GEOVision
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a division of Blackhawk Geometrics

GEOPHYSICAL INVESTIGATION

Aerial Photographic Anomaly Area 44
Marine Corps Air Station, El Toro, California

GEOVision Project No. 0260

Prepared for

The IT Group
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Prepared by

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July 20, 2000

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A Member of The IT Group

July 27, 2000

Contracting Officer
Naval Facilities Engineering Command
Southwest Division
Bozier H. Demarree
1220 Pacific Highway
San Diego, CA 92132-5187

Attention: Ms. Lynn Hornecker

Subject: Transmittal of Geophysical Investigation Report, APHO 44
Contract N68711-93-D-1459, Delivery Order 070,
Remediation of Various UST, AOC and RFA Sites, MCAS El Toro, California

Dear Ms. Hornecker:

Attached is the Geophysical Investigation Report for Aerial Photograph Anomaly Area 44, dated July 20, 2000. This report was prepared by GEOVision Geophysical Services, under a subcontract for Delivery Order 070.

The report documents the findings from the field surveys conducted at APHO 44 in May and July 2000. The aerial extent of the survey is shown in Figure 1 of the report. Figure 2 shows the location of the surveyed area in comparison with the verification trenches that Earth Tech used to delineate the lower portion of Site 17. The field survey identified a series of soil mounds that stretch over an area of approximately 200 feet by 200 feet. The mounds do not appear to have a significant amount of buried metallic debris, but their linear nature may be indicative that they were placed there as part of the landfill work.

GEOVision indicated that a change in surface soil conductivity occurs near the drainage channel terminus at the southwestern end of the APHO area. As the drainage appeared to pass through the Site 17 area, GEOVision indicated that surface samples might be collected in that vicinity.

If you have any questions or have any comments please call or e-mail me.

Sincerely,

William Sedlak, P.E.
Sr. Project Manager

Attachment: Geophysical Report, APHO 44

cc: L. Holloway, COTR 1C/1E
OHM PMO File 1C/1E
Project File, Communications B.01.

OHM Remediation Services Corp.
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OHM TRANSMITTAL/DELIVERABLE RECEIPT

CONTRACT N68711-93-D-1459 **DOCUMENT CONTROL NO: SW8890**

TO: Contracting Officer
Naval Facilities Engineering Command
Southwest Division
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1220 Pacific Highway
San Diego, California 92132-5190

Date: 28-Jul-00

D.O.: 70

Location: MCAS EL TORO

FROM:

Stewart Bornhoft, Program Manager

Edwin G. Bond, Contracts Manager

DESCRIPTION OF ENCLOSURE: ***Transmittal of Geophysical Investigation Report, APHO 44, Remediation of Various UST, AOC and RFA Sites 1, dated July 27, 2000***

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SCHEDULED DELIVERY DATE: 28-Jul-00 **ACTUAL DELIVERY DATE:** 28-Jul-00

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1 INTRODUCTION

A geophysical investigation was conducted on May 2 to July 5, 2000 in an approximate 9-acre area encompassing Aerial Photographic Anomaly Area 44, Marine Corps Air Station (MCAS), El Toro, California. The purpose of the investigation was to screen the site for buried metallic and/or construction debris and fill soils.

The geophysical survey area consisted of an open dirt field located southeast of Quarry Road and the Wherry Housing Area, northeast of Irvine Boulevard, and west of the Site 17 Landfill. Chain link fences parallel and perpendicular to Quarry Road formed the northwest and southwest edges of the survey area. The location of the survey area is shown on Figure 1.

There was no surficial evidence of disposal activities at the site, except possibly for several linear mounds of soil in the southeastern portion of the survey area, immediately west of the Site 17 Landfill. Surficial cultural features within the survey area that could adversely affect the geophysical data included monitoring wells, fences, and scattered surface debris.

Geophysical techniques used during this investigation included the magnetic and electromagnetic (EM) induction methods. These techniques complement one another as each responds to different physical properties or subsurface materials and has different strengths and limitations. The magnetic method was applied to this investigation because it has the greatest depth of investigation of the geophysical techniques typically applied to mapping buried metallic debris. However, this greater depth of investigation comes at the expense of lateral resolution. The EM induction technique was applied to this investigation because it can map both shallow buried metallic debris and variations in soil conductivity. Changes in soil conductivity may be used to infer the presence of fill soils, providing the fill has a different composition than native soils.

Geophysical techniques used during the investigation are discussed in Section 2. Field procedures are described in Section 3. Data processing and interpretation are discussed in Section 4. Conclusions are presented in Section 5, and our professional certification is presented in Section 6.

2 GEOPHYSICAL TECHNIQUES

This section presents background information on the magnetic and EM methods used during this investigation. A description of the geophysical methods used during this investigation, common applications of the methods, photographs of the instruments, and example applications are included in Appendix A.

2.1 Magnetic Method

The magnetometers used during this investigation consisted of a Geometrics G858 optically pumped cesium-vapor magnetometer (G858) and a GEM GSM-19 base station magnetometer. These instruments measure the intensity of the earth's magnetic field in nanoteslas (nT).

The earth's magnetic field is believed to originate in convection currents in the earth's liquid outer core. The magnetic field varies in intensity from about 25,000 nT at the equator, where it is parallel to the earth's surface to about 70,000 nT at the poles where it perpendicular to the earth's surface. The intensity of the earth's magnetic field in North America varies from about 45,000 to 60,000 nT, and has an associated inclination that varies from about 60 to 75 degrees. The earth's magnetic field undergoes low-frequency diurnal variations (drift) caused by the earth's rotation. The magnetic field can also undergo short-period, high-amplitude variations during periods of sunspot activity called magnetic storms. Often magnetic field intensity can be so variable during a magnetic storm that meaningful magnetic data cannot be acquired. When it is necessary to correct for magnetic drift a base station magnetometer is set up in a quiet portion of the site and programmed to record total magnetic field intensity at fixed increments (i.e. 5-second intervals) throughout the day. This base station data is then used to remove the effects of drift from the field data. In small survey areas where the data is acquired over a small amount of time and the anomalies have large amplitudes correction for diurnal variation is not necessary.

Buried ferromagnetic objects give rise to local perturbations (anomalies) in the earth's magnetic field. In North America, these anomalies are often dipolar with a positive response south and a negative response north of the object. The dimensions and amplitude of a magnetic anomaly are a function of the size, mass, depth and magnetic properties of the source. Magnetometers can typically locate a metallic object the size of a 55-gallon drum to a depth of about 10 feet providing background noise levels are not too high and the object is not significantly corroded. Larger metallic objects can be located to greater depths. The magnetic anomaly due to an object the size of a 55-gallon drum is expected to have dimensions of greater than 10- by 10-feet. Magnetometers are not able to detect nonferrous metals such as aluminum or brass.

Typical applications of the magnetic method include:

- Locating pits and trenches containing ferrous metallic debris
- Locating buried drums, tanks and pipes
- Delineating boundaries of landfills containing ferrous debris
- Locating abandoned well casing
- Detecting unexploded ordnance
- Mapping basement faults and geology

- Mapping archeological sites.

Some advantages of magnetic surveys are:

- Rapid – modern instruments can acquire up to 10 readings per second as the operator walks down survey lines
- Depth of investigation – magnetometers can often locate buried ferrous metallic objects to greater depths than other methods
- Anomalies are much larger than the source allowing for larger line spacing in some situations

Some limitations of the magnetic surveys are:

- Unable to detect nonferrous metals such as aluminum or brass
- Magnetic anomalies are unsymmetrical and much larger than the source and it can, therefore, be difficult to determine the precise locations and size of the source
- Ineffective in areas having extensive metallic debris at the surface as no distinction can be made between anomalies caused by surface and buried debris
- Metallic structures such as buildings, fences, reinforced concrete, and light posts interfere with the measurements
- High voltage powerlines can often strongly interfere with the measurements
- Data can be very noisy in areas containing volcanic rock, specifically basalt

2.2 Electromagnetic Induction Method

EM induction equipment used during this investigation consisted of a Geonics EM-31 terrain conductivity meter (EM-31) coupled to a digital data logger. The EM-31 consists of a transmitter and receiver coil, one at each end of 12-foot long boom. An alternating current is applied to the transmitter coil, causing the coil to radiate a primary EM field. This primary EM field generates eddy currents in subsurface materials, which give rise to a secondary EM field. The EM-31 measures the components of the secondary EM field both in-phase and 90-degrees out-of-phase with the primary EM field. The out-of-phase component is converted to apparent conductivity in millisiemens per meter (mS/m) and the in-phase component is measured as parts per thousand of the primary EM field. A negative EM-31 response with positive shoulders is generally observed over shallow, buried metallic objects. The EM-31 can locate both ferrous and nonferrous metallic objects and can locate a metallic object the size of a 55-gallon drum to a maximum depth of about 5 feet. The EM-31 must pass directly over or immediately adjacent to a buried metallic object to detect it. Because of the 12-foot separation between the transmitter and receiver coils, the EM-31 cannot detect very small, buried metallic objects. The EM-31 can also map changes in the electrical conductivity of subsurface soils caused by certain types of conductive contaminants (i.e. brines, drilling mud, chloride, metals, etc.) or simply a change in soil type (i.e. low conductivity sand to high conductivity clay).

