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TECHNICAL MEMORANDUM GEOPHYSICAL INVESTIGATION OF BURIED DRUM AREA SITE 10 NAS PENSACOLA FL

9/14/1994

ENSAFE

TECHNICAL MEMORANDUM

Geophysical Investigation of Buried Drum Area Site 10 (West), Naval Air Station Pensacola

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Prepared by:

EnSafe/Allen & Hoshall
5720 Summer Trees Drive, Suite 8
Memphis, TN 38134
(901) 372-9115

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SUMMARY

Responding to the discovery of several buried drums at the southwest corner of Murray and Taylor roads, west of Site 10 at Naval Air Station Pensacola, EnSafe/Allen & Hoshall conducted a gradient magnetics geophysical survey to define the extent of drum burial. The survey identified a 100-foot-by-120-foot zone where drums might be present. Excavating this zone is recommended. A large part of the study area appears to be clear of drums, suggesting that this may not be an extensive site of systematic disposal, but more likely is limited in size and the number of drums disposed of.

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1.0 INTRODUCTION

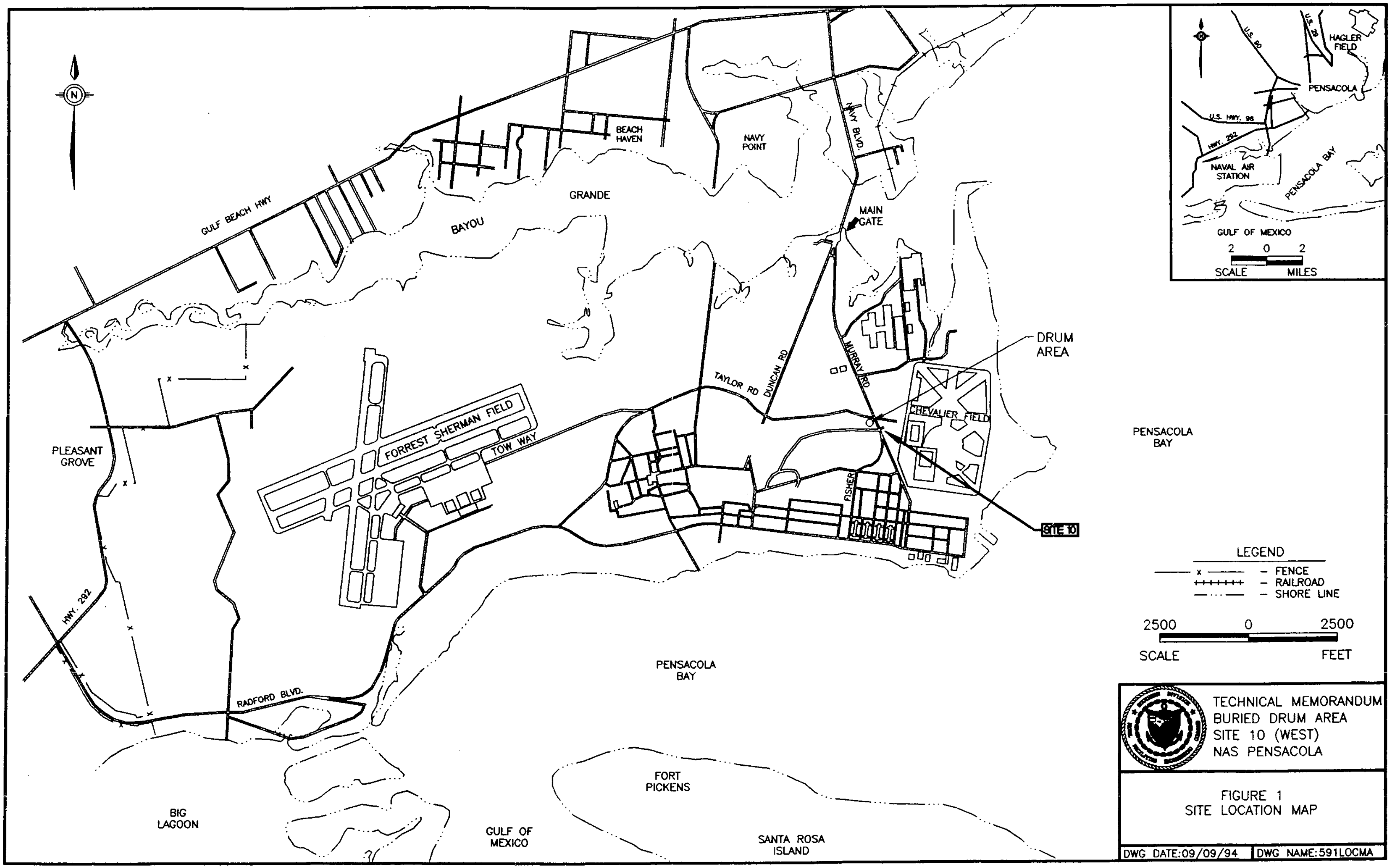
As a part of the Comprehensive Long-Term Environmental Action Navy (CLEAN) contract with the United States Navy, EnSafe/Allen & Hoshall conducted a geophysical survey in March 1994 to investigate an area where several buried drums were discovered at Naval Air Station (NAS) Pensacola in Pensacola, Florida. The survey area lies west of Site 10, on the southwest corner of Murray and Taylor roads (see Figure 1). This Technical Memorandum describes the investigation of this area and recommends followup action.

