460-1,480 E
80	SW Site	>2000	fenceline	OE, 60-80 N
81**	North Central	>2000	building	620 N, 390-410 E
82	NE Site	>500	edge of burial site	not recommended
83	SW Site	>2000	metal pipe, rubble	130 E, 200-210 N
84	SW Site	>1000	rubble	70 E, 190-200 N
85	SW Site	>1000	foundation edge	40 E, 250-260 N
86**	Eastern Site	>2000	fenceline	1000 N, 1,430-1,440 E
87**	Eastern Site	>1000	RR tracks	940 N, 1,470-1,480 E
88**	Eastern Site	>1000	RR tracks	950 N, 1,480-1,490 E
89	SW Site	>500	gravel road	120 E, 220-240 N
90	SW Site	>500	foundation	120 E, 250-260 N
91	SW Site	>500	foundation	110 E, 270-280 N
92	SW Site	>500	scrap metal	230 E, 270-280 N

*Single-line anomalies greater than 500 gammas influenced by a cultural source
**Recommended test-pit location

The following approach is recommended for the test-pit program. All anomalies proposed for test pitting will be field screened with a metal detector before digging to correctly locate their position and extent.

Sixty-seven anomalies greater than 500 gammas were identified in the southwest and northwest areas of the site (Figure 2). Of these total areas, 11 of the strongest and most extensive anomalous areas were selected from the Category 1 and Category 2 areas (Tables 5-1 and 5-2). Anomalies that were located above concrete foundations were not chosen primarily because of the age of the possible sources (assuming that these structures are at least 50 years old). The total field magnetic contour map was used to help identify the strongest areas (Attachment D). The anomalous areas were selected to provide reasonable areal coverage of the southwest and northwest portions of the site. Tables 5-1 and 5-2 present the justification for not recommending other Category 1 and Category 2 areas for the test-pit program.

6.1 Test-Pit Program

The following 11 areas are recommended for the test-pit program in the southwest and northwest portions of the site: Areas 2, 3, 9, 11, 13, 15, 16, 32, 33, 40, and 45.

CH2M HILL believes that these test pits will provide a representative characterization of the type of ferromagnetic materials buried at the site. We feel that additional test areas would not significantly add to the characterization of the ferrous material present. If drums are found in any of the test pits in the northwest and southwest areas, it will be assumed that drums may exist in the other anomalous areas and no further excavations will be necessary. If drums are found, the need for additional monitoring well coverage will be evaluated based on analytical results from the test-pit program. If no drums are found, the possibility that this area is still a source of contamination will be evaluated by using groundwater quality data obtained from the existing and proposed monitoring wells located downgradient of this area.

Anomalous areas located in other portions of the site will be investigated as follows. Areas 1, 49, 73, and 82 appear to be related to radiation burial areas at the site and will not be investigated through the test pit program because of health and safety concerns.

Areas 29, 41, 43, 50, 87, and 88 are believed to be related to old railroad tracks that are now covered with asphalt. These anomalies will be traced with a metal detector and the position of the tracks will be confirmed at several locations.

Area 8 is thought to be the location of an abandoned underground storage tank. This location should not be test pitted if the location of the abandoned tank can be confirmed in this area.

The fifteen remaining anomalous areas (10, 18, 42, 53, 56, 61, 64, 65, 66, 71, 72, 73, 79, 81, and 86) will be test pitted at the locations shown in Tables 5-1 through 5-4.

If test pits in addition to the ones recommended above are required, then priority of the followup investigations should be based on the areal extent of the buried metal (an indication of volume), the strength of the magnetic anomalies, site history, and field observations. The test-pit program should concentrate on the strongest anomalies within the recommended test-pit areas, in order to characterize the type of materials that are producing the largest anomalies. The investigation should progress from those areas consisting of multiple-line anomalies to the areas defined by single-line anomalies. Single-line anomalies may be less significant as potential sources.

The extent of the test pit will be sufficient to characterize the source of the magnetic anomaly. The test pit will target the strongest part of the anomaly. A test pit excavated within the locations provided in Tables 5-1 to 5-4 should be sufficient to characterize the anomaly.

TECHNICAL MEMORANDUM CH2MHILL

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PREPARED BY: Mary Kate Dwyer/CH2M HILL

COPIES: Jeffrey Bartlett/Stepan Company
Roger Julian/Stepan Company
Ted Kielbasa/Stepan Company
Rick Ramuglia/Alliance

DATE: March 4, 1992

SUBJECT: Surface Geophysics Investigation--Amended Stepan Property

PROJECT: NJO22948.ST.GP

1.0 Introduction

1.1 Purpose and Scope

A surface geophysical investigation was conducted at the Stepan Company (Stepan) in Maywood, New Jersey, from December 10 to December 12, 1991. The survey, performed as part of the Remedial Investigation at the site, was conducted over approximately 2.8 acres of property west of the Department of Energy (DOE)/Stepan fenceline (Figure 1). The survey was conducted by CH2M HILL personnel Mary Kate Dwyer and Joe Merchak.

The objectives of the geophysical investigation are to identify potential sources of chemical contamination. Specifically, the geophysical investigation was performed in an effort to locate and define abandoned ferromagnetic containers in the overburden of the Stepan property. Due to the nature of deposits at the Stepan site, a magnetic survey was determined to be the most effective geophysical method available. The magnetometer can identify areas of buried metal but cannot distinguish drums from other ferrous materials or determine whether there is chemical contamination present. Therefore, the results of the magnetometer investigation were used to select locations for test pits that will be used to characterize the buried material. The Stepan site has been filled with approximately 10 feet of material, and it is likely that other types of non-hazardous metal debris and old building material may be the cause of a significant number of anomalies identified at the site.

The geophysical investigation was performed in several steps. First a grid was established in the survey areas. A magnetometer was then used to collect and store the geophysical data along the survey lines. The raw data was transferred from the magnetometer to the computer and the data was then arranged in spreadsheet form.

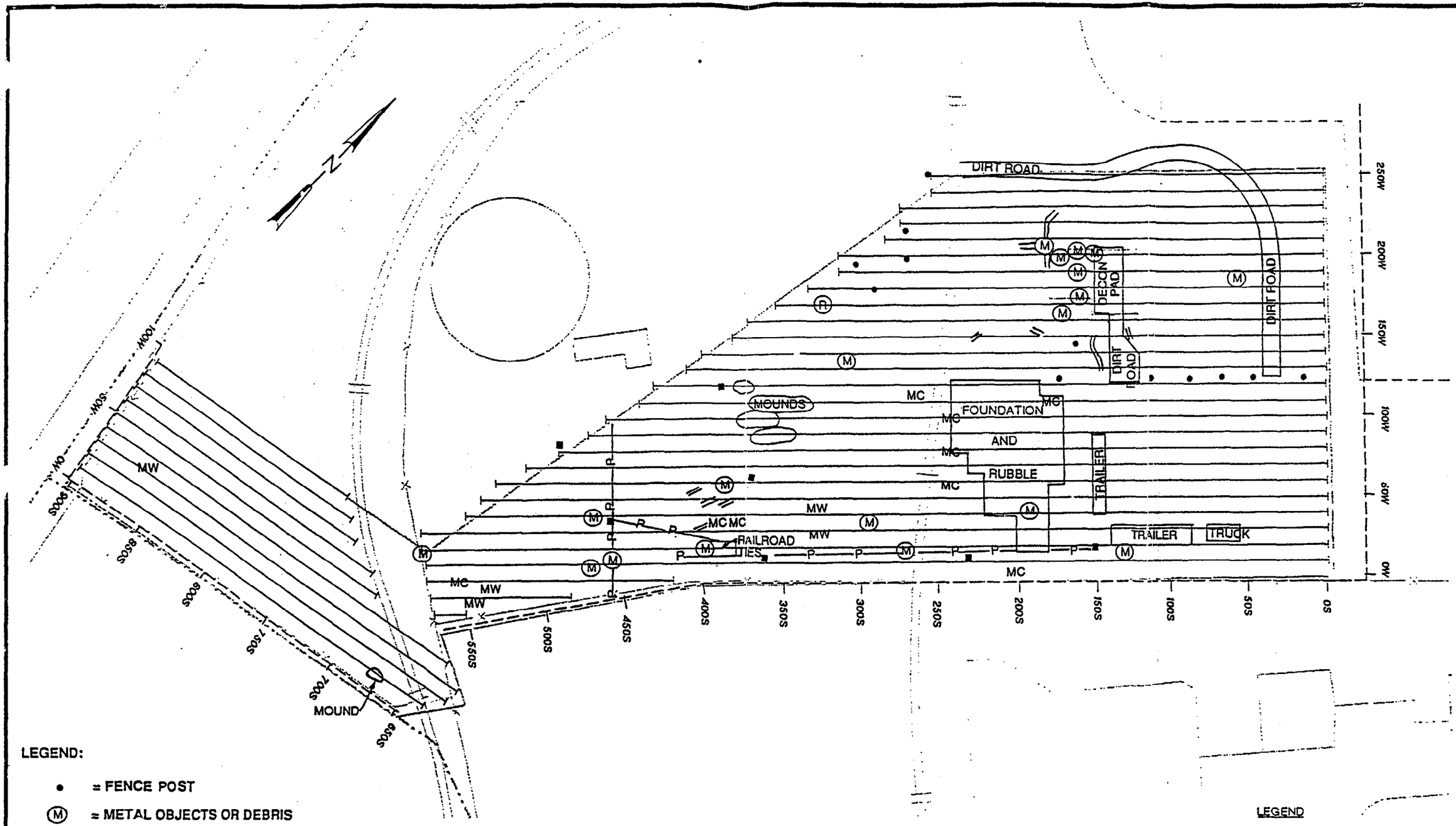


Figure 1
AMMENDED
STEPAN PROPERTY
CULTURAL FEATURES MAP

Survey Grid and Extent of Magnetometer Investigation
Cultural Features Map
STEPAN COMPANY
MAYWOOD, NJ

CH2MHILL

The data were graphed and anomalies were identified. The locations of the source of the anomalies were interpreted and put on the base map. The anomalies that could not be explained by cultural features were evaluated to identify possible areas of buried metal.

This technical memorandum (TM) is organized into six sections and supplemented with three attachments. The remainder of this introduction presents an overview of the report organization. The magnetometer selected and the theory of magnetics is described in Section 2.0. Section 3.0 describes the procedures employed in the collection of the data. Section 4.0 describes the methods used to interpret the data. Section 5.0 presents the results of the survey, the interpretation of the data, and the limitations of the results. A map showing the location of buried metal is included as part of this interpretation. Finally, Section 6.0 discusses recommendations for use of the data. Attachment A contains letters from CH2M HILL to the United States Environmental Protection Agency (EPA) regarding the change in the magnetometer used for the survey. Attachment B contains profile plots of the data collected during the investigation. Attachment C contains letters from CH2M HILL and EPA regarding a change in interpretation procedures for the anomalous areas.

2.0 Magnetometer and Theory of Magnetics

2.1 Magnetometer

A GEM GSM-19G overhauser gradiometer was used for the magnetic investigation. This magnetometer is different from the Geometrics G866 originally proposed in the workplan. The change in method was presented to the EPA before the survey was performed. The change in method was approved by the EPA. The letters documenting the change in method, the technical rationale for the change, and the advantages of the GEM magnetometer are presented in Attachment A.

2.2 Theory of Magnetics

The GEM is a proton precession magnetometer that measures the magnitude of the earth's magnetic field and vertical magnetic gradient. The magnetic field measured by the magnetometer is the sum of the earth's field, fields due to geologic formations, and fields due to cultural features such as buildings, cars, and other ferrous metal. The vertical magnetic gradient is the difference between two simultaneous total field measurements made at different heights above the ground. The gradiometer sensor supplied with the GEM magnetometer consists of two sensors about 2 feet apart. The vertical gradient often provides higher resolution of magnetic anomalies and may allow the collection of useful data closer to buildings than do total field measurements.