Applications of EM Induction methods include:

- Locating buried tanks

- Locating pipes and utilities
- Locating pits and trenches containing metallic and/or nonmetallic debris
- Delineating landfill boundaries
- Delineating oil production sumps and mud pits
- Mapping conductive soil and groundwater contamination
- Mapping soil salinity in agricultural areas
- Characterizing shallow subsurface geology
- Mapping buried channel deposits
- Locating sand and gravel deposits
- Mapping conductive fault and fracture zones
- Mapping lateral variation in subsurface soil type

Strengths of EM Induction Methods include:

- Rapid – data can be acquired at a slow walking pace
- Locate both metallic and some nonmetallic targets
- Better resolution than magnetometer
- Not as sensitive to very small surface debris as other methods
- Can locate electrical and telephone cables which often cannot be located by other methods
- Anomalies of buried objects have simple shape facilitating identification and positioning of the source

Limitations of EM Induction Methods include:

- Metallic structures such as buildings, fences, reinforced concrete, and light posts interfere with the measurements
- High voltage powerlines can often strongly interfere with the measurements
- Depth of investigation not as great as that of a magnetometer for detection of buried ferrous metallic objects
- Highly variable soil conductivity can complicate quadrature component interpretation

3 FIELD PROCEDURES

This section describes the field procedures used during the investigation, including site preparation, magnetic and EM-31 survey procedures, and field verification procedures.

3.1 Site Preparation

Before conducting the geophysical investigation, 4-foot long survey lathe were placed at 20-foot intervals along the southwest (SW) and northeast (NE) edges and in the middle of the approximate 550- by 550- foot original survey area to provide control for the geophysical survey. The survey area was later expanded to the southeast (SE) to map the extents of an anomalous zone located in the southeastern portion of the original survey area. The survey expansion was about 350- by 300-feet in size.

A Sokkia GIR1000 single-frequency global positioning system (GPS) was coupled to the geophysical instruments to provide horizontal control for the geophysical data. Differential corrections were applied to the GPS data using GPS base station data recorded at the Sokkia office in Orange, California. GPS data were collected in geodetic coordinates based on the WGS84 system and transformed to approximate California State Plane Coordinates, Zone 6, North American Datum of 1983 (NAD83) after applying differential corrections. Ellipsoid heights measured using the GPS system were converted to NAVD 88 elevations using the Geoid Model of 1996. Maximum horizontal errors in the corrected GPS data are estimated to be about 3 feet, with average errors being about 1 to 2 feet.

The GPS system was also used to map pertinent surficial features at the site, including dirt roads, monitoring wells, fences, and surface debris. Additionally, the GPS system was used to relocate geophysical anomalies during the field verification phase. Site mapping activities were conducted on May 3, May 11, and July 5, 2000.

A site map showing the location of the geophysical survey area, State Plane Coordinate System, and surficial features is presented as Figure 2.

3.2 Magnetic Survey

Original magnetic data were acquired on May 2 to 3, 2000. On June 13, 2000 the survey was expanded to the southeast to map an anomalous zone extending beyond the original survey area. Prior to data acquisition, the base station magnetometer was set up north of the survey area in a location free of surface debris. The internal clock of the base station and G858 were synchronized to GPS time and the base station was programmed to record the magnetic field intensity of the earth at 5-second intervals throughout the day. The G858 and GPS unit were then programmed with the appropriate settings. The magnetometer was operated with the sensor about 3 feet above ground surface. Measurements of the earth's total magnetic field intensity were made at 0.2-second intervals as the operator walked along SW-NE survey lines nominally spaced 10 feet apart. The 0.2-second sampling interval resulted in an average station spacing of about 1 foot. The stakes placed at the ends and middle of the survey area allowed the instrument operator to walk a relatively straight line, thereby ensuring uniform site coverage. It was not possible to walk straight lines in all areas due to heavy vegetation, large shrubs and trees, and soil mounds. The magnetic data were stored in the internal memory of the magnetometer, along with line number, and time of measurement. If an error was made on a survey line the line was deleted from the magnetometer's internal memory and reacquired. GPS, base station and field magnetic data were downloaded to a laptop computer at the end of the magnetic survey.

3.3 Geonics EM-31 Survey

EM-31 data were acquired concurrently with magnetic data on May 2 to 3, and June 13, 2000. Prior to data acquisition, the EM-31 was assembled and battery levels were checked and found to be within acceptable levels. The in-phase component was then set to zero in a portion of the site with no buried metallic objects. The EM-31 digital data logger was synchronized to GPS time and programmed with the appropriate file name, line number, measurement increment, and direction. Changes in these parameters were made as necessary throughout the survey. The EM-31 was operated in vertical dipole mode with an approximate 3-foot instrument height and the instrument boom parallel to the survey lines. EM-31 measurements of conductivity and in-phase component were made at 0.5-second intervals as the operator walked along SW-NE survey lines nominally spaced 10 feet apart. The 0.5-second sampling interval resulted in an average station spacing of about 2 feet. The EM-31 data were stored in a digital data logger along with line and station number. If an error was made acquiring a line, a note was made in the field log and the line repeated. EM-31 and GPS data were downloaded to a laptop computer at the end of each field day.

3.4 Field Verification

The verification phase of the investigation was conducted on July 5, 2000 after processing of the magnetic and EM-31 data. A discussion of data processing procedures is provided in the following section. Most magnetic and EM-31 anomalies were relocated with GPS and field checked to verify that they had subsurface sources. This phase of the investigation revealed that about half of the small geophysical anomalies were caused by small pieces of surface debris and that the most significant geophysical anomalies had subsurface sources. Two pipes along the NW edge of the survey area were traced with an EM utility locator and surveyed using GPS. Additional surface features such as monitoring wells and test pit locations located SE of the survey area were surveyed for spatial reference.

4 DATA PROCESSING AND INTERPRETATION

This section presents the data processing procedures and interpretation of the geophysical data.

4.1 Data Processing

Color-enhanced contour maps of magnetic and EM-31 data were generated using the GEOSOFT® geophysical mapping system. Prior to contour map generation, a number of preprocessing steps were completed. These preprocessing steps consisted of the following:

- Backup of all original field data files to floppy disk.
- Downloading GPS base station data from Sokkia bulletin board.
- Applying differential corrections to GPS data and outputting an ASCII file containing approximate State Plane Coordinates, elevation, and time.
- Correcting of all data acquisition errors (typically only deleting the first portion of a reacquired line, renaming lines incorrectly labeled, deleting additional readings outside the grid, etc.)
- Reformatting field data files to free format XYZ files containing at a minimum GPS time and field measurements.
- Merging GPS position data and geophysical data using in-house software.
- Removing diurnal variation from total magnetic field measurements using the base station data file and in-house software, if necessary.
- Merging of multiple data files into a single file and sorting, if necessary.

These data adjustments were made using a combination of commercial and in-house software. All adjustments made to data files and resulting file names were documented and are retained in project files.

The outputs of the data preprocessing were data files containing California State Plane, Zone 6, NAD83 Easting and Northing, and the various data measurements. The magnetic data file contained total magnetic field intensity. The EM-31 data file contained conductivity and in-phase response.