2.0 SITE HISTORY

In December 1992, a child playing with a metal detector discovered a drum exposed at the surface just east of the tennis court. As a result of the discovery, the area was fenced to prevent access until the present investigation could be made.

Geophysics was applied to this site because it is non-invasive and can provide a comprehensive overview of potential buried drum locations relatively quickly and inexpensively. The objectives of the investigation were to:

- Determine the areal extent of the disposal area.
- Determine if this is a larger drum disposal area or if only a few drums are present.



TECHNICAL MEMORANDUM
BURIED DRUM AREA
SITE 10 (WEST)
NAS PENSACOLA

FIGURE 1
SITE LOCATION MAP

3.0 METHODS

Magnetic Field Measurements

The study was done with a gradient magnetics geophysical survey, which responds exclusively to ferrous metals. This type of survey measures two magnetic parameters: the total magnetic field and the vertical magnetic gradient.

The *total magnetic field* has units of nanoTeslas (nT). By far the largest contribution to this measurement is the earth's magnetic field, which is roughly 50,000 to 52,000 nT in the southeast United States. Superposed on this large signal is a much smaller signal from local buried and above-ground metals. A buried object such as a drum can be thought of as a large, weak magnet with a positive pole at one end and a negative pole at the other. Depending upon the orientation of the drum and the position of the magnetometer at the surface, the drum magnetic field may add to or subtract from the earth's magnetic field value. By making sufficient measurements from the surface, the overall pattern of positive and negative anomalies can be mapped and the drum position and depth can be estimated.

The response of a buried drum varies greatly with the degree of remanent magnetism imparted by manufacture, the integrity of the drum, and its orientation and depth. Field experience shows that drums near the surface exhibit anomalies in the 20 to 200 nT range. Modern magnetometers can detect a single drum at up to 5 meters deep in the absence of noise.

An interfering factor in magnetic field measurements is "drift" caused by variations in solar activity. During solar storms, and particularly during peaks in the 11-year solar activity cycle, particles are ejected in a plasma from the sun's atmosphere and are blown outward by the solar wind. Some of these particles are trapped in the earth's magnetic field and flow down the earth's field lines into the atmosphere. This causes a current to flow, and hence a secondary magnetic field that varies with time. Solar pulsations can range from a few seconds to years in duration, and magnitudes during a single day can exceed 500 nT, although 10 to 100 nT is more normal during "quiet" solar periods (as is the case for this year). In studies where the total magnetic field is the chief parameter to be interpreted, considerable effort is needed to correct for magnetic drift.