The magnetometer sensor consists of a small container filled with an organic, hydrogen-rich fluid, such as kerosene. A current is passed through a coil wrapped around the container, causing the molecules of the liquid to orient themselves with the inducing magnetic field produced by the coil. When the current to the coil is stopped, the

molecules realign (precess) themselves with the earth's magnetic field. A small electric field, produced by the molecules as they realign themselves, is measured by the coil around the container and amplified. The strength of this field is proportional to the strength of the earth's magnetic field. The electronic circuitry of the magnetometer converts the measured field to a digital display of the magnetic field strength.

The earth's field varies during the day due to solar activity, and these variations are called diurnal drift. Diurnal drift is measured by periodic readings at a base station and removed from the data if necessary. Diurnal drift is usually negligible compared to anomalies caused by the presence of buried metal. The vertical gradient is not subject to diurnal drift.

Anomalies due to geologic formations can be and often are negligible, depending on the nature of the formation and its depth. Geologic anomalies are usually related to igneous or metamorphic rock formations. These rock types are not present near the surface at the Maywood site. Therefore, the anomalies at Stepan are not thought to be geologic.

3.0 Field Procedures

3.1 Establishing the Grid

Survey grids were established over the Stepan property before geophysical data was collected. Two separate grids were established to facilitate data collection on the property owned by Stepan. One grid was established for data collected north of the southern DOE fenceline and the other grid was placed south of this fenceline. The grids were placed to allow accurate and systematic sampling and to cite the positions of anomalies in the field. The grids were based on two perpendicular base lines formed by placing markers (pin flags or spray paint) at regular intervals across the site by using a compass and measuring tape. The north-south base lines for the major survey grid were parallel to the DOE fenceline. The north-south lines for the smaller grid was established parallel to the fenceline east of the south survey area. Grid north was oriented approximately 50 degrees east of true north for the major site grid and approximately 80 degrees east of true north for the smaller grid area.

Figure 1 shows the extent of the survey and the grid coordinates. East-west base lines were marked at 20-foot intervals. The east-west base lines corresponded with the 100-foot intervals along the north-south grid lines. The location of metal objects and other sources of interference at the site are also shown in Figure 1.

3.2 Base Station

A base station was established to determine the amount of diurnal (daily) drift in the earth's magnetic field. The station was located in an area free from magnetic anomalies and away from any detectable sources of interference. Readings were taken

throughout the day in the morning, midday, and late afternoon and were entered into the field notes. On all days, the drift was less than 30 gammas. No drift correction was performed because the maximum observed drift of 30 gammas is small compared to the anomalies recorded over the site, which typically measured from greater than 500 gammas up to 5,000 gammas.

3.3 Magnetometer Survey

Data were systematically collected at 10-foot intervals along the north-south grid lines across most of the site. In areas that could not be surveyed in the north-south direction, data was collected at 10-foot intervals along east-west lines. The line number and direction, station number, and the station spacing were programmed into the magnetometer at the start of each grid line. Data were collected and stored in the internal memory of the instrument. Measurements were also recorded in the field logbook at regular intervals. Locations of features such as roads, fences, power lines, utilities, buildings, and scrap metal that may have affected the readings were recorded. Data from the digital logger were transferred to a computer on a daily basis, and the data were reviewed to determine if they were properly recorded and were checked for consistency with the data manually recorded in the logbook. Data were then processed as described in Section 4.0.

No functional checks are prescribed in the operator's manual for the magnetometer. Initial readings were compared against the total magnetic intensity predicted for the area, as shown on a map that was provided with the equipment. Equipment was determined to be responsive by taking measurements at different locations and noting that the measurements did not remain constant.

4.0 Interpretation Procedures

4.1 Magnetic Data

Preparation and plotting of the magnetometer data consisted of the following steps. The data were received in XYZ format, imported into a spreadsheet, and rearranged into a spreadsheet format with the columns representing survey lines and the rows representing station positions along the line. Profile plots of magnetic intensity and vertical magnetic gradient were prepared (Attachment B). The profile plots were used to interpret the location of the source of each anomaly.

A magnetic anomaly normally consists of both a magnetic high and a magnetic low. The pair of high and low values is due to the magnetic field induced in the buried metal by the earth's field. The magnetic field induced in the buried object has both a north and south magnetic pole, which results in a net increase and decrease, respectively, in the measured total field. In the northern hemisphere, the magnetic high is on the south side of the source and the low is on the north side. The source of the anomaly is interpreted as extending from the peak of the magnetic high to the

lowest value north of the high. The high/low pairs are not always well-defined due to nearby interferences and grid line orientation. Professional judgement is required in delineating magnetic sources. An anomaly was chosen if it was recognizable over the same station interval on both the total field and the vertical gradient profiles. Once an anomaly was identified, the interpreted location of the source of the anomaly was transferred to the base map.

Many geophysical constraints and potential magnetic interferences are present on the Stepan property and were described in the workplan. As was stated in the workplan, the combined effect of magnetic interferences from old building foundations, utilities, and other features present at the Stepan site could not be predicted before the survey. These combined interferences affect the anomaly amplitude required before an anomaly is recognizable in areas of high magnetic intensity. After the data were reviewed on the profiles and anomalies plotted on the base map, it was determined that a different approach (i.e., anomaly amplitude) would be necessary for interpretation of the data. This approach was brought to the EPA's attention. The letters included in Attachment C document the correspondence between CH2M HILL and EPA.

Ordinarily, at a site free of construction debris and other cultural features, a 100 gamma anomaly, as stated in the workplan, would be recognizable and considered significant. However, because of the large amount of anomalies with large amplitude and areal extent identified at the site, the investigation approach is focused on the strongest and largest anomalies. Multiple-line anomalies less than 500 gammas were also identified as anomalous areas, west of the DOE fenceline. All anomalies greater than 100 gammas were plotted on the base map, when they could be recognized, as was stated in the workplan.

5.0 Results of Investigation

5.1 Buried Metal

The extent of the magnetometer survey conducted on the amended Stepan property is shown in Figure 1. Magnetic data are presented in Attachment B. Figure 2 presents the locations that are interpreted to contain buried metal.

Forty areas of buried metal have been identified at the site (Figure 2). The areas shown on the map have been identified based on magnetic anomalies that are not a result of known sources. Anomalies resulting from known sources, such as power lines, surface metal, or buildings have not been shown unless other buried material is suspected based upon the amplitude of the anomaly. The location of metal objects and other sources of interference encountered at the site are shown in Figure 1. Note that a qualitative attempt was made to prioritize the anomalies by numerical order based on the areal extent of the interpreted location of the source and the amplitude of magnetic anomalies within the area.

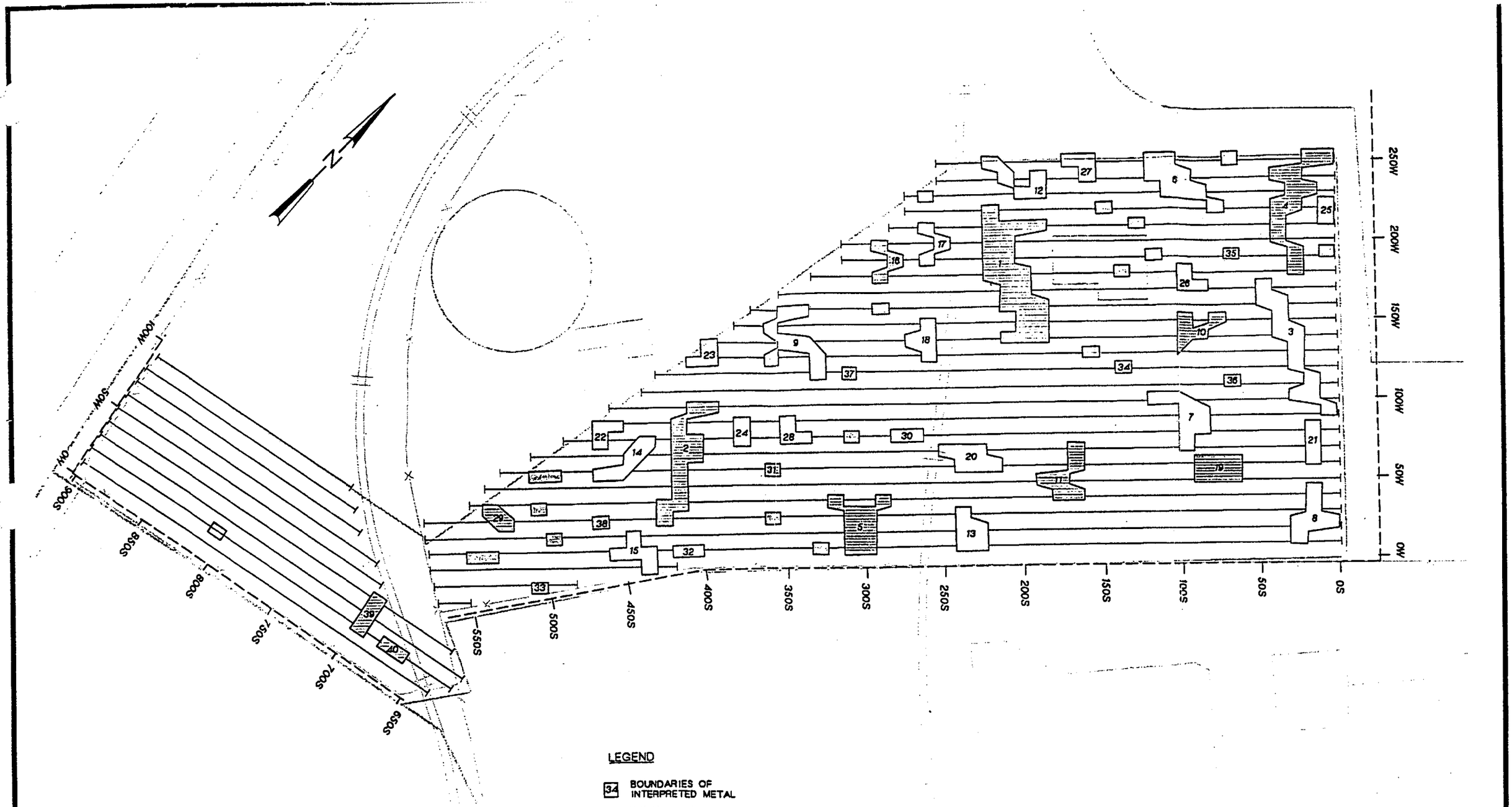


FIGURE 2
Interpreted Areas of Buried Metal
STEPAN COMPANY
MAYWOOD, NJ

CH2MHILL

20-49c026.rgn 22-Jan-1992

5.2 Categories of Buried Metal

The areas of buried metal were divided into four different categories, based on their overall extent, magnetic amplitude, and whether there were cultural features that may have contributed to the anomaly at the surface.

5.2.1 Category 1 Areas

Category 1 areas are characterized by multiple-line anomalies that are greater than 500 gammas and are not influenced by any observed surface or subsurface source of interference. These areas are listed in Table 5-1 along with their site location, their strength, and test-pit locations. Potential test-pit locations given in these tables indicate the strongest source of the anomaly and the location to begin digging if the source is investigated.

5.2.2 Category 2 Areas

Category 2 areas consist of multiple-line anomalies that are greater than 500 gammas and may be influenced by a source of interference at the surface. These areas are shown in Table 5-2. The cultural feature that may have contributed to the magnetic field is also listed.

5.2.3 Category 3 Areas

Category 3 areas are classified as single-line anomalies less than 500 gammas that may or may not be influenced by a cultural feature. These areas are listed in Table 5-3.