These data files were imported into the GEOSOFT® mapping system and the following data processing steps applied:

- Reformatting of data files to GEOSOFT® format.
- Generating final map scale.
- Gridding data using minimum curvature and a 5-foot cell size.
- Masking grid in areas where data not acquired (i.e. around obstructions).
- Applying a single pass Hanning filter to smooth the data.
- Generating color zone file describing color for different data ranges.
- Contouring the data.
- Generating map surrounds (title block, legend, scale, color bar, north arrow, etc.)
- Annotating anomalies.
- Merging various plot files and plotting final map.

The names of the files generated and the processing parameters used were recorded on data processing forms. All completed data processing forms are retained in project files. All files generated during the processing sequence were archived on CD-ROM.

4.2 Interpretation

Color-enhanced contour maps of total magnetic field intensity, EM-31 conductivity and EM-31 in-phase response are presented as Figures 3 to 5, respectively. The coordinates shown in these figures reference the California State Plane Coordinate System, Zone 6, NAD83. The color bar indicates the amplitude of the measured quantity with the magenta and cyan colors indicating high- and low-amplitudes, respectively. The light orange, yellow and light green colors in the contour maps of total magnetic field intensity and EM-31 in-phase response indicate average "background" values of the measured quantity.

Significant anomalies in the magnetic and EM-31 data were field checked to determine if a metallic object at the surface caused the anomaly. A number of surface metallic features, such as fences, monitoring wells, and metallic surface debris caused anomalies in the geophysical data. These anomalies are labeled as “SM” on the contour maps.

There is an anomaly on the contour maps of magnetic and EM-31 data (Figures 3 to 5) interpreted as being caused by a buried pipe(s). This anomaly is labeled as “P” on the contour maps and approximate locations of the pipes are shown on Figure 2.

There are numerous small magnetic anomalies and several small EM-31 anomalies interpreted as being caused by small, buried metallic objects. These anomalies are labeled as “B” on the respective contour maps and are depicted on Figure 2. The anomalies are probably caused by small pieces of metallic debris at shallow depth. This debris is probably similar to the debris scattered on the surface. Some of the anomalies interpreted as buried objects appear to have larger sources, as depicted by a different symbol on Figure 2. These larger anomalies may be caused by small pits containing metallic debris or large buried objects (i.e. piece of sheet metal, large pipe segment, etc.)

There are three large anomalous areas in the magnetic data requiring further discussion. These anomalies are labeled as A-1 to A-3 on the contour map of magnetic data (Figure 3) and are discussed below.

Anomaly A-1 consists of a small area centered at 6118350E, 2191700N with abundant, high-amplitude magnetic anomalies and sparse EM-31 anomalies. This anomalous zone is interpreted as an area containing a high concentration of buried metallic debris as shown on Figure 2. The absence of EM-31 anomalies over most of this area indicates that much of the debris may be greater than 5 feet in depth. Alternatively, some of the debris may just be too small to give rise to EM-31 anomalies, although the sources of the larger magnetic anomalies should be large enough to give rise to EM-31 anomalies, if at shallow depth.

Anomaly A-2 is located immediately SE of A-1 and consists of lower amplitude, less concentrated magnetic anomalies. This anomalous zone is interpreted as an area containing scattered buried metallic debris. There is a minor amount of surface debris in this area and much of the buried debris may consist of small, buried objects at relatively shallow depth. The specific interpreted locations of the buried metallic debris in this area are shown on Figure 2.

Anomaly A-3 is located immediately SE of A-2 and has similar characteristics to A-2; however most of the anomalies appear to be caused by surface debris. This anomalous zone is located in a portion of the site containing parallel, linear soil mounds and is interpreted as an area containing scattered surface debris and minor buried debris. The buried debris probably consists of small pieces of debris at shallow depth. Stakes identifying former test pit locations indicate that the Site 17 landfill is located immediately SE of anomaly A-3 and the soil mound area. An absence of significant buried debris within the soil mound area indicates that the mounds may have been present at the time of landfilling. If this assumption is correct, then anomalies A-2 and A-1 may be westward extensions of the landfill.

The EM-31 conductivity data (Figure 4) provided no conclusive evidence for the placement of large amounts of fill soil. Near-surface soil conductivities are quite variable at the site, ranging from about 14 to 34 mS/m. The near-surface soils in the lower conductivity zones probably consist of coarser grained soils with only minor amounts of clay (i.e. clean sand), whereas the higher conductivity zones probably have silty sands, clayey sands or silt in the near surface. Soil conductivity varies from about 14 to 18 mS/m over much of the site and this conductivity range will be considered background for the purpose of discussion. A NW trending zone of slightly elevated conductivity (above background) is identified as anomaly A-4 on Figure 4. Much of magnetic anomalies A-1 and A-2 are located within this area, which may lead one to conclude that the elevated conductivities are somehow related to disposal activities at the site. However the orientation of this elevated conductivity zone is not parallel to magnetic anomalies A-1 and A-2 and the adjacent Site 17 landfill, indicating that the conductivity variation may just be related to natural soil deposition. Soil conductivity is also beginning to increase along the NE edge of the survey area providing additional evidence that near-surface soils are somewhat variable across the site. Soil conductivity is also slightly elevated in parts of a heavily vegetated area in the SW portion of the survey area (Figure 2 and 4). This heavily vegetated area is located at the end of a very small intermittent drainage, and the elevated conductivity may be related to the accumulation of fine-grained sediments. It should be noted that this minor drainage appears to pass through or adjacent to the Site 17 landfill.

5 SUMMARY

A magnetic and Geonics EM-31 (EM-31) survey was conducted in the approximate 9-acre Aerial Photographic Anomaly Area 44 at MCAS EL Toro, California to screen the site for buried metallic and/or construction debris and fill soils. Interpretation of the geophysical data is presented in Figure 2. Contour maps of total magnetic field intensity and EM-31 conductivity and in-phase response are presented as Figures 3 to 5, respectively.

The geophysical survey revealed the presence of a large area containing buried metallic debris in the southeastern portion of the site. This area is subdivided into three zones referred to as A-1 to A-3 in Figure 2, and may be considered a westerly extension of the Site 17 landfill. The Site 17 landfill is currently mapped as terminating at the eastern edge of a series of narrow, northeast trending soil mounds. Very little evidence of buried metallic debris was found in the geophysical data collected in the soil mound area, indicating that the soil mounds may have been present in during landfilling activities. Anomalous zone A-3, interpreted as scattered surface debris with only minor amounts of buried debris, is located within the soil mound area as shown on Figure 2. Buried metallic debris is however found northwest of the soil mounds (areas A-1 and A-2 on Figure 2). The westernmost anomalous zone (A-1) is interpreted as containing significant amounts of buried metallic debris, possibly at depths of greater than 5 feet. The central zone (A-2) is interpreted as containing scattered buried metallic debris with the specific interpreted locations of debris presented on Figure 2. These two areas (A-1 and A-2) could be considered part of the Site 17 landfill, however they appear to be separated from the main landfill by the soil mound area.

The geophysical data also revealed the presence of two pipes along the northwestern edge of the survey area and numerous small, buried metallic objects/debris as shown on Figure 2. Most of the buried metallic objects appear to be very small, shallow pieces of debris, probably similar in nature to the surface debris scattered around the site. Some of the buried metallic debris/objects are larger, as depicted by a different symbol on Figure 2. These larger buried metallic features may consist of small pits containing metallic/construction debris or buried metallic objects with dimensions of several feet on a side.

Near-surface soil conductivity is quite variable at the site ranging from about 14 to 34 mS/m. Much of the conductivity variation is probably related to natural soil variation. A large northwest trending zone of elevated conductivity passes through the anomaly A-1/A-2 area; however, this is probably a coincidence, as the two features appear to have different orientations. Soil conductivities are also slightly higher in a heavily vegetated area in the southwestern portion of the survey area that is the terminus of a very small, intermittent drainage. This drainage appears to pass adjacent to or through the Site 17 landfill. Several shallow soil samples could be collected to confirm that the variation in soil conductivity at the site is a function of soil type rather than some other feature.

The geophysical survey was designed to map small accumulations of metallic debris in the subsurface and strong variations in near-surface soil type that could be indicative of fill soils. It was assumed that any debris buried at the site would contain enough metallic components (i.e. rebar, pipe segments, steel plates, etc.) to be detectable by the magnetic and EM methods.

6 CERTIFICATION

All geophysical data, analysis, interpretations, conclusions, and recommendations in this document have been prepared under the supervision of and reviewed by a **GEO*Vision*** California Registered Geophysicist.