Another interfering factor is instrument noise. Most instruments can detect field changes as small as 0.1 nT, but slight variations in positioning of the sensor and other factors make the practical field noise threshold significantly larger. A good rule-of-thumb is that the smallest detectable field is about ± 1 nT.

The *vertical magnetic gradient* has units of nanoTeslas per meter (nT/m). Two magnetometer sensors are mounted at a fixed separation on a vertical pole. Each sensor measures the total magnetic field. The gradient is the difference in the two sensor readings, normalized to a 1-meter (m) separation. Gradient measurements have several strong advantages. First, since each of the two sensors responds equally to solar pulsations, these effects are removed from the gradient parameter. Similarly, strong magnetic effects from distant buildings and other magnetic features also are minimized in gradient data. However, for localized sources such as a drum, the lower sensor sees a stronger signal than the upper sensor, resulting in a gradient anomaly. In effect, gradient data separate local anomalies from regional anomalies. Most environmental applications are thus well served by making gradient measurements.

In a completely magnetic-free environment, the gradient is zero. Buried drums have responses of 10 to 200 nT/m, and the sign can be positive or negative, depending upon the drum's orientation and magnetic polarity. Practical field repeatability is about ± 1 nT/m.

Noise Sources

It is a rare project where the only metallic objects are buried drums. Nearly every site has other metallic debris, which is considered "noise" in terms of drum recognition. Chief among these is "culture," or man-made features such as buried pipes, cables, electric lines, fences, culverts, light poles, reinforced concrete, etc. Culture is widespread at most environmental sites and can render magnetic measurements useless in certain cases.

In addition, there is the problem of surface clutter. Usually if drums are buried at a site, one also finds other metallic debris. Smaller items often can be distinguished from drum-sized objects, but in cases of extreme clutter this is difficult.

Technical Approach

The total magnetic field and the vertical gradient were measured with a GEM Systems GSM-19 proton-precession gradiometer with an Overhauser device. Data were obtained on a 10-foot-by-10-foot grid, which was tied to official NAS Pensacola easting/northing coordinates using the Navy CLEAN global positioning satellite (GPS) system. Two sensors were mounted on a vertical pole at a fixed separation of 56 centimeters (cm); the lower sensor was 2.2 m above ground surface. Measurements took only a few seconds, including the time required to walk to the next station. The data were stored automatically in a data recorder and were displayed on the instrument for evaluation of data quality and identification of anomalies. Data were transferred to a personal computer for processing and screen display.

In all, 1,575 measurements were made. An additional quantity of quality assurance (QA) and quality control (QC) measurements also was obtained.

QA/QC Results

Data accuracy is not directly checked in geophysical work because data precision is of far greater importance to detecting and interpreting field anomalies. Data accuracy is assured by proper factory construction and calibration of the instrument.

Data precision was checked 11 times throughout the two-day survey by repeating data at 11 stations along a baseline (Line 3300E, stations 3500 to 3600). The average standard deviation for all the repeated gradient data was ±0.59 nT/m. The baseline crossed an "anomalous" and a "background" area; precision over the anomaly was slightly poorer than in the background area (±0.75 nT/m vs. ±0.50 nT/m, respectively), because slight positioning variations result in large data changes near an anomaly. The worst standard deviation at any single station was ±1.13 nT/m. Hence, one can consider the worst-case repeatability to be about ±1 nT/m. This is far smaller than the expected response from a single drum.