5.2.4 Category 4 Areas

Category 4 areas are described as multiple-line anomalies less than 500 gammas that may or may not be influenced by the presence of a cultural feature. These areas are shown in Table 5-4. The cultural feature that may have contributed to the magnetic field is also listed.

5.3 Limitation of Results

Prioritization for followup investigations of the interpreted areas of buried metal should not be based only on geophysical data. Other factors, such as site history and visual observations, should also be considered. The instrument is sensitive enough to see the anomaly associated with several drums to a depth of 20 feet. This depth is greater than the thickness of the overburden at the site. Because of the complex nature of the site and the existence of many cultural sources of interference, anomalies that were identified in some cases may not contain buried metal or appear to be as extensive as

Table 5-1
Category 1 Areas*

Area	Strength of Anomalies (gammas)	Potential Test-Pit Location	Justification for Not Recommending Area As a Test-Pit Location**
1***	500-5,000	160 W, 200-210 S	Recommended test-pit location.
2***	225-1,825	70 W, 410-420 S	Recommended test-pit location.
3	300-1,100	130 W, 20-30 S	Similar in strength and orientation as Area 4. Between Area 4 and Area 19.
4***	100-1,100	240 W, 30-40 S	Recommended test-pit location.
5***	275-2,000	10 W, 290-310 S	Recommended test-pit location.
6	150-1,000	230 W, 90-110 S	Between Area 4 and Area 1.
7	500-725	90 W, 90-100 S	Adjacent to Area 19.
8	200-900	20 W, 10-30 S	Similar in strength and orientation as Area 4. Close to Area 19.
10***	200-1,800	100 S, 140-150 W	Recommended test-pit location.
12	200-650	230 W, 180-200 S	Adjacent to Area 1. Strength of anomaly much weaker than Area 1.
19***	2,400	60 W, 60-90 S	Recommended test-pit location.
21	100-500	70 W, 10-20 S	Similar in strength and orientation as Area 4. Close to Area 19.
24	400-950	90 W, 370-380 S	Close to Area 2. Strength of anomaly much weaker than Area 2.
25	250-1,050	220 W, 0-10 S	Adjacent to Area 4. Related to Area 4.

* Multiple-line anomalies greater than 500 gammas not influenced by cultural sources.
** Recommendations based on amplitude of anomalies, aerial extent and location of areas, site history, and areal photographs.
*** Recommended test-pit location.

Table 5-2
Category 2 Areas*

Area	Strength of Anomalies (gammas)	Observed Cultural Feature	Potential Test-Pit Location	Justification for Not Recommending Area As a Test-Pit Location**
11***	300-2,350	Foundation, rubble	40 W, 160-180 S	Recommended test-pit location.
13	350-2,000	Electric pole, powerline, rubble	20 W, 220-240 S	Close to Area 11. Near old building foundation.
14	200-1,175	Powerline	80 W, 430-440 S	Adjacent to Area 2.
15	150-1,500	Metal pipe, powerline	10 W, 450-460 S	Similar to strength and orientation to Area 2. Adjacent to Area 2.
16***	575-2,000	Fence post	190 W, 270-280 S	Recommended test-pit location.
17	300-3,500	Railroad	200 W, 240-250 S	Close to Area 16. Strength of anomaly may be affected by railroad.
18	300-1,175	Railroad	130 W, 250-260 S	Close to Area 16. Strength of anomaly may be affected by railroad.
20	1,875-3,200	Rubble, reinforced concrete	60 W, 210-240 S	Close to Area 11. Located on former building foundation.
22	625-800	Powerline	80 W, 460-470 S	Close to Area 2. Located on trade water sewer.
23	100-625	Metal pole	130 W, 390-410 S	Weaker in strength and similar in orientation to Area 2. Adjacent to Area 2.

* Multiple-line anomalies greater than 500 gammas that may be influenced by a cultural source.
** Recommendations based on amplitude of anomalies, aerial extent and location of areas, observed cultural features, site history, and areal photographs.
*** Recommended test-pit location.

Table 5-3
Category 3 Areas*

Area	Strength of Anomalies (gammas)	Observed Cultural Feature	Potential Test-Pit Location	Justification for Not Recommending Area As a Test-Pit Location**
30	1,825	None	80 W, 260-280 S	Close to Area 5.
31***	2,300	Pole	60 W, 350-360 S	Recommended test-pit location.
32	1,050	Fenceline, powerline, railroad ties	10 W, 400-420 S	Similar in strength and orientation to Area 2. Adjacent to Area 2.
33	1,250	Fence	10 E, 500-510 S	Close to Area 2. Located over sewer line.
34	525	Dirt road	120 W, 130-140 S	Adjacent to Area 10.
35	600	None	190 W, 60-70 S	Between Area 4 and Area 10.
36	700	None	110 W, 60-70 S	Between Area 19 and Area 10.
37	525	None	120 W, 300-310 S	Between Area 16 and Area 5.
38	900	Powerline, pole and guywire	30 W, 460-470 S	Between Area 2 and Area 29. Located over trade water sewer and a sewer line.
40***	625	None	20 W, 660-680 S	Recommended test-pit location.

* Single-line anomalies greater than 500 gammas that may or may not be influenced by a cultural source.
** Recommendations based on amplitude of anomalies, aerial extent and location of areas, observed cultural features, site history, and areal photographs.
*** Recommended test-pit location.

Table 5-4 Category 4 Areas*				
Area	Strength of Anomalies (gammas)	Observed Cultural Feature	Potential Test-Pit Location	Justification for Not Recommending Area As a Test-Pit Location**
9	125-300	None	120 W, 320-330 S	Between Area 16 and Area 2. Weak anomaly.
26	200-400	None	180 W, 90-100 S	Adjacent to Area 10. Weak anomaly.
27	175-425	None	240 W, 150-160 S	Close to Area 1. Weak anomaly.
28	225	Surface mound	90 W, 340-350 S	Between Area 5 and Area 2. Weak anomaly.
29***	175-375	None	30 W, 520-530 S	Recommended test-pit location.
39***	150-325	Train car	20 W, 690-700 S	Recommended test-pit location.

* Single- or multiple-line anomalies less than 500 gammas that may or may not be influenced by a cultural source.
** Recommendations based on amplitude of anomalies, aerial extent and location of areas, observed cultural features, site history, and areal photographs.
*** Recommended test-pit location.

they are shown on the map. Other locations that may contain minor amounts of buried metal may have been missed due to magnetic interferences from known or unknown sources.

6.0 Discussion and Recommendations

Buried metal has been identified in 40 areas west of the DOE fenceline. The largest concentration of areas is north of the southern DOE fenceline. Numerous building structures were formerly located in this area. These buildings can be seen on aerial photographs to occupy most of the area north of the DOE fenceline. Numerous anomalies located here appear to correspond with former building locations. Buried demolition debris that was generated when the structures were leveled is probably the source of most of these anomalies. However, the nature of the buried metal cannot be determined from the data and further investigations will be necessary. Only anomalies that exceeded 500 gammas, or multiple-line anomalies less than 500 gammas, were identified as anomalous areas. Single-line anomalies less than 500 gammas were insignificant in comparison to the selected areas and some may be caused by surface features or related to the larger anomalies.

The following approach is recommended for the test-pit program. All anomalies proposed for test pitting will be field screened with a metal detector before digging to correctly locate their position and extent.

Forty areas of buried metal comprised of anomalies greater than 100 gammas were identified on Stepan property west of the DOE fenceline (Figure 2). Of these total areas, 12 areas are recommended for the test-pit investigation. Nine of the strongest and most extensive anomalous areas were selected from the Category 1 through Category 4 areas for test-pitting north of the DOE fenceline (Tables 5-1 through 5-4). Area 29 was selected in the southern portion of the major grid area for areal coverage and to characterize the source of a weaker anomalous area (Table 5-4). Anomalies that were located above concrete foundations were not chosen primarily because of the age of the possible sources (assuming that these structures are at least 50 years old). The anomalous areas were selected to provide reasonable areal coverage of the amended property. Two areas of buried metal were recommended for test-pitting south of the DOE fenceline. These areas were recommended because it appeared that buildings were never present in this area. Tables 5-1 through 5-4 present the justification for not recommending other Category 1 through Category 4 areas for the test-pit program.

6.1 Test-Pit Program

The following 12 areas are recommended for the test-pit program on the amended Stepan property: Areas 1, 2, 4, 5, 10, 11, 16, 19, 29, 31, 39, and 40.

CH2M HILL believes that these test pits will provide a representative characterization of the type of ferromagnetic materials buried at the site. We feel that additional test areas would not significantly add to the characterization of the ferrous material present. If drums are found in any of the test pits on the amended Stepan property, it will be assumed that drums may exist in the other anomalous areas and no further excavations will be necessary. If drums are found, the need for additional monitoring well coverage will be evaluated based on analytical results from the test-pit program. If no drums are found, the possibility that this area is still a source of contamination will be evaluated by using groundwater quality data obtained from the existing monitoring wells located downgradient of this area.

If test pits in addition to the ones recommended above are required, then priority of the followup investigations should be based on the areal extent of the buried metal (an indication of volume), the strength of the magnetic anomalies, site history, and field observations. The test-pit program should concentrate on the strongest anomalies within the recommended test-pit areas, in order to characterize the type of materials that are producing the largest anomalies. The investigation should progress from those areas consisting of multiple-line anomalies to the areas defined by single-line anomalies. Single-line anomalies may be less significant as potential sources.

The extent of the test pit will be sufficient to characterize the source of the magnetic anomaly. The test pit will target the strongest part of the anomaly. A test pit excavated within the locations provided in Tables 5-1 to 5-4 should be sufficient to characterize the anomaly.

PREPARED FOR: Jeffrey Gratz/USEPA, Region II

PREPARED BY: Mary Kate Dwyer/CH2M HILL

COPIES: Jeffrey Bartlett/Stepan Company
Rick Ramuglia/Alliance

DATE: December 10, 1991

SUBJECT: Surface Geophysics Investigation--Vicinity Properties

PROJECT: NJO22948.ST.GP

1.0 Introduction

Surface geophysical investigations (magnetometer surveys) were conducted on the properties adjacent to Stepan Company as part of a Remedial Investigation. These properties are DeSaussure, Federal Express, Gulf, Sunoco, and AMP Realty (former Hunter Douglass property). All properties are located in Maywood, New Jersey. The lot and block numbers referred to in the description of each property have changed from those contained in the workplan. The surveys were conducted by CH2M HILL personnel, Don Johnson, Mary Kate Dwyer, Bob Jackson, and Joe Merchak.

1.1 Scope

1.1.1 DeSaussure

A surface geophysical investigation was conducted at the DeSaussure property (Lot 17, Block 124) from September 12 to 13, 1991. The survey was conducted over approximately 1.7 acres of open area around the facility. The remaining 1.5 acres of the site was not investigated because it was occupied by the site building and mature woods on the north portion of the site.

1.1.2 Federal Express

A surface geophysical investigation was conducted at the Federal Express property (Lot 4, Block 124) from September 18 to 20, 1991. The survey was conducted over approximately 2.6 acres of open area around the facility. The remaining 1.4 acres of the site was not investigated because it was occupied by the warehouse building and a pond in the northern part of the site.

1.1.3 Gulf

A surface geophysical investigation was conducted on the Gulf property (Lot 1, Block 124) on October 29, 1991. The survey was conducted over approximately 0.38 acres of open area around the Gulf station building.

1.1.4 Sunoco

A surface geophysical investigation was conducted on the Sunoco property (Lot 2, Block 124) on October 31, 1991. The survey was conducted over approximately 1.0 acres of open area around the station. The remaining 0.3 acres was occupied by the gas station building, trucks, and other vehicles that were moved to the northern portion of the property.

1.1.5 AMP Realty

A surface geophysical investigation was conducted at the AMP Realty property (Lot 3, Block 124) from November 14 to 15, 1991. The survey was conducted over approximately 0.9 acres of open area around the facility. The remaining 0.3 acres of the property was not investigated because it was occupied by the site building and a drainage channel filled with surface water runoff on the eastern boundary of the property.