REGISTERED GEOPHYSICIST
ANTONY JEFFREY MARTIN
GP 989
Exp. 3/31/01
STATE OF CALIFORNIA

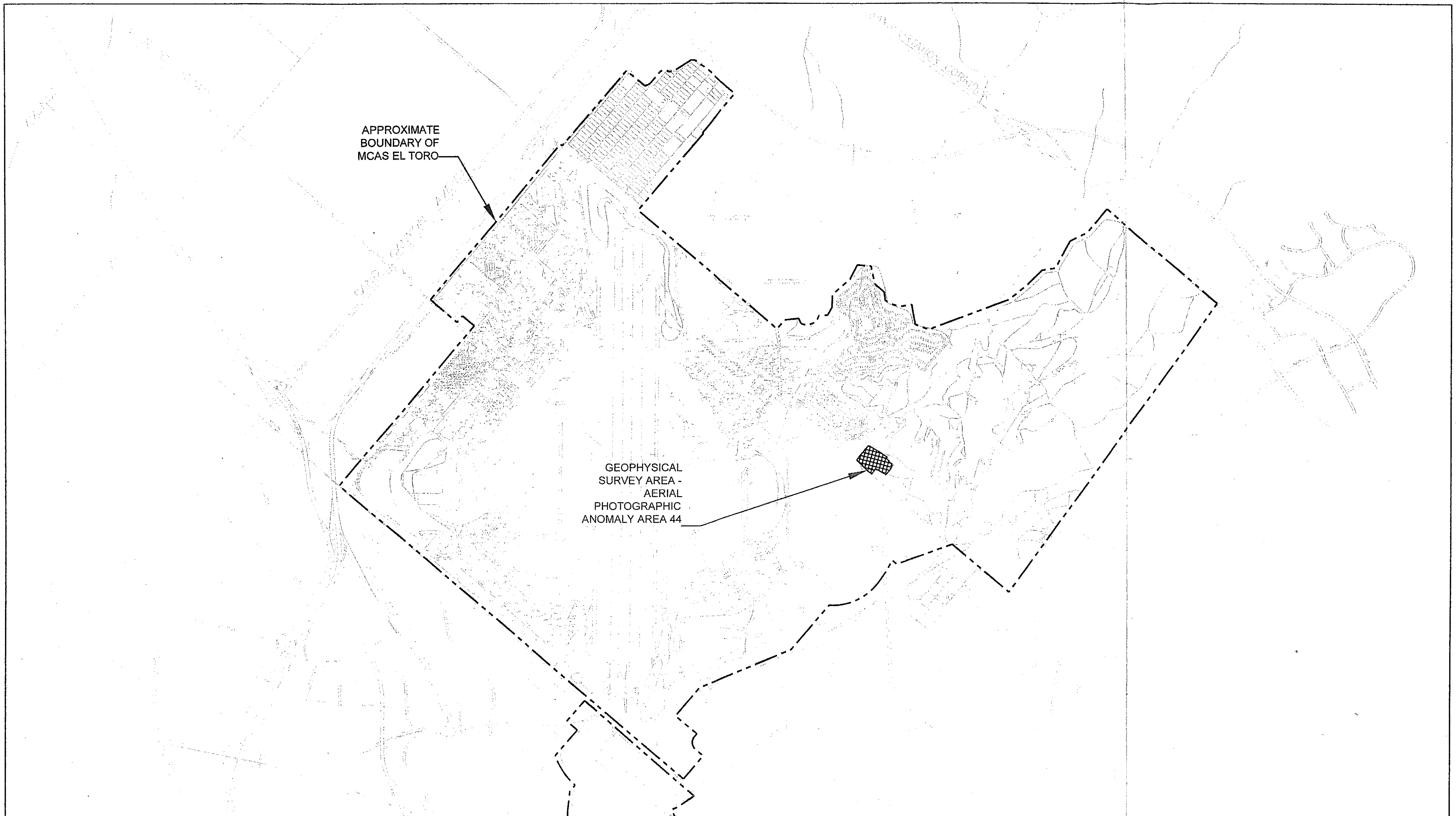
Antony J. Martin
California Registered Geophysicist GP989
GEO*Vision* Geophysical Services

7/21/03
Date

* This geophysical investigation was conducted under the supervision of a California Registered Geophysicist using industry standard methods and equipment. A high degree of professionalism was maintained during all aspects of the project from the field investigation and data acquisition, through data processing interpretation and reporting. All original field data files, field notes and observations, and other pertinent information are maintained in the project files and are available for the client to review for a period of at least one year.

A registered geophysicist's certification of interpreted geophysical conditions comprises a declaration of his/her professional judgment. It does not constitute a warranty or guarantee, expressed or implied, nor does it relieve any other party of its responsibility to abide by contract documents, applicable codes, standards, regulations or ordinances.

FIGURES



NOTES:
1. BASE MAP PROVIDED BY THE IT GROUP
2. COORDINATES ARE IN THE CALIFORNIA STATE PLANE COORDINATE SYSTEM, ZONE 6, NAD83
3. ESTIMATED MAP ACCURACY = 10-30 FEET

GEOVision
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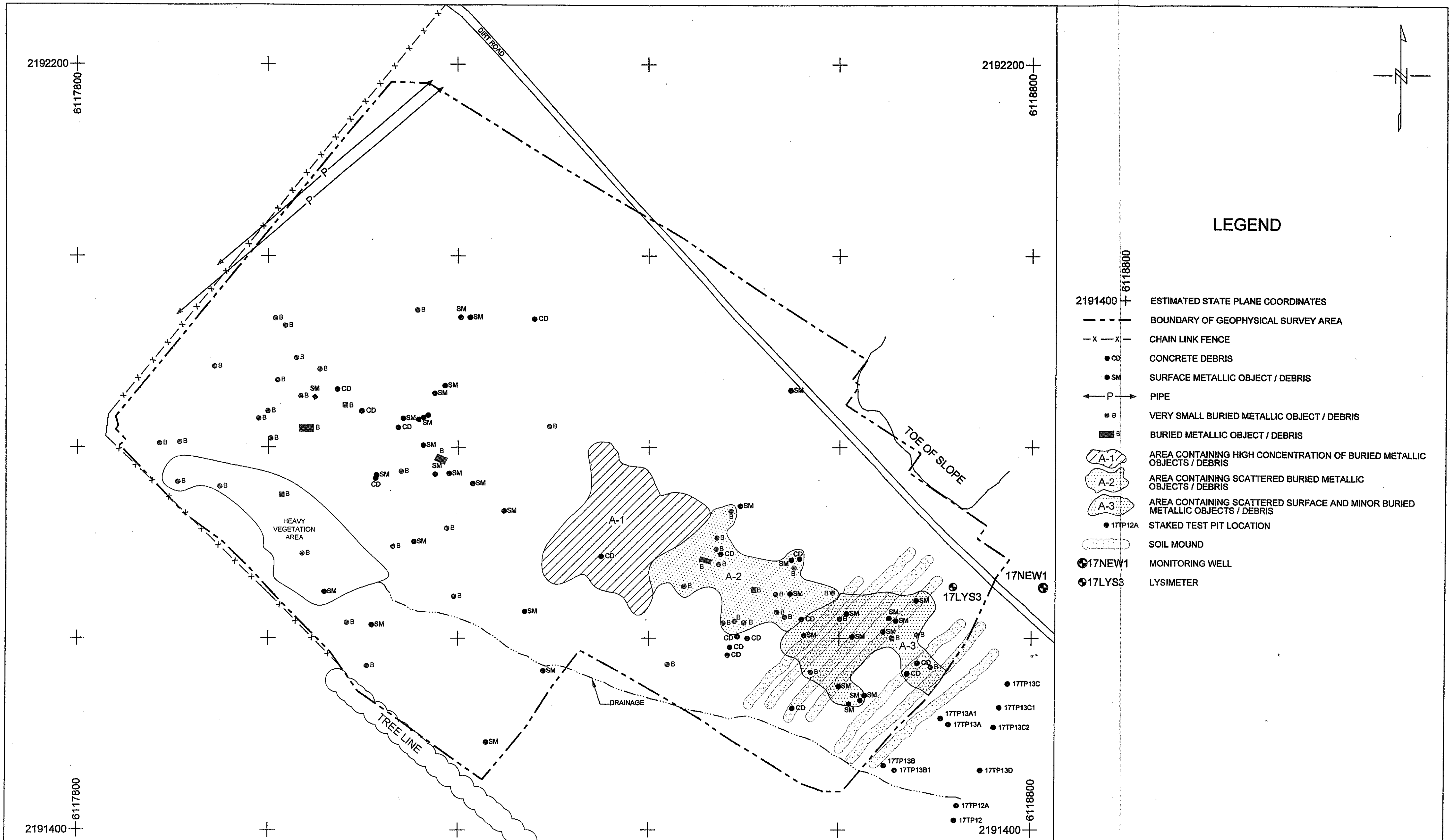
Project No. 0260-44	Date Jul 20,2000
Developed by	A MARTIN
Drawn by	T RODRIGUEZ
Approved by	[signature]
File	C:\AcadMap2K\0260\S44\0260-44-1.dwg