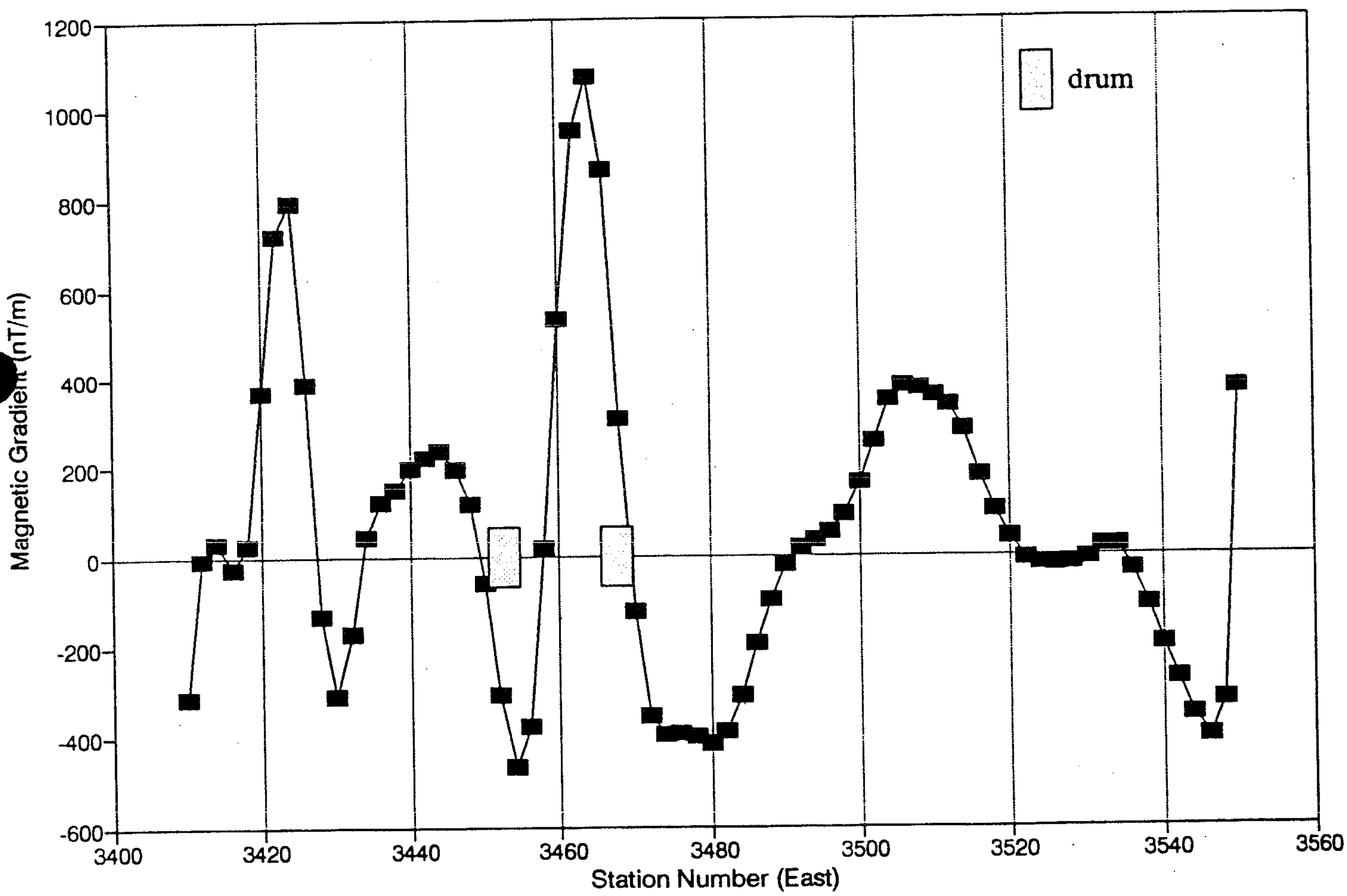
Magnetic drift due to solar activity also was monitored in the baseline data. Drift is a minor issue since it does not affect the gradient parameter, which is used for the present interpretation. For the record, drift in the total magnetic field parameter at station 3300E/3500N was small and fairly slow. The total field there averaged 50,097.0±12.6 nT over the course of the survey. Although there is no reason to do so now, the repeated data provide sufficient information to correct the total field measurements for drift.