1.2 Purpose

The objective of the geophysical investigations is to identify potential sources of chemical contamination. Specifically, the geophysical investigations were performed in an effort to locate and define abandoned ferromagnetic containers in the overburden of the adjacent properties. Due to the nature of deposits in the Maywood area, a magnetic survey was determined to be the most effective geophysical method available. The magnetometer can identify areas of buried metal but cannot distinguish drums from other ferrous materials or determine whether there is chemical contamination present. Therefore, the results of the magnetometer investigations were used to select locations for test pits that will be used to characterize the buried material.

The geophysical investigations were performed in several steps. First a grid was established in the survey areas. A magnetometer was then used to collect and store the geophysical data along the survey lines. The raw data was transferred from the magnetometer to the computer and the data was then arranged in spreadsheet form.

The data were graphed and anomalies were identified. The locations of the source of the anomalies were interpreted and put on the base maps. The anomalies that could not be explained by cultural features were evaluated to identify possible areas of buried metal.

This technical memorandum (TM) is organized into six sections and supplemented with six attachments. The remainder of this introduction presents an overview of the report organization. The magnetometer selected and the theory of magnetics is described in Section 2.0. Section 3.0 describes the procedures employed in the collection of the data. Section 4.0 describes the methods used to interpret the data. Section 5.0 presents the results of the surveys, the interpretation of the data, and the limitations of the results. A map showing the location of buried metal is included as part of this interpretation. Finally, Section 6.0 discusses recommendations for use of the data. Attachment A contains letters from CH2M HILL to the United States Environmental Protection Agency (EPA) regarding the change in the magnetometer used for the survey. Attachment B contains profile plots of the DeSaussure data. Attachment C contains profile plots of the Federal Express data. Profile plots of the data for Gulf are contained in Attachment D. Attachment E contains profile plots of the Sunoco data. Attachment F contains profile plots of the AMP Realty data.

2.0 Magnetometer and Theory of Magnetics

2.1 Magnetometer

A GEM GSM-19G overhauser gradiometer was used for the magnetic investigations. This magnetometer is different from the Geometrics G866 originally proposed in the workplan. The change in method was presented to the EPA before the surveys were performed. The change in method was approved by the EPA. The letters documenting the change in method, the technical rationale for the change, and the advantages of the GEM magnetometer are presented in Attachment A.

2.2 Theory of Magnetics

The GEM is a proton precession magnetometer that measures the magnitude of the earth's magnetic field and vertical magnetic gradient. The magnetic field measured by the magnetometer is the sum of the earth's field, fields due to geologic formations, and fields due to cultural features such as buildings, cars, and other ferrous metal. The vertical magnetic gradient is the difference between two simultaneous total field measurements made at different heights above the ground. The gradiometer sensor supplied with the GEM magnetometer consists of two sensors about 2 feet apart. The vertical gradient often provides higher resolution of magnetic anomalies and may allow the collection of useful data closer to buildings than do total field measurements.

The magnetometer sensor consists of a small container filled with an organic, hydrogen-rich fluid, such as kerosene. A current is passed through a coil wrapped around the container, causing the molecules of the liquid to orient themselves with the inducing magnetic field produced by the coil. When the current to the coil is stopped, the molecules realign (precess) themselves with the earth's magnetic field. A small electric field, produced by the molecules as they realign themselves, is measured by the coil around the container and amplified. The strength of this field is proportional to the

strength of the earth's magnetic field. The electronic circuitry of the magnetometer converts the measured field to a digital display of the magnetic field strength.

The earth's field varies during the day due to solar activity, and these variations are called diurnal drift. Diurnal drift is measured by periodic readings at a base station and removed from the data if necessary. Diurnal drift is usually negligible compared to anomalies caused by the presence of buried metal. The vertical gradient is not subject to diurnal drift.

Anomalies due to geologic formations can be and often are negligible, depending on the nature of the formation and its depth. Geologic anomalies are usually related to igneous or metamorphic rock formations. These rock types are not present near the surface at the Maywood site. Therefore, the anomalies on the adjacent properties are not thought to be geologic.

3.0 Field Procedures

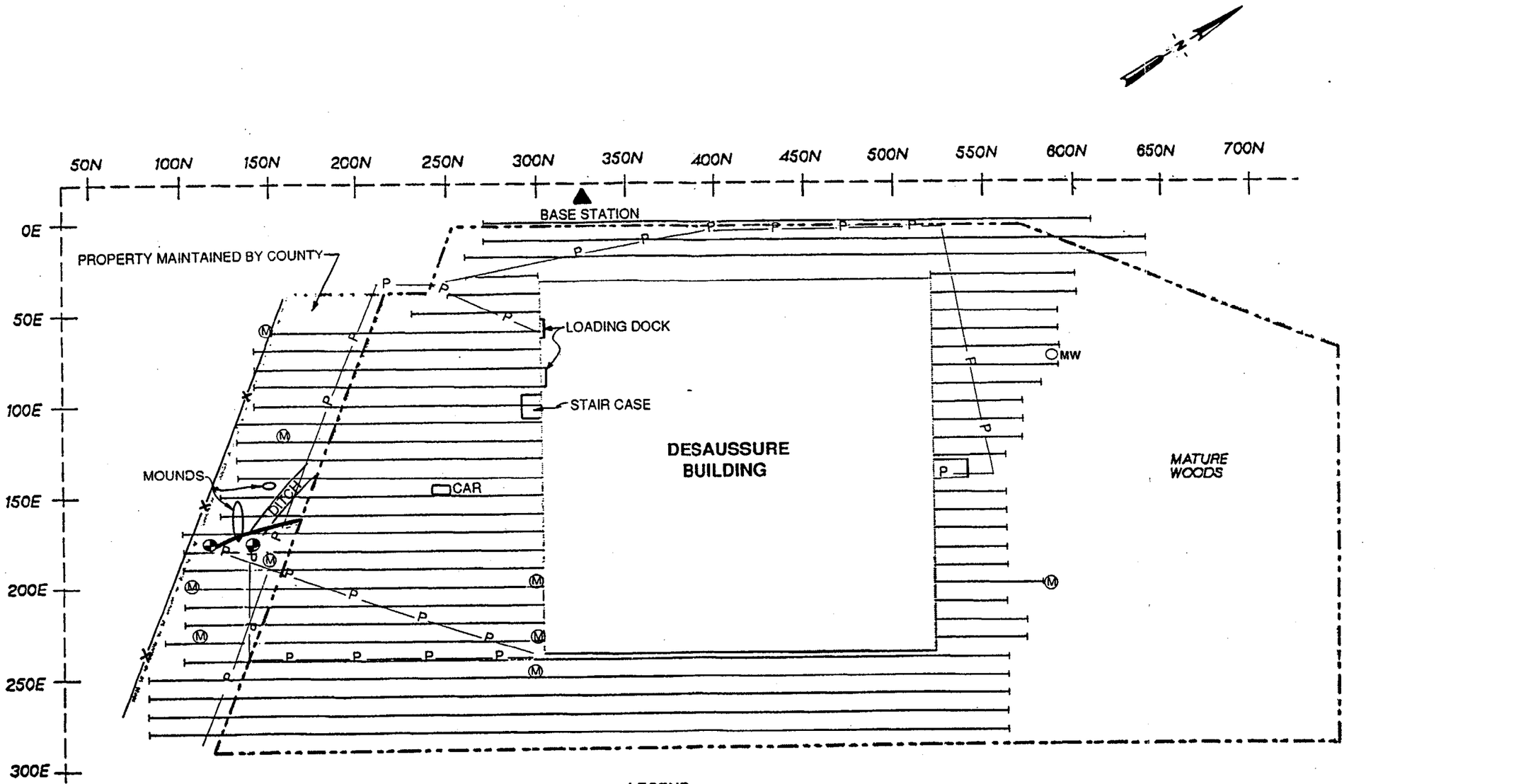
3.1 Establishing the Grid

Survey grids were established over the properties before geophysical data was collected in areas clear of mature vegetation and building structures. The grids were placed to allow accurate and systematic sampling and to cite the positions of anomalies in the field. The grids were based on two perpendicular base lines formed by placing markers (pin flags or spray paint) at regular intervals across the site by using a compass and measuring tape. The east-west base lines were marked at 20-foot intervals. The east-west base lines corresponded with the 100-foot intervals along the north-south grid lines. Grid north was oriented approximately 30 degrees east of true north for the major site grid on DeSaussure, 45 degrees east of true north on Federal Express, and 80 degrees east of true north on Gulf, Sunoco, and AMP Realty.

Figures 1 through 5 show the extent of the surveys and the grid coordinates on the DeSaussure, Federal Express, Gulf, Sunoco, and AMP Realty properties, respectively.

3.2 Base Station

A base station was established to determine the amount of diurnal (daily) drift in the earth's magnetic field. The station was located in an area free from magnetic anomalies and away from any detectable sources of interference. A base station was not established on Gulf, Sunoco, and AMP Realty properties due to the short duration of the surveys. Readings were taken throughout the day in the morning, midday, and late afternoon and were entered into the field notes. On all days, the drift was less than 100 gammas. No drift correction was performed because the maximum observed drift of 100 gammas is small compared to the anomalies recorded over the sites, which typically measured from greater than 200 gammas up to 3,000 gammas.



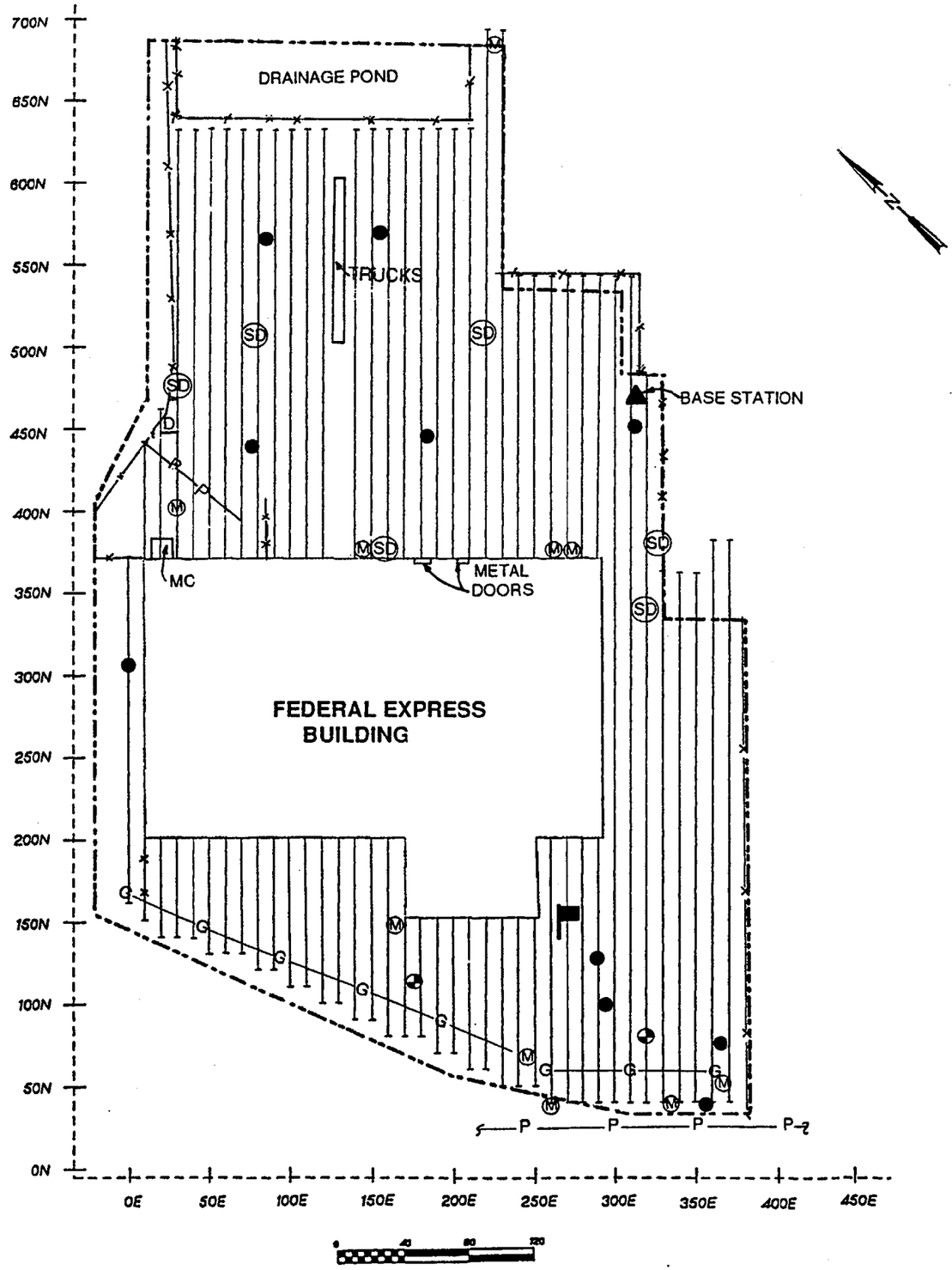
LEGEND:

- = SURVEY LINE
- = PROPERTY LINE
- = FENCE LINE
- = METAL OBJECTS OR DEBRIS
- = POWER LINE
- = GUARD RAIL
- = MANHOLE
- MW = MONITORING WELL

Figure 1
SURVEY GRID AND EXTENT
OF MAGNETOMETER SURVEY
CULTURAL FEATURES MAP

DESAUSSURE PROPERTY
MAYWOOD, NEW JERSEY

CH2M HILL



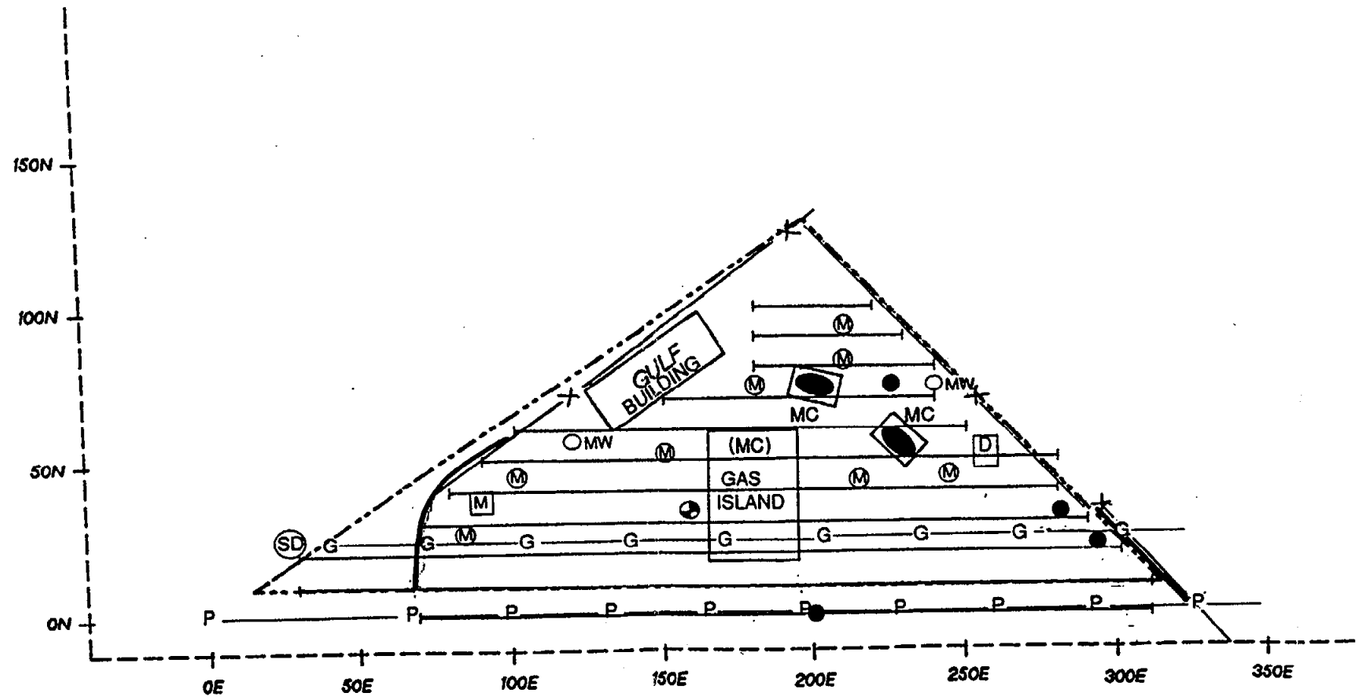
LEGEND:

- = SURVEY LINE
- = PROPERTY LINE
- = FENCE LINE
- = RUBBLE
- = METAL OBJECTS OR DEBRIS
- = HYDRANT
- = POWER LINE
- = GAS LINE
- = SEWER LINE
- MC = REINFORCED CONCRETE (REBAR)
- = FLAG POLE
- = TELEPHONE POLE
- = POWER POLE/LIGHT POLE
- MW = MONITORING WELL
- = STORM DRAIN
- = DUMPSTER
- = GUARDRAIL
- = MANHOLE

Figure 2
SURVEY GRID AND EXTENT OF MAGNETOMETER SURVEY CULTURAL FEATURES MAP

FEDERAL EXPRESS PROPERTY MAYWOOD, NEW JERSEY

CH2M-HILL



LEGEND:

= SURVEY LINE

= PROPERTY LINE

= FENCE LINE

= METAL OBJECTS OR DEBRIS

= POWER LINE

= GAS LINE

= POWER POLE/LIGHT POLE

= DUMPSTER

= GUARD RAIL

= STORM DRAIN

= MANHOLE

MW = MONITORING WELL

MC = REINFORCED CONCRETE (REBAR)

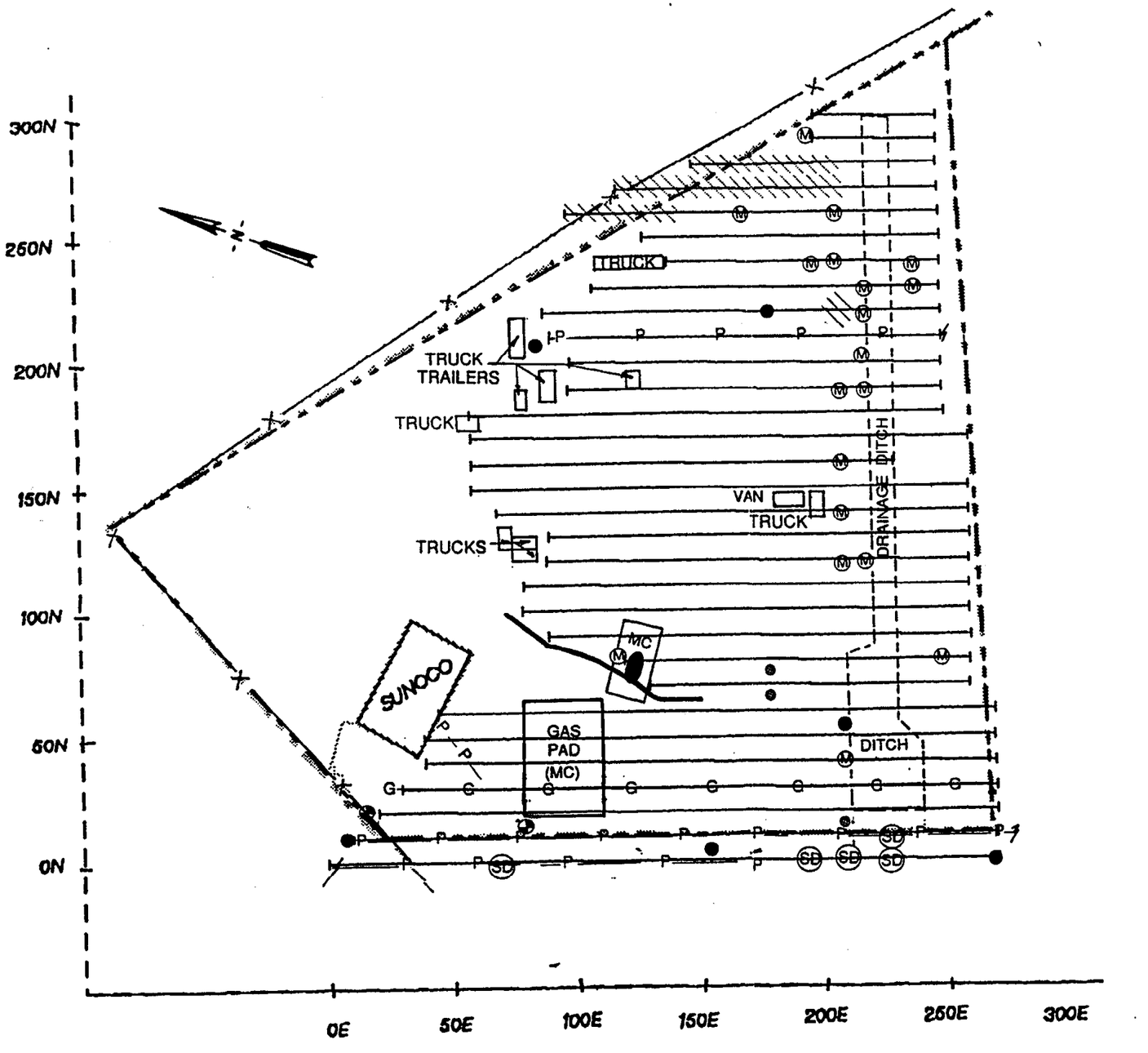
= SUSPECTED UNDERGROUND TANK

0 25 50 75

Figure 3
SURVEY GRID AND EXTENT OF MAGNETOMETER SURVEY CULTURAL FEATURES MAP

GULF PROPERTY
MAYWOOD, NEW JERSEY

CH2MHILL



LEGEND:

- ——— = SURVEY LINE
- — — — = PROPERTY LINE
- —X— = FENCE LINE
- \\\\ = RUBBLE
- M / Ⓜ = METAL OBJECTS OR DEBRIS
- ■ = HYDRANT
- —P— = POWER LINE
- —G— = GAS LINE
- —S— = SEWER LINE
- MC = REINFORCED CONCRETE (REBAR)
- ⚑ = FLAG POLE
- ○ = TELEPHONE POLE
- ● = POWER POLE/LIGHT POLE
- MW = MONITORING WELL
- Ⓢ = STORM DRAIN
- D = DUMPSTER
- ——— = GUARDRAIL
- ◓ = MANHOLE
- ⊙ = SIGN
- ⬬ = SUSPECTED UNDERGROUND TANK