FIGURE - 1
SITE LOCATION MAP

MARINE CORPS AIR STATION, EL TORO

ORANGE COUNTY, CALIFORNIA

PREPARED FOR THE IT GROUP



NOTES:
1. COORDINATES ARE IN CALIFORNIA STATE PLANE COORDINATE SYSTEM, ZONE 6, NAD83

0 50 100 200
(feet)

GEOVision
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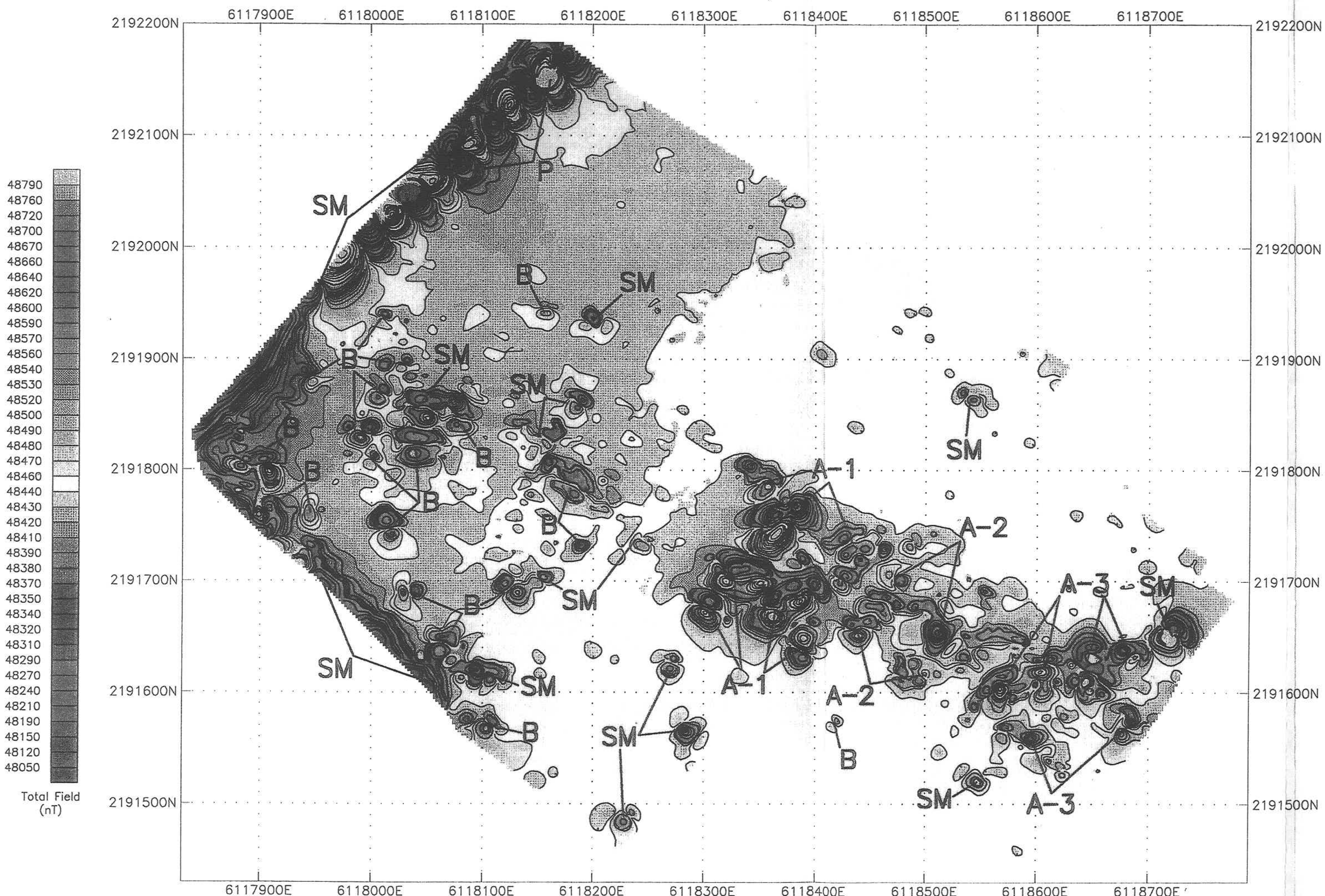
Project #	0260
Date	Jul 20,2000
Developed by	A MARTIN
Drawn by	T RODRIGUEZ
Approved by	[signature]
File	C:\AcadMap2K\0260\S44\0260-44.dwg

FIGURE - 2
SITE MAP WITH GEOPHYSICAL INTERPRETATION

AERIAL PHOTOGRAPHIC ANOMALY AREA 44
MCAS EL TORO
ORANGE COUNTY, CALIFORNIA

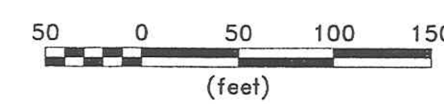
PREPARED FOR
THE IT GROUP



CONTOUR INTERVAL = 20 NANOTESLAS

LEGEND

A-1	GEOPHYSICAL ANOMALY DISCUSSED IN REPORT
P	ANOMALY CAUSED BY BURIED PIPE
B	ANOMALY CAUSED BY SMALL BURIED METALLIC OBJECT OR DEBRIS
SM	ANOMALY CAUSED BY SURFACE METALLIC OBJECT OR DEBRIS



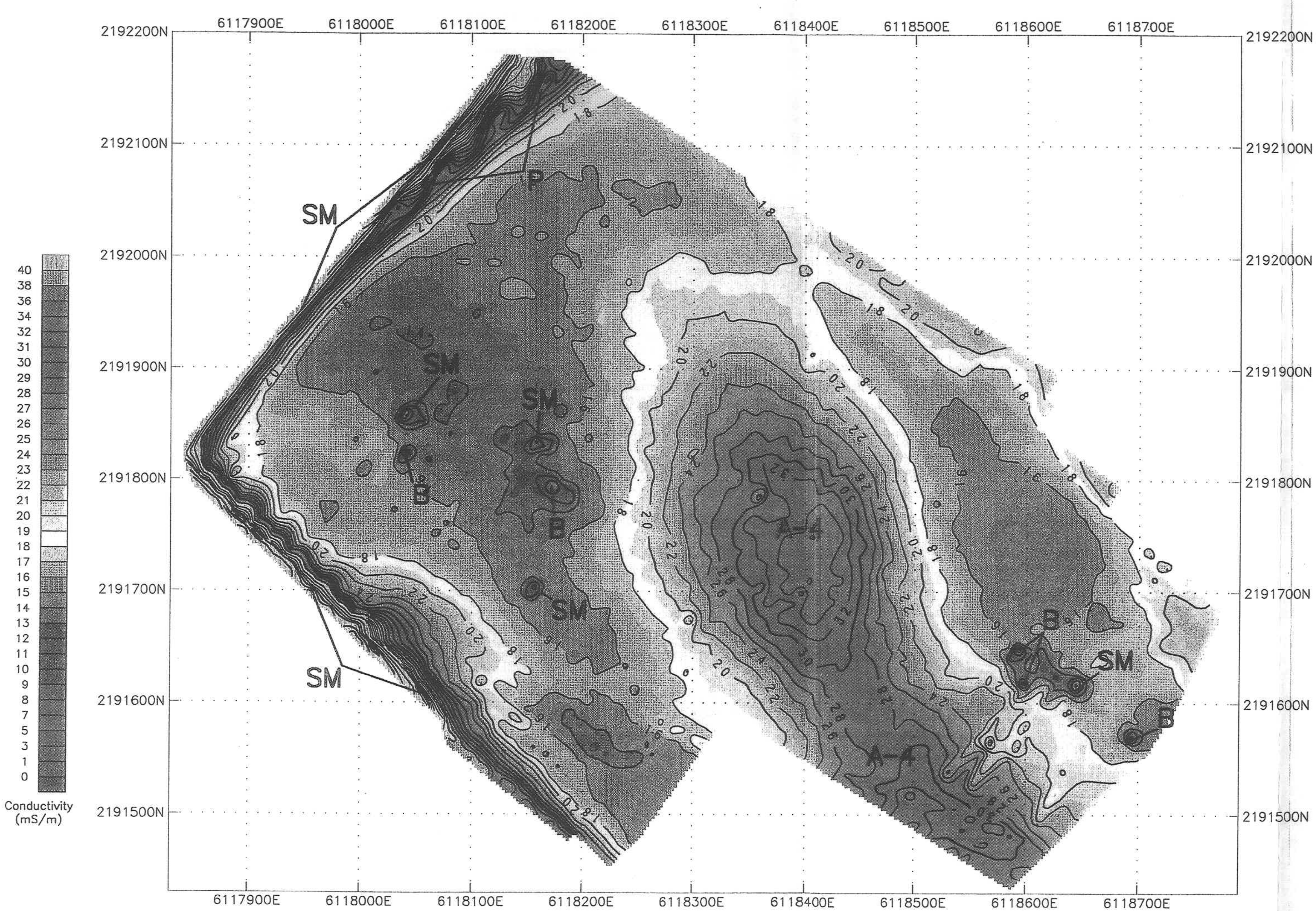
Note: Coordinates are in the California State Plane Coordinate System, Zone 6, NAD83