Spatial aliasing is a more important consideration. Aliasing occurs whenever sampling is done at a cruder interval than the variations being measured. The result is a hit-and-miss pattern of anomalies, with some resolved and others unresolved, depending upon the coincidental locations of sampling points. A familiar example of this in environmental work is soil sampling, during which one rarely has the luxury of having enough sample points to resolve all contaminant variations in an area (instead, a quasi-statistical sampling approach is often used to show the extent of contamination and, in some cases, to statistically sample the contaminant population).

An aliasing check was made by obtaining data at 2-foot increments along line 3588E inside the fenced drum area. This test line crossed two partially buried drums. Figure 2 shows the magnetic gradient data along the aliasing test line. The 2-foot station density defines a number of smoothly varying anomalies. The width of the smallest anomaly is about 6 feet, although most are wider than 10 feet. Thus, with a sampling density of 10 feet, one would encounter a moderate aliasing effect. However, the objective of this work is to define the areal extent of drum burial; it is not necessarily helpful or cost-effective to achieve full definition of every small anomaly (indeed, "noise" from surficial metal debris and underground pipes prevent such detailed definition in many areas). In light of the overall objective, then, aliasing has little practical impact on the final results.

Figure 2 also shows a *typical drum response*, with positive-to-negative "crossovers" in the gradient data over the two known drums. This response is quite typical of data obtained over buried metals on north-facing lines. Anomaly amplitudes are as small as 200 nT/m and as large as 1,000 nT/m. These rather large anomalies may be enhanced by underground pipes or metal debris at the surface. But the test line serves as a template for recognizing other potential drum anomalies.