0 50 100 150 FEET

Figure 4
SURVEY GRID AND EXTENT
OF MAGNETOMETER SURVEY
CULTURAL FEATURES MAP

SUNOCO PROPERTY
MAYWOOD, NEW JERSEY

CH2MHILL

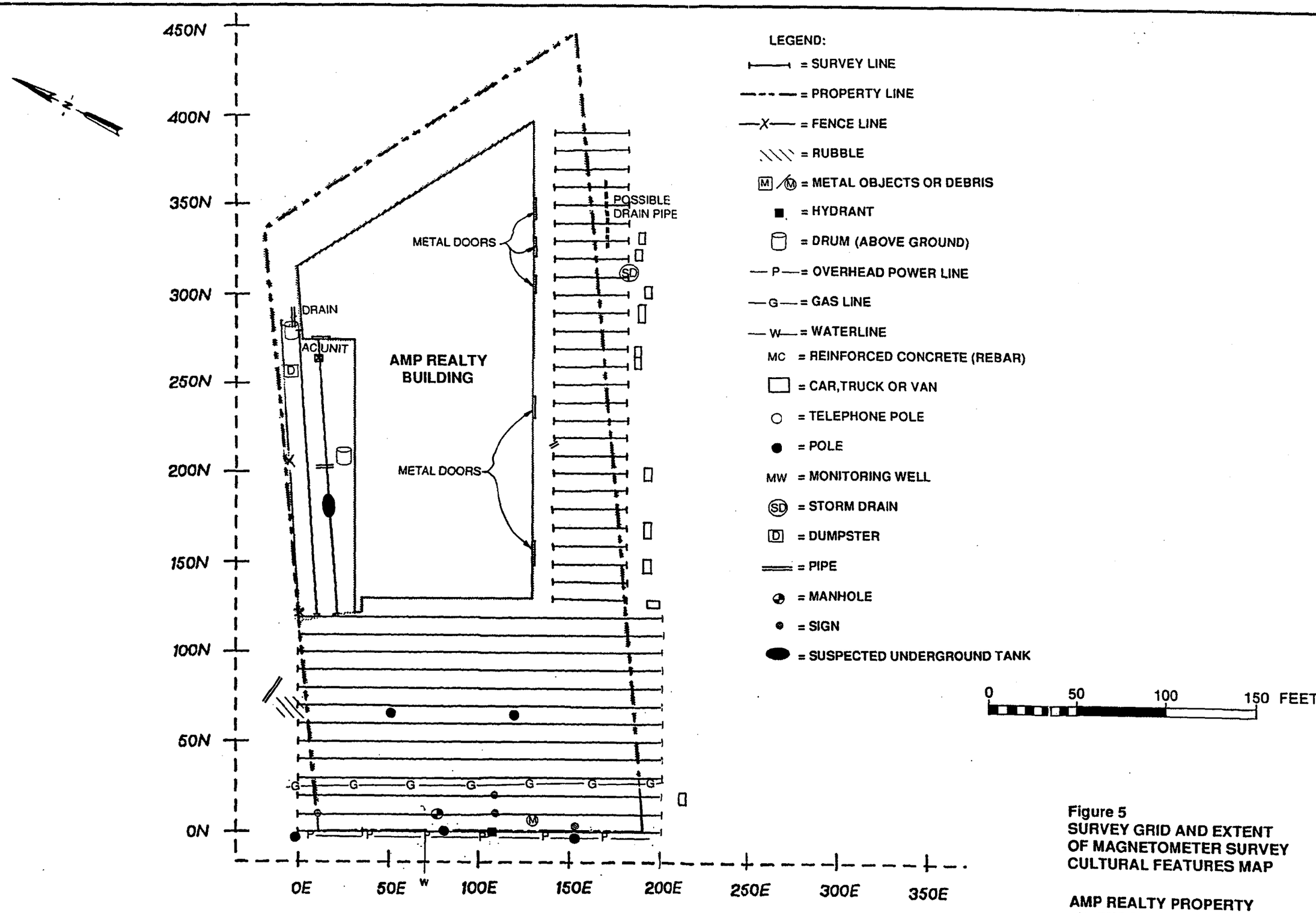


Figure 5
SURVEY GRID AND EXTENT
OF MAGNETOMETER SURVEY
CULTURAL FEATURES MAP

AMP REALTY PROPERTY
MAYWOOD, NEW JERSEY

CH2MHILL

3.3 Magnetometer Surveys

Data were systematically collected at 10-foot intervals along the north-south grid lines across most of the sites. At the Gulf, Sunoco, and AMP Realty properties, data was collected at 10-foot intervals along east-west lines since these lines corresponded closely with the true north direction. The line number and direction, station number, and the station spacing were programmed into the magnetometer at the start of each grid line. Data were collected and stored in the internal memory of the instrument. Measurements were also recorded in the field logbook at regular intervals. Locations of features such as roads, fences, power lines, utilities, buildings, and scrap metal that may have affected the readings were recorded. Data from the digital logger were transferred to a computer on a daily basis, and the data were reviewed to determine if they were properly recorded and were checked for consistency with the data manually recorded in the logbook. Data were then processed as described in Section 4.0.

No functional checks are prescribed in the operator's manual for the magnetometer. Initial readings were compared against the total magnetic intensity predicted for the area, as shown on a map that was provided with the equipment. Equipment was determined to be responsive by taking measurements at different locations and noting that the measurements did not remain constant.

4.0 Interpretation Procedures

4.1 Magnetic Data

Preparation and plotting of the magnetometer data consisted of the following steps. The data were received in XYZ format, imported into a spreadsheet, and rearranged into a spreadsheet format with the columns representing survey lines and the rows representing station positions along the line. Profile plots of magnetic intensity and vertical magnetic gradient were prepared. The profile plots were used to interpret the location of the source of each anomaly. Profile plots for DeSaussure are included in Attachment B. Profile plots for Federal Express are included in Attachment C. Profile plots for Gulf are included in Attachment D. Profile plots for Sunoco are included in Attachment E. Profile plots for AMP Realty are included in Attachment F.

A magnetic anomaly normally consists of both a magnetic high and a magnetic low. The pair of high and low values is due to the magnetic field induced in the buried metal by the earth's field. The magnetic field induced in the buried object has both a north and south magnetic pole, which results in a net increase and decrease, respectively, in the measured total field. In the northern hemisphere, the magnetic high is on the south side of the source and the low is on the north side. The source of the anomaly is interpreted as extending from the peak of the magnetic high to the lowest value north of the high. The high/low pairs are not always well-defined due to nearby interferences and grid line orientation. Professional judgement is required in delineating magnetic sources. An anomaly was chosen if it was recognizable over the

same station interval on both the total field and the vertical gradient profiles. Once an anomaly was identified, the interpreted location of the source of the anomaly was transferred to the base maps.

5.0 Results of Investigation

5.1 Buried Metal

5.1.1 DeSaussure

The extent of the magnetometer survey conducted at DeSaussure is shown in Figure 1.

Fifteen areas of buried metal have been identified at the site (Figure 6). The areas are numbered from north to south across the property.

Anomalies range in strength from 100 to 3,000 gammas. The areas are characterized by both single- and multiple-line anomalies. These areas are listed in Table 5-1 along with their strength, nearby cultural features, and test-pit locations.

5.1.2 Federal Express

The extent of the magnetometer survey conducted at Federal Express is shown in Figure 2.

Nine areas of buried metal have been identified at the site (Figure 7). The areas are numbered from west to east across the property.

Anomalies range in strength from 100 to 2,500 gammas. The areas are characterized by both single- and multiple-line anomalies. These areas are listed in Table 5-2 along with their strength, nearby cultural features, and test-pit locations.

5.1.3 Gulf

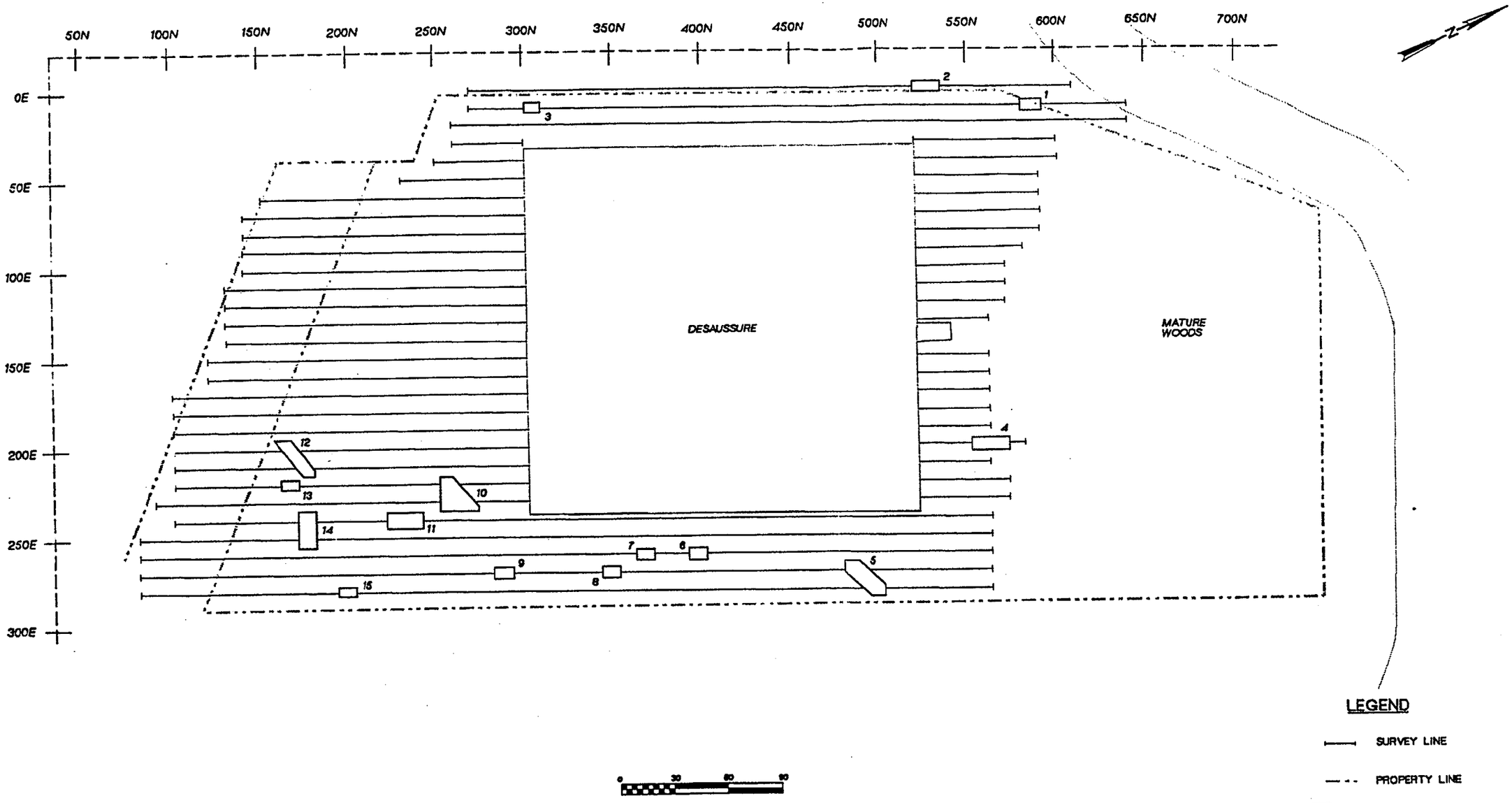
The extent of the magnetometer survey conducted on Gulf is shown in Figure 3.

Two areas of buried metal have been identified at the site (Figure 8). The following is a description of these two areas.

Area 1--Line 40N, 220-230E. Area 1 is a single-line anomaly that is approximately 300 gammas. It is located 5 feet south of a metal plate on the ground surface.

Area 2--Line 10N, 230-240E. Area 2 is a single-line anomaly that is approximately 300 gammas. It is not influenced by any surface feature.