FIGURE 3
CONTOUR MAP OF TOTAL MAGNETIC FIELD INTENSITY

AERIAL PHOTOGRAPHIC ANOMALY AREA 44
MCAS EL TORO, CALIFORNIA

PREPARED FOR
THE IT GROUP

GEOVISION GEOPHYSICAL SERVICES



CONTOUR INTERVAL = 2 MILLISIEMENS PER METER

Note: Coordinates are in the California State Plane Coordinate System, Zone 6, NAD83

LEGEND

A-1	GEOPHYSICAL ANOMALY DISCUSSED IN REPORT
P	ANOMALY CAUSED BY BURIED PIPE
B	ANOMALY CAUSED BY SMALL BURIED METALLIC OBJECT OR DEBRIS
SM	ANOMALY CAUSED BY SURFACE METALLIC OBJECT OR DEBRIS

50 0 50 100 150

(feet)

FIGURE 4

CONTOUR MAP OF GEONICS EM-31 CONDUCTIVITY RESPONSE

AERIAL PHOTOGRAPHIC ANOMALY AREA 44
MCAS EL TORO, CALIFORNIA

PREPARED FOR
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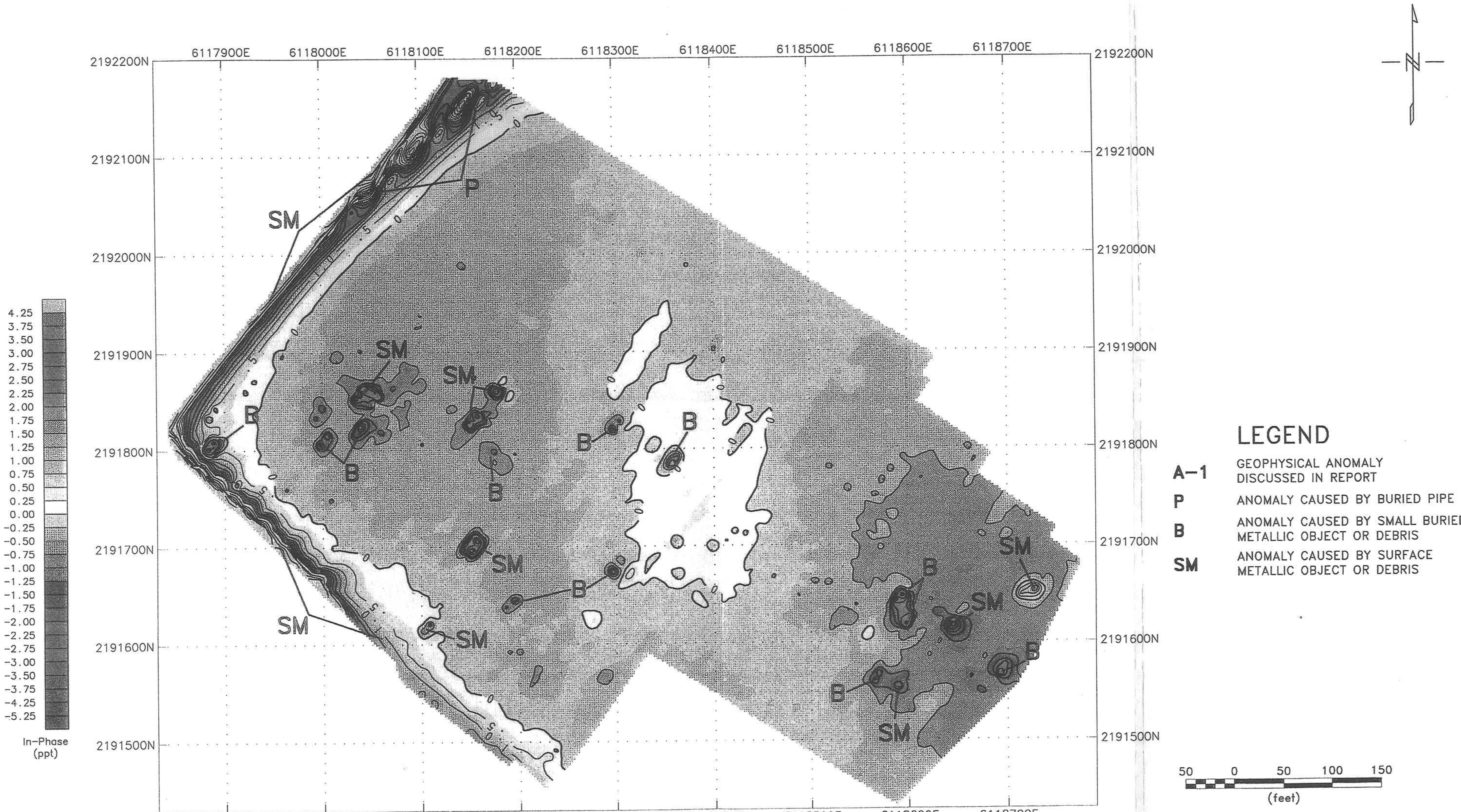

CONTOUR INTERVAL = 0.5 PARTS PER THOUSAND

Note: Coordinates are in the California State Plane Coordinate System, Zone 6, NAD83