Figure 2
Aliasing Test, Line 3588E



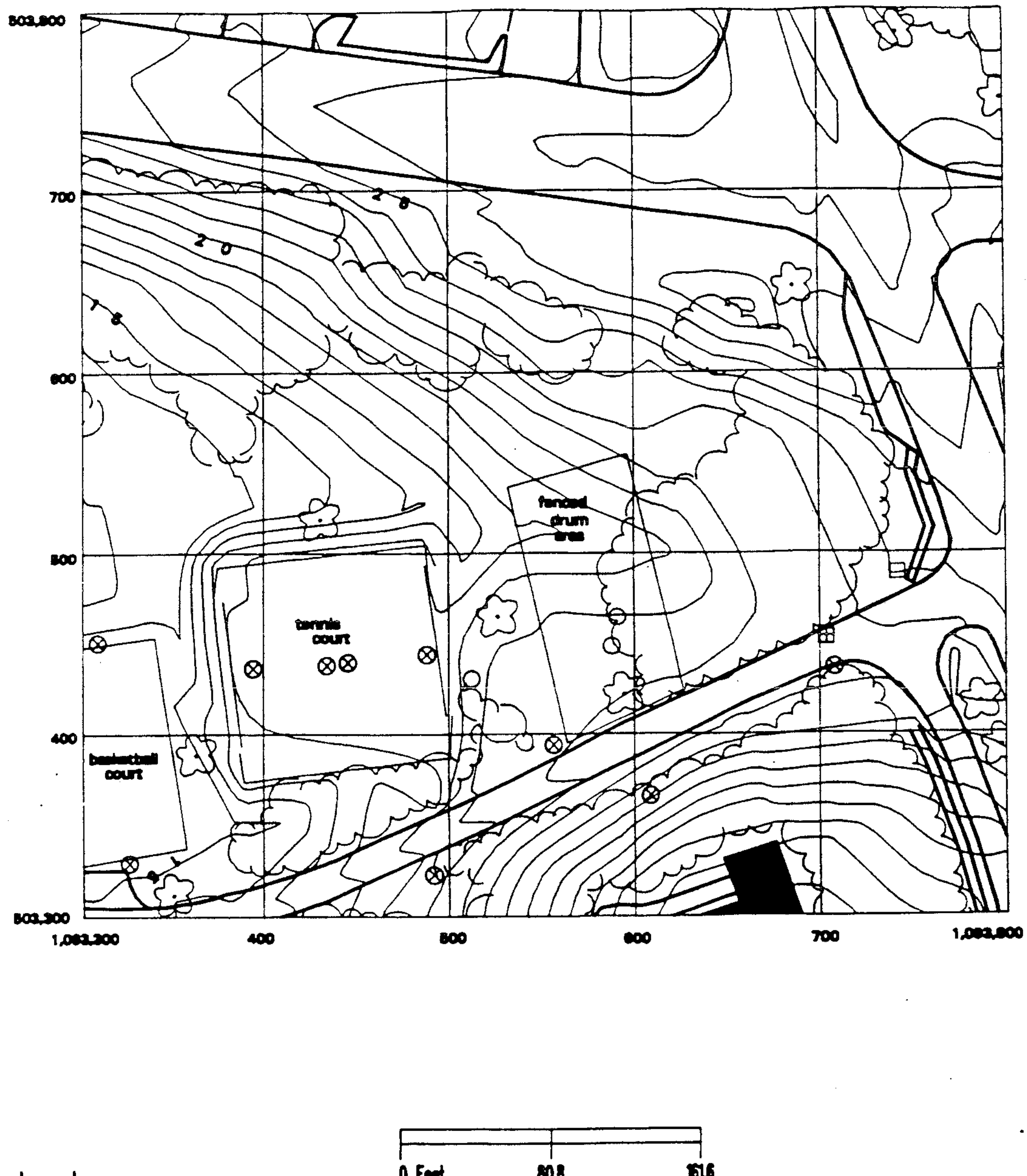
4.0 SUMMARY OF FINDINGS

The survey included a visual site inspection. The survey area is mostly planted with grass and contains a tennis court, an unfenced basketball court, and access roads to the officers' quarters. Two partially buried drums were observed inside the fenced area (see Figure 3 for locations). One of these drums is in a vertical position; its end is punctured, revealing standing water inside it. The second drum also may be vertical. A third iron object resembling a drum rim was observed between the fenced area and the tennis court. The terrain near these three objects is slightly hummocky. Smaller, rusted metal debris was observed at the surface, suggesting this was a minor disposal area. No odors, visible staining, or other indications of a contaminant release were observed here.

Figure 4 shows the total magnetic field, with no drift correction applied. Since the magnetic gradient parameter is the most definitive data set, comments are confined to those data. Trends in the two data sets are similar.

Figure 5 shows the vertical gradient of the magnetic field. A clear overlay is provided to reference key topographic features and metal objects that may affect the data. Small gradient values are in yellow-green, yellow, and yellow-orange; these can be regarded as "background" responses. Warmer colors (orange to purple) indicate significant positive gradients (i.e., above background); cooler colors (green to dark blue) indicate significant negative gradients (below background). Both positive and negative gradients are regarded as potential indicators of buried metals.

The strongest magnetic responses are from culture. Dominant among these are the very strong anomalies around the fences. Several linear features are underground utility lines. The linear feature extending off to the northwest portion of the area is most likely a buried phone cable. Its clumpy "string-of-pearls" appearance is an artifact of spatial aliasing, in which some data points happened to lie right over an anomaly crest, while others were on an upward or



Legend

- Metallic Grate
- Metallic Box
- Metallic Pole
- Suspected or Known Drum

Technical Memorandum
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Figure 03
Geophysics Survey
Buried Drum Area, Site 10 (west)

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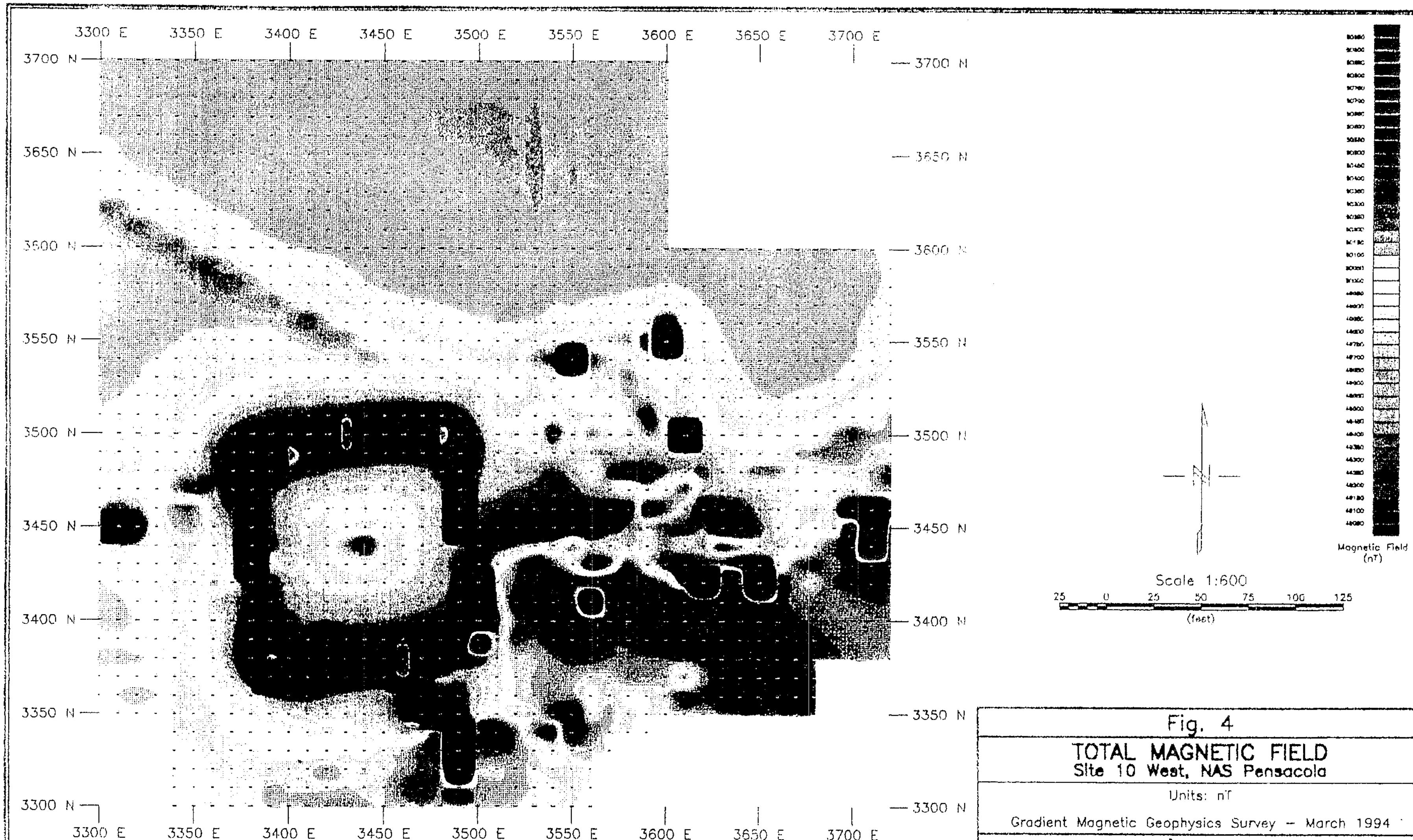

Fig. 4

TOTAL MAGNETIC FIELD
Site 10 West, NAS Pensacola

Units: nT

Gradient Magnetic Geophysics Survey – March 1994

EnSafe/Allen & Hoshall