Figure 6



LEGEND

SURVEY LINE

PROPERTY LINE

12 BOUNDARIES OF INTERPRETED METAL

FIGURE 6
Interpreted Areas of Buried Metal
DESAUSSURE PROPERTY
MAYWOOD, NJ

CH2MHILL

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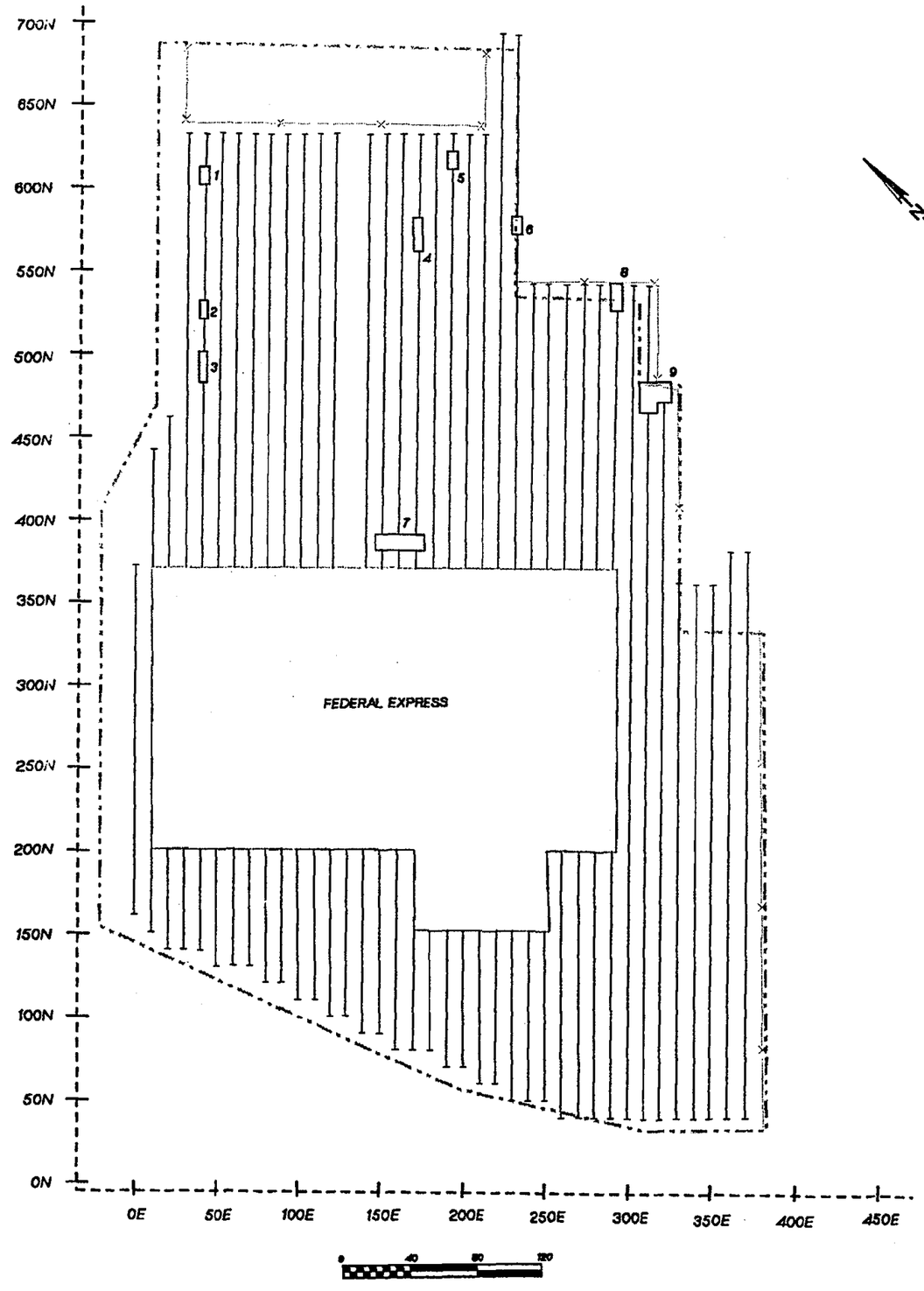
Table 5-1
Interpreted Areas of Buried Metal
DeSaussure Property

Area	Strength of Anomalies (gammas)	Cultural Feature	Potential Test-Pit Location
1	270	none	10E, 580-590N
2	500	powerline, pole*	0E, 520-530N
3	150	powerline	10E, 300-310N
4	750	none	200E, 550-560N
5	170	none	270E, 480-490N
6	230	none	260E, 390-400N
7	700	none	260E, 360-370N
8	110	none	270E, 340-350N
9	300	none	270E, 280-290N
10	3,000	powerline	220E, 250-260N
11	900	powerline	240E, 220-230N
12	1,200	none	200E, 160-170N
13	170	may be related to Area 12	220E, 160-170N
14	100	none	250E, 170-180N
15	170	none	280E, 190-200N

*Location of feature will be confirmed during reconnaissance and utility stake-out surveys.

Figure 7



LEGEND

SURVEY LINE

FENCE LINE

PROPERTY LINE

8 BOUNDARIES OF INTERPRETED METAL

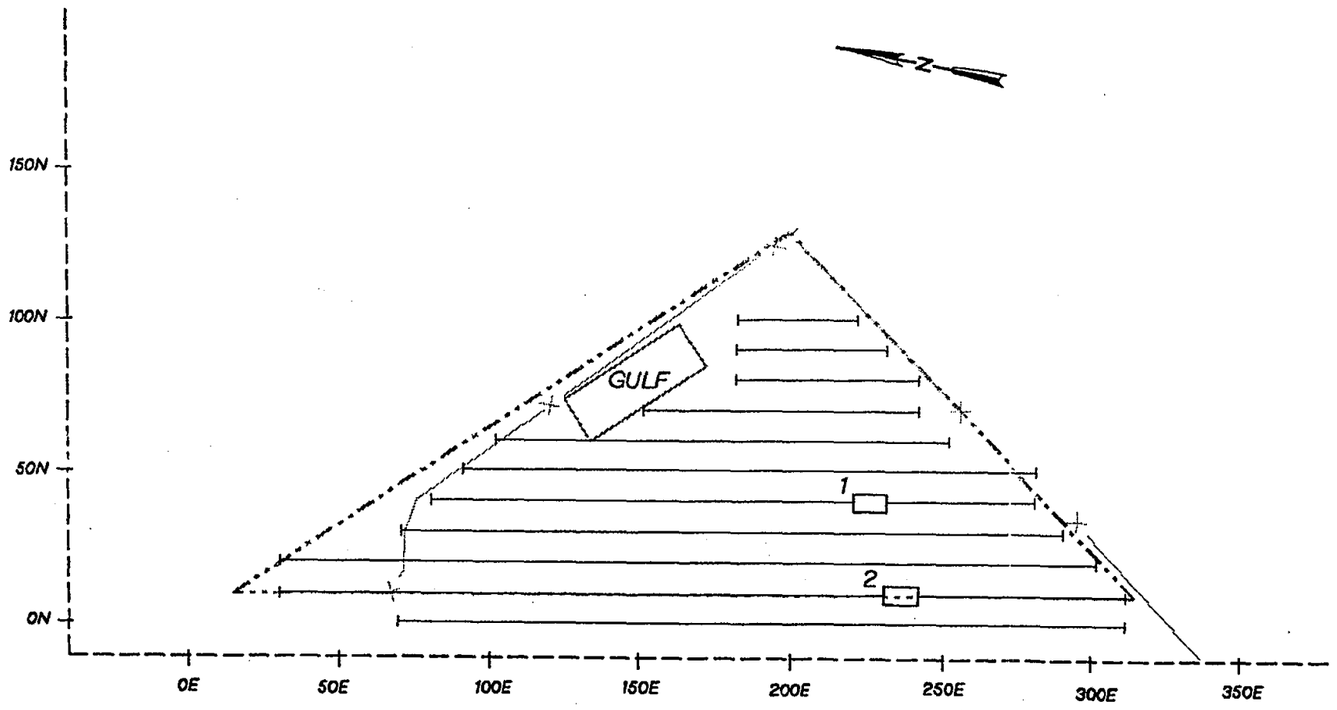
FIGURE 7
Interpreted Areas of Buried Metal

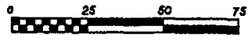
FEDERAL EXPRESS PROPERTY
MAYWOOD, NJ

CH2MHILL

Table 5-2
Interpreted Areas of Buried Metal
Federal Express Property

Area	Strength of Anomalies (gammas)	Cultural Feature	Potential Test-Pit Location
1	600	none	40E, 600-610N
2	200	none	40E, 520-530N
3	500	may be affected by nearby dumpster	40E, 480-490N
4	370	light pole to west at 155E	170E, 560-570N
5	250	fenceline	190E, 610-620N
6	200	none	230E, 570-580N
7	900	may be related to concrete slab	150E, 380-390N
8	2,350	fence	290E, 520-530N
9	1,400	fence, light pole at 315E, 450N	310E, 470-480N





LEGEND

- SURVEY LINE
- PROPERTY LINE
- FENCE LINE
- 1 BOUNDARIES OF INTERPRETED METAL

FIGURE 8
Interpreted Areas of Buried Metal
GULF PROPERTY
MAYWOOD, NJ

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5.1.4 Sunoco

The extent of the magnetometer survey conducted on Sunoco is shown in Figure 4.

Fifteen areas of buried metal have been identified at the site (Figure 9). The areas are numbered from east to west across the property. Anomalies range in strength from 300 to 3,000 gammas. The areas are characterized by both single- and multiple-line anomalies. These areas are listed in Table 5-3 along with their strength, nearby cultural features, and test-pit locations.

5.1.5 AMP Realty

The extent of the magnetometer survey conducted on AMP Realty is shown in Figure 5.

Seven areas of buried metal have been identified at the site (Figure 10). One of the areas (Area 1) is located on the SWS Realty property. The areas are numbered from east to west across the property. Anomalies range in strength from 500 to 2,250 gammas. The areas are characterized by both single- and multiple-line anomalies. These areas are listed in Table 5-4 along with their strength, nearby cultural features, and test-pit locations.

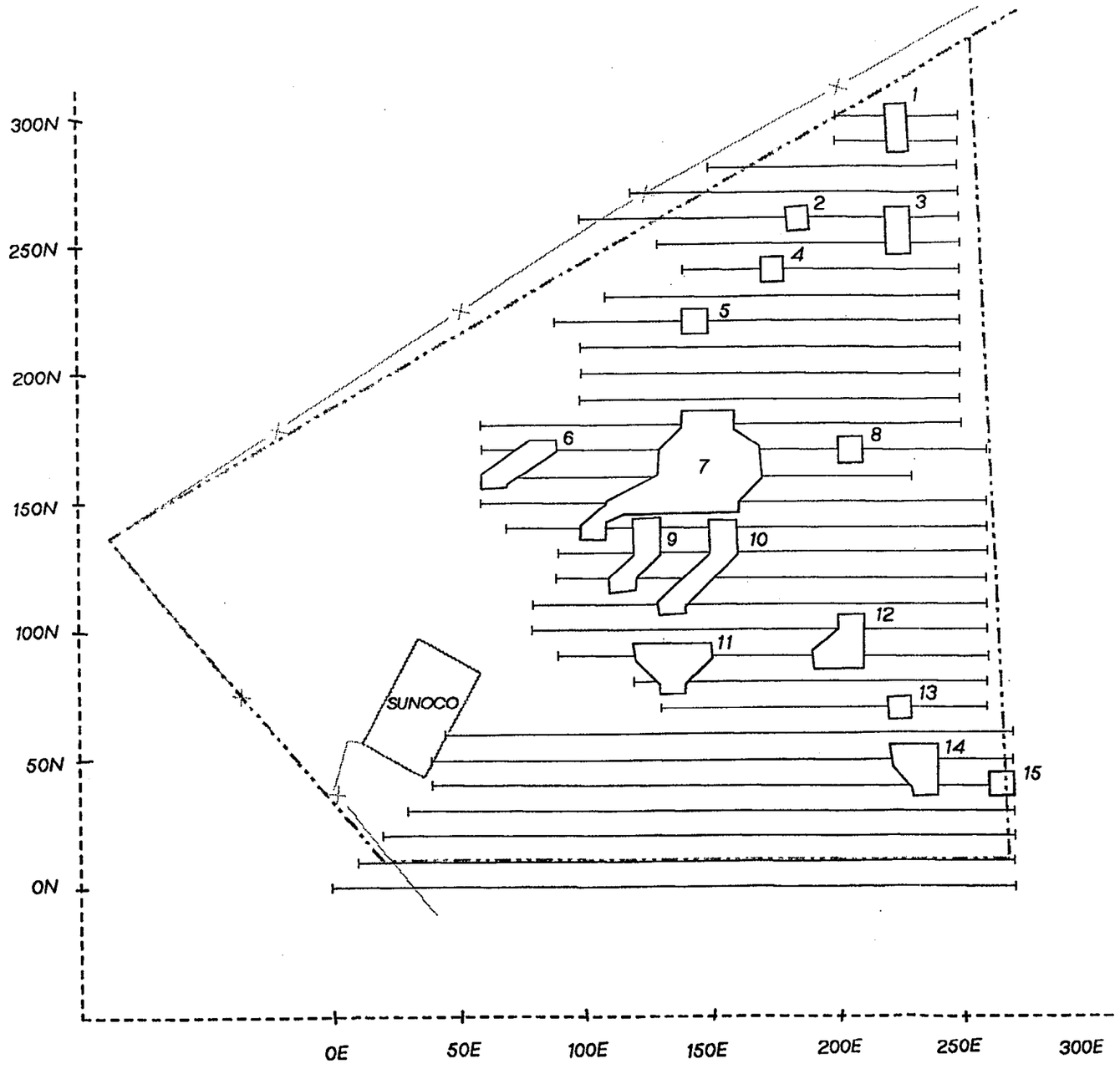
5.2 Anomaly Identification and Test-Pit Location