FIGURE 5
CONTOUR MAP OF GEONICS EM-31 IN-PHASE RESPONSE

AERIAL PHOTOGRAPHIC ANOMALY AREA 44
MCAS EL TORO, CALIFORNIA

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APPENDIX A

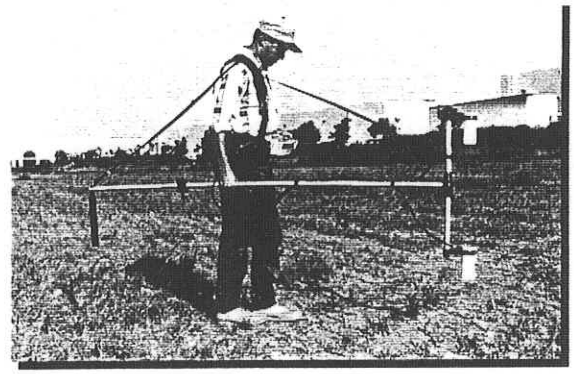
GEOPHYSICAL TECHNIQUES FOR SHALLOW ENVIRONMENTAL INVESTIGATIONS

GEOPHYSICAL TECHNIQUES FOR SHALLOW ENVIRONMENTAL INVESTIGATIONS

GEOVision
geophysical services
a division of Blackhawk Geometrics

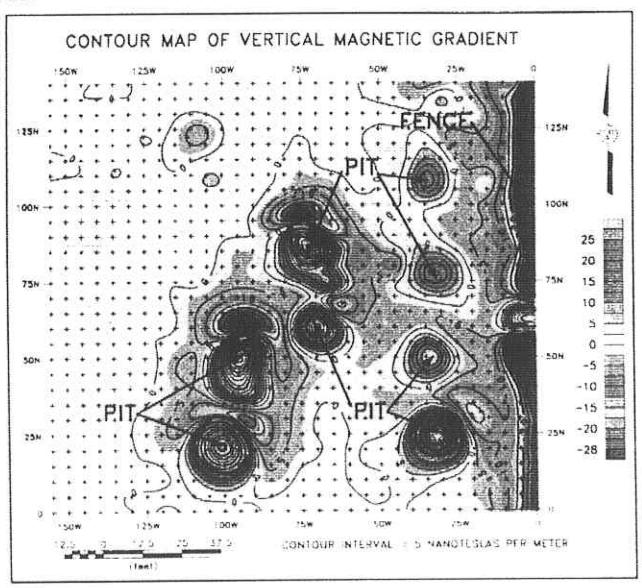
MAGNETIC METHOD

The magnetic method generally involves the measurement of the earth's magnetic field intensity or vertical gradient of the earth's magnetic field. Anomalies in the earth's magnetic field are caused by induced or remanent magnetism. Induced magnetic anomalies are the result of secondary magnetization induced in a ferrous body by the earth's magnetic field. The shape and amplitude of an induced magnetic anomaly is a function of the orientation, geometry, size, depth, and magnetic susceptibility of the body as well as the intensity and inclination of the earth's magnetic field in the survey area. The magnetic method is an effective way to search for small metallic objects, such as buried ordnance and drums, because magnetic anomalies have spatial dimensions much larger than those of the objects themselves. Typically, a single buried drum can be detected to a depth of about 10 feet. Larger metallic objects can often be located to greater depths. Induced magnetic anomalies over buried objects such as drums, pipes, tanks, and buried metallic debris generally exhibit an asymmetrical, south up/north down signature (positive response south of the object and negative response to the north).

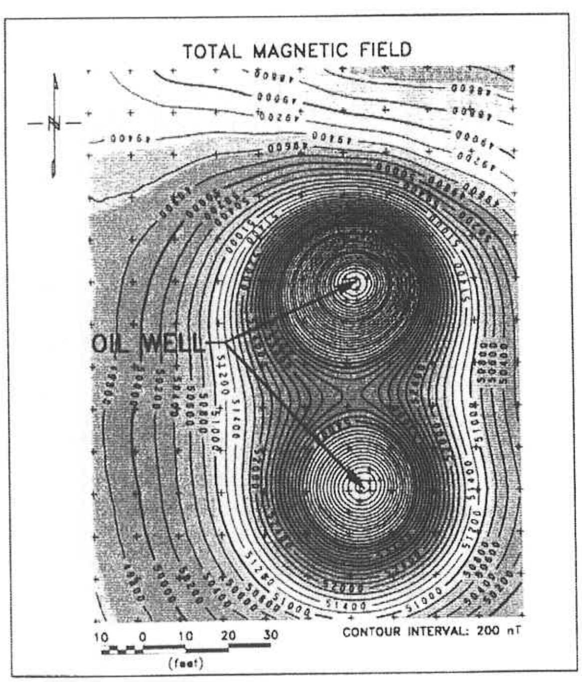


Geometrics G858 Cesium Magnetic Gradiometer

Magnetic data is typically acquired along a grid with results being presented as color-enhanced contour maps generated by the Geosoft™ Mapping System or OASIS montaj. The approximate location and depth of magnetic objects can be calculated using the Geosoft™ UXO System.



Magnetic Survey to Locate Pits Containing Buried Metallic Containers



Magnetic Survey to Locate Abandoned Oil Wells

Magnetic surveys are typically conducted to:

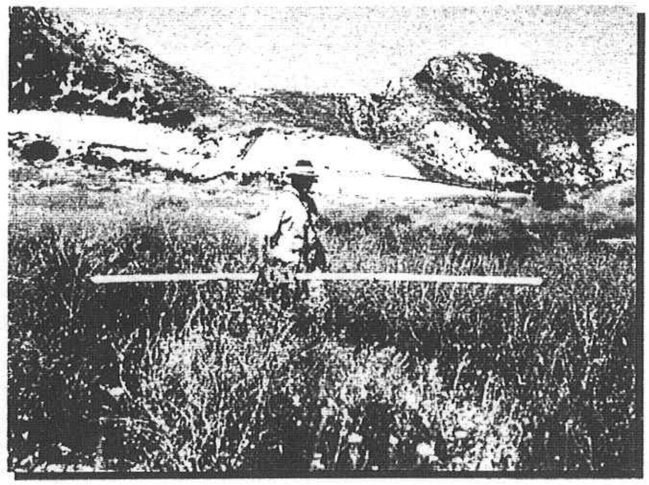
- Locate abandoned steel well casings
- Locate buried tanks and pipes
- Locate pits and trenches containing buried metallic debris
- Detect buried unexploded ordnance (UXO)
- Map old waste sites and landfill boundaries
- Clear drilling locations
- Map basement faults and geology
- Investigate archaeological sites

ELECTROMAGNETIC METHODS

Electromagnetic (EM) methods typically applied to shallow environmental investigations include frequency domain EM methods, such as EM induction and EM utility location methods, time domain electromagnetic (TDEM) metal detection methods, and ground penetrating radar (GPR) methods.

EM Induction Method

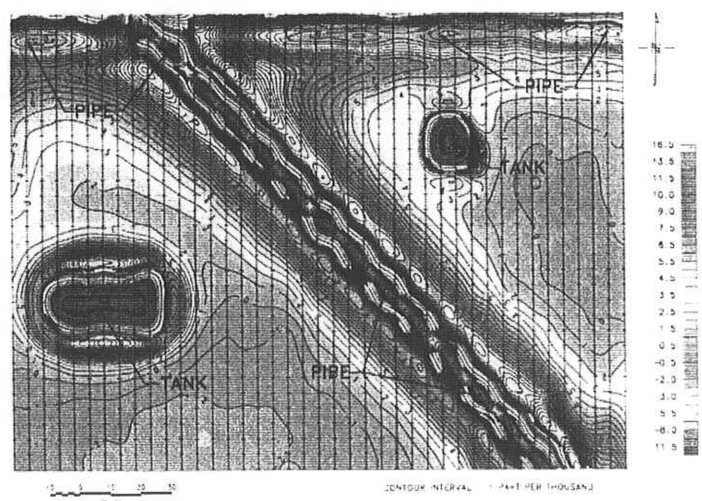
EM induction surveys are often conducted using the Geonics EM-31 terrain conductivity meter (EM-31). The EM-31 consists of a transmitter coil mounted at one end and a receiver coil mounted at the other end of a 3.7-meter long plastic boom. Electrical conductivity and in-phase component field strength are measured and stored along with line and station numbers in a digital data logger. In-phase component measurements generally only respond to buried metallic objects; whereas conductivity measurements also respond to conductivity variations caused by changes in soil type, moisture or salinity and the presence of nonmetallic bulk wastes. The EM-31 must pass over or immediately adjacent to a buried metallic object to detect it. Typical EM-31 anomalies over small, buried metallic objects consist of a negative response centered over the object and a lower amplitude positive response to the sides of the object. When the instrument boom is oriented parallel to long, linear conductors such as pipelines a strong positive response is observed. The EM-31 can explore to depths of about 6 meters, but is most sensitive to materials about 1 meter below ground surface. Single buried drums can typically be detected to depths of about 5 feet.



Geonics EM-31 Terrain Conductivity Meter

EM-31 surveys are typically conducted to:

- Locate buried tanks and pipes
- Locate pits and trenches containing metallic and/or nonmetallic debris
- Delineate landfill boundaries
- Delineate oil production sumps and mud pits
- Map conductive soil and groundwater contamination
- Map soil salinity in agricultural areas
- Characterize shallow subsurface hydrogeology
  - Map buried channel deposits
  - Locate sand and gravel deposits
  - Locate conductive fault and fracture zones



Geonics EM-31 Survey to Locate Underground Storage Tanks

EM Utility Location Methods

EM utility locators; such as the Metrotech 810, Metrotech 9890 and Radiodetection RD400, are designed to accurately trace metallic pipes and utility cables and clear drilling/excavation locations. These utility locators consist of a separate transmitter and a receiver. The transmitter emits a radio frequency EM field that induces secondary fields in nearby metallic pipes and cables. The receiver detects these fields and is used to accurately locate and trace the pipes, often to distances over 200 feet from the transmitter. Many of the utility locators have a passive 60Hz mode to locate live electrical lines. Modern utility locators are also capable of providing rough depth estimates of the pipes.

⇦ ***Metrotech EM Utility Locator***

TDEM Metal Detection Methods

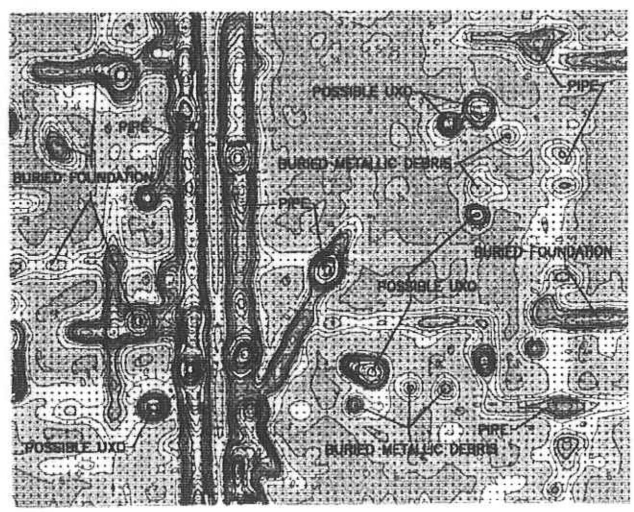
A Geonics EM-61 (EM-61) is a high sensitivity, time-domain, digital metal detector which is often used to detect both ferrous and non-ferrous metallic objects. It is designed specifically to locate buried metallic objects such as drums, tanks, pipes, UXO, and metallic debris and to be relatively insensitive to above ground structures such as fences, buildings, and vehicles.

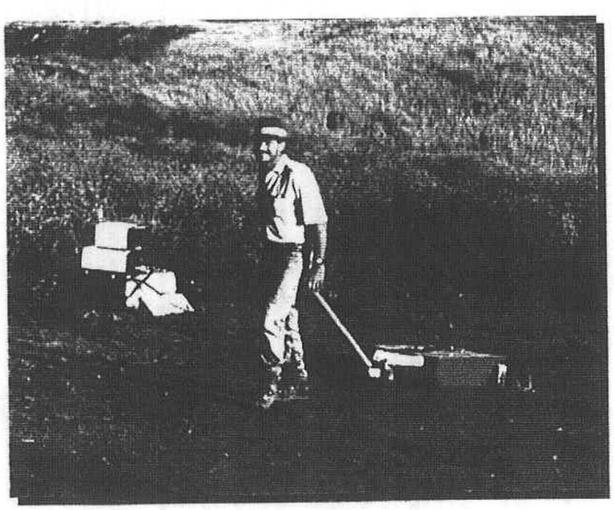
Geonics EM-61 Digital Metal Detector

The EM-61 consists of two square, 1-meter coils, one mounted over the other and arranged on a hand-towed cart. The bottom coil acts as both a transmitter and receiver while the top coil is a receiver only. While transmitting the bottom coil generates a pulsed primary magnetic field, which induces eddy currents into nearby metallic objects. When the transmitter is in its off cycle both coils measure the decay of these eddy currents in millivolts (mV) with the results being stored in a digital data logger along with position information. The decay of the eddy currents is proportional to the size and depth of the metallic target. A symmetrical positive anomaly is recorded over metallic objects with the peak centered over the object. The signal from the top coil is amplified in such a way that both coils record effectively the same response for a metallic object on the surface and the top coil records a larger response for buried metallic objects. The response of near surface objects can, therefore, be suppressed by subtracting the lower coil response from the upper coil response (differential response).

In practice, the usable depth of investigation of the EM-61 depends on the size and shape of the object and the amount of above ground interference encountered at the site. A single buried drum can often be detected at a depth of about 10 feet.

Geonics EM-61 Survey to Map Subsurface Infrastructure and Potential UXO





GSSI SIR-10A GPR Unit

GPR Methods

Ground-penetrating radar (GPR) is a high-frequency electro-magnetic method commonly applied to a number of engineering and environmental problems.

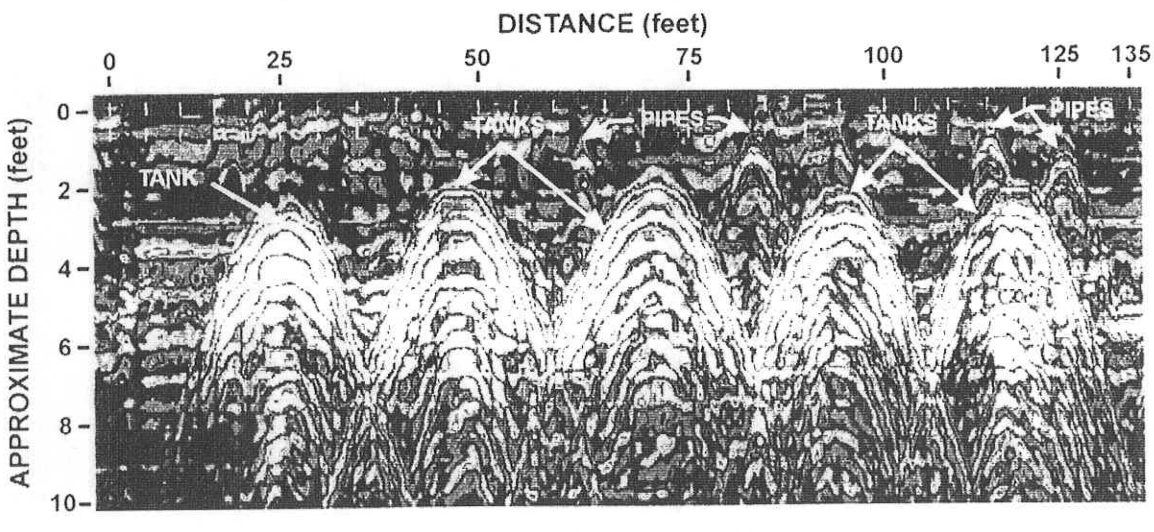
A GPR system radiates short pulses of high-frequency EM energy into the ground from a transmitting antenna. This EM wave propagates into the ground at a velocity that is primarily a function of the relative dielectric permittivity of subsurface materials. When this wave encounters the interface of two materials having different dielectric properties, a portion of the energy is reflected back to the surface, where it is detected by a receiver antenna and transmitted to a control unit for processing and display.

Depth penetration is a function of antenna frequency and the electrical conductivity of the soils in the survey area. Lower frequency antennas achieve greater depth penetration than higher frequency antennas, but have poorer spatial resolution. Conductive soils, such as clays, attenuate the radar waves much more rapidly than resistive dry sand and rock. In many environments in California, depth penetration of 500 and 300 MHz antennas is limited to 3 to 5 feet. Depth penetration may be greater if shallow soils consist of clean sands and less if shallow soils consist of clay.

GPR surveys are typically conducted to:

- Locate and delineate underground storage tanks (metallic and non-metallic)
- Locate metallic and nonmetallic pipes and utility cables
- Map rebar in concrete structures
- Map landfill boundaries
- Delineate pits and trenches containing metallic and nonmetallic debris
- Delineate leach fields and industrial cribs
- Delineate previously excavated and backfilled areas
- Map shallow groundwater tables
- Map shallow soil stratigraphy
- Map shallow bedrock topography
- Map shallow subsurface voids and cavities
- Characterize archaeological sites

Geophysical Survey Systems Inc. (GSSI) SIR-2 or SIR-10 GPR systems with antennas in the frequency range of 50 to 1,000 MHz are often used during GPR investigations. Mala Geoscience and Sensors and Software, Ltd also manufacture GPR systems. GPR data is processed using a variety of software including the RADAN™ or GRADIX software packages by GSSI and Interpex Ltd., respectively.



GPR Survey to Locate Underground Storage Tanks