The areas of interpreted buried metal shown on the maps have been identified based on magnetic anomalies that are not a result of known sources. Anomalies resulting from known sources, such as power lines, surface metal, or buildings have not been shown unless other buried material is suspected based upon the amplitude of the anomaly. The location of metal objects and other sources of interference encountered on the sites are shown on the base maps (Figures 1 through 5).

Potential test pit locations given in Tables 5-1 through 5-4 indicate the strongest source of the anomaly and the location to begin digging if the source is investigated.

5.3 Limitation of Results

Prioritization for followup investigations of the interpreted areas of buried metal should not be based only on geophysical data. Other factors, such as site histories and visual observations, should also be considered. The instrument is sensitive enough to see the anomaly associated with several drums to a depth of 20 feet. This depth is greater than the thickness of the overburden on the sites. Because of the existence of many cultural sources of interference on the sites, anomalies that were identified in some cases may not contain buried metal or appear to be as extensive as they are shown on the map. Other locations that may contain minor amounts of buried metal may have been missed due to magnetic interferences from known or unknown sources.



N

LEGEND

- SURVEY LINE
- FENCE LINE
- PROPERTY LINE
- BOUNDARIES OF INTERPRETED METAL

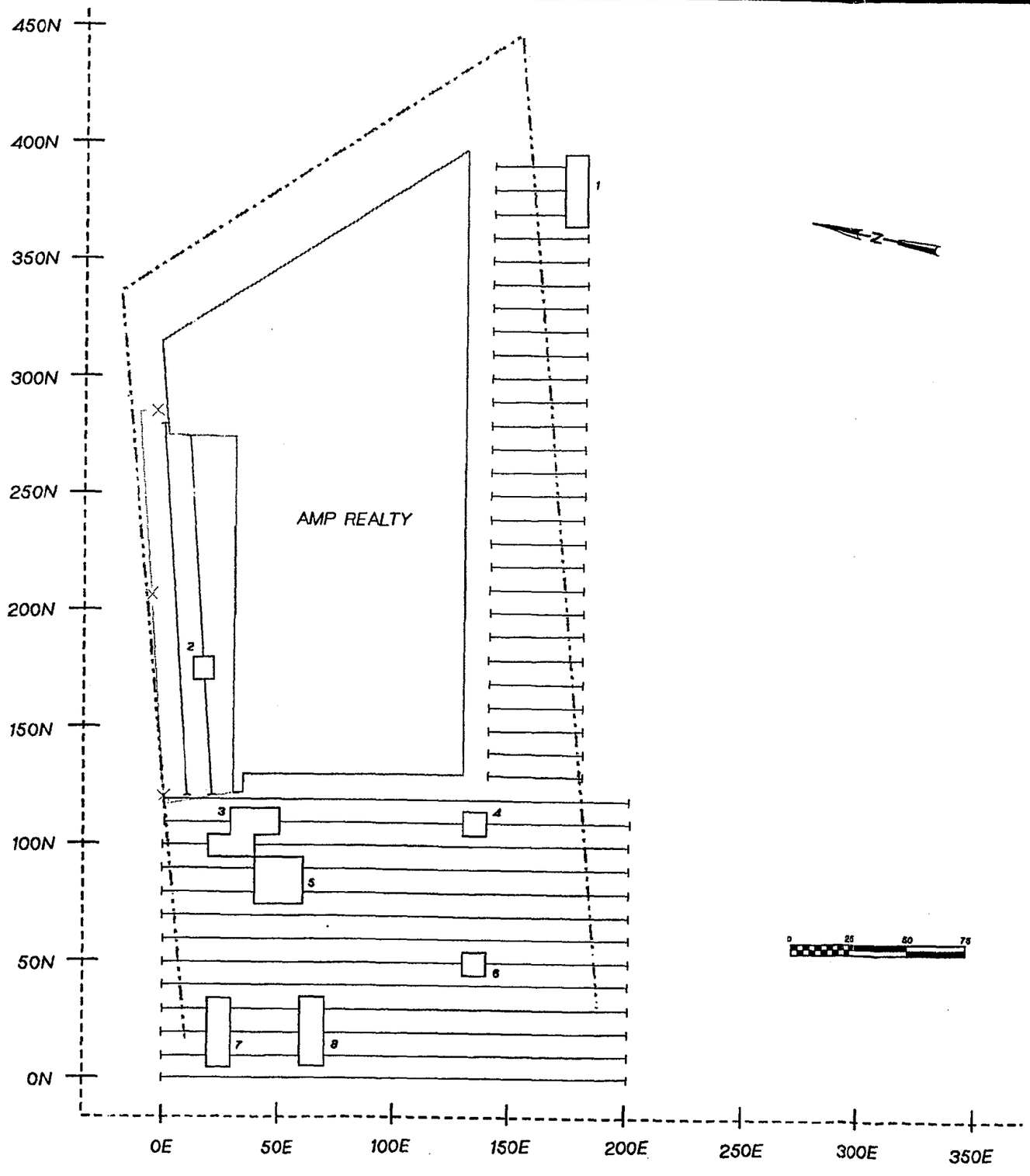
0 25 50 75

FIGURE 9
Interpreted Areas of Buried Metal
SUNOCO PROPERTY
MAYWOOD, NJ

CH2MHILL

Table 5-3
Interpreted Areas of Buried Metal
Sunoco Property

Area	Strength of Anomalies (gammas)	Cultural Feature	Potential Test-Pit Location
1	300	drainage ditch	300N, 220-230E
2	gradient too high	none	260N, 180-190E
3	280	drainage ditch	260N, 220-230E
4	325	none	240N, 170-180E
5	2,250	none	220N, 140-150E
6	1,100	none	160N, 60-70E
7	2,900	none	160N, 130-140E
8	400	near heat pipes	170N, 200-210E
9	700	none	130N, 120-130E
10	875	none	130N, 150-160E
11	3,000	near guard rail	90N, 120-130E
12	675	none	90N, 190-200E
13	450	drainage ditch	70N, 220-230E
14	650	drainage ditch	50N, 220-230E
15	900	none	40N, 260-270E



LEGEND

- SURVEY LINE
- FENCE LINE
- PROPERTY LINE
- 5 BOUNDARIES OF INTERPRETED METAL

FIGURE 10
Interpreted Areas of Buried Metal
AMP REALTY
MAYWOOD, NJ

CH2MHILL

Table 5-4
Interpreted Areas of Buried Metal
AMP Realty Property

Area	Strength of Anomalies (gammas)	Cultural Feature	Potential Test-Pit Location
1	1,300	possible drain pipe	380N, 170-180E
2	400-1,800	suspected underground tank	20E, 180N
3	800	possible utility line	110N, 30-40E
4	900	electric line to overhead lights*	110N, 130-140E
5	780	possible utility line	90N, 40-60E
6	500	electric line to overhead lights*	50N, 130-140E
7	2,250	gasline at 27N*	30N, 20-30E
8	700	suspected water line	10N, 60-70E

*Location of feature will be confirmed during reconnaissance and utility stake-out surveys.

6.0 Discussion and Recommendations

Based on our evaluation of the magnetometer data, the recommended approach to excavating the areas of buried metal is in an order that is based on the areal extent and the strength of the magnetic anomaly.

6.1 DeSaussure

Buried metal has been identified in 15 areas distributed around the site. Some of the anomalies may be the result of overhead powerlines or other sources of interference.

The recommended order for the test-pit program on the DeSaussure property if all anomalous areas are to be investigated is as follows: Area 10, 12, 11, 4, 7, 2, 9, 1, 6, 5, 13, 15, 3, 14, and 8.

6.2 Federal Express

Buried metal has been identified in nine areas distributed on the northern portion the site. Some of the anomalies may be the result of overhead lights, reinforced concrete, fencelines, or other sources of interference.

The recommended order for the test-pit program on the Federal Express property if all anomalous areas are to be investigated is as follows: Area 7, 9, 8, 1, 3, 4, 5, 2, and 6.

6.3 Gulf

Buried metal has been identified in two areas on the property. Test-pitting activities are not recommended for these areas because it is possible that the anomalies are due to overhead powerlines, underground utilities (gasline), and traffic movement in this area.

6.4 Sunoco

Buried metal has been identified in 15 areas distributed around the site. Some of the anomalies may be the result of overhead lights, guardrail, or other sources of interference.

The recommended order for the test-pit program on the Sunoco property if all anomalous areas are to be investigated is as follows: Area 7, 11, 10, 9, 12, 5, 2, 6, 13, 8, 3, 1, and 4. Areas 14 and 15 are not recommended for test-pitting due to an underground gasline in this area.

6.5 AMP Realty

Buried metal has been identified in seven areas distributed around the site. One area was located on the SWS property. Some of the anomalies may be the result of underground utility lines, drain pipes, and an underground storage tank.

The recommended order for the test-pit program on the AMP Realty property if all anomalous areas are to be investigated is as follows: Area 3, 5, 4, and 6. Area 1 is recommended for follow-up investigation on the SWS Realty property. Areas 7 and 8 are not recommended for test-pitting due to an underground gasline and other utilities in this area. Area 2 is suspected to be the location of an underground storage tank and will not be investigated if its presence can be confirmed with the owner.

6.6 Generalized Test-Pitting Approach

The nature of the buried metal cannot be determined from the data and further investigations will be necessary. All anomalies proposed for test-pitting will be field screened with a metal detector before digging to correctly locate their position and extent. If metal is not detected in areas where a cultural feature is present, the cultural feature will be determined to be the source of the anomaly and the anomaly will not be test-pitted. All anomalies greater than 100 gammas have been identified.

Priority of the follow-up investigations (i.e., test-pitting) should be based on the areal extent of the buried metal (an indication of volume), the strength of the magnetic anomalies, site history, and field observations. The test-pit program should concentrate on the strongest anomalies within the recommended test-pit areas, in order to characterize the type of materials producing the largest anomalies. The investigation should progress from those areas consisting of multiple-line anomalies to the areas defined by single-line anomalies. Single-line anomalies may be less significant as potential sources.

The extent of the test pit will be sufficient to characterize the source of the magnetic anomaly. The test pit will target the strongest part of the anomaly. A test pit excavated within the locations provided in Tables 5-1 to 5-4 should be sufficient to characterize the anomaly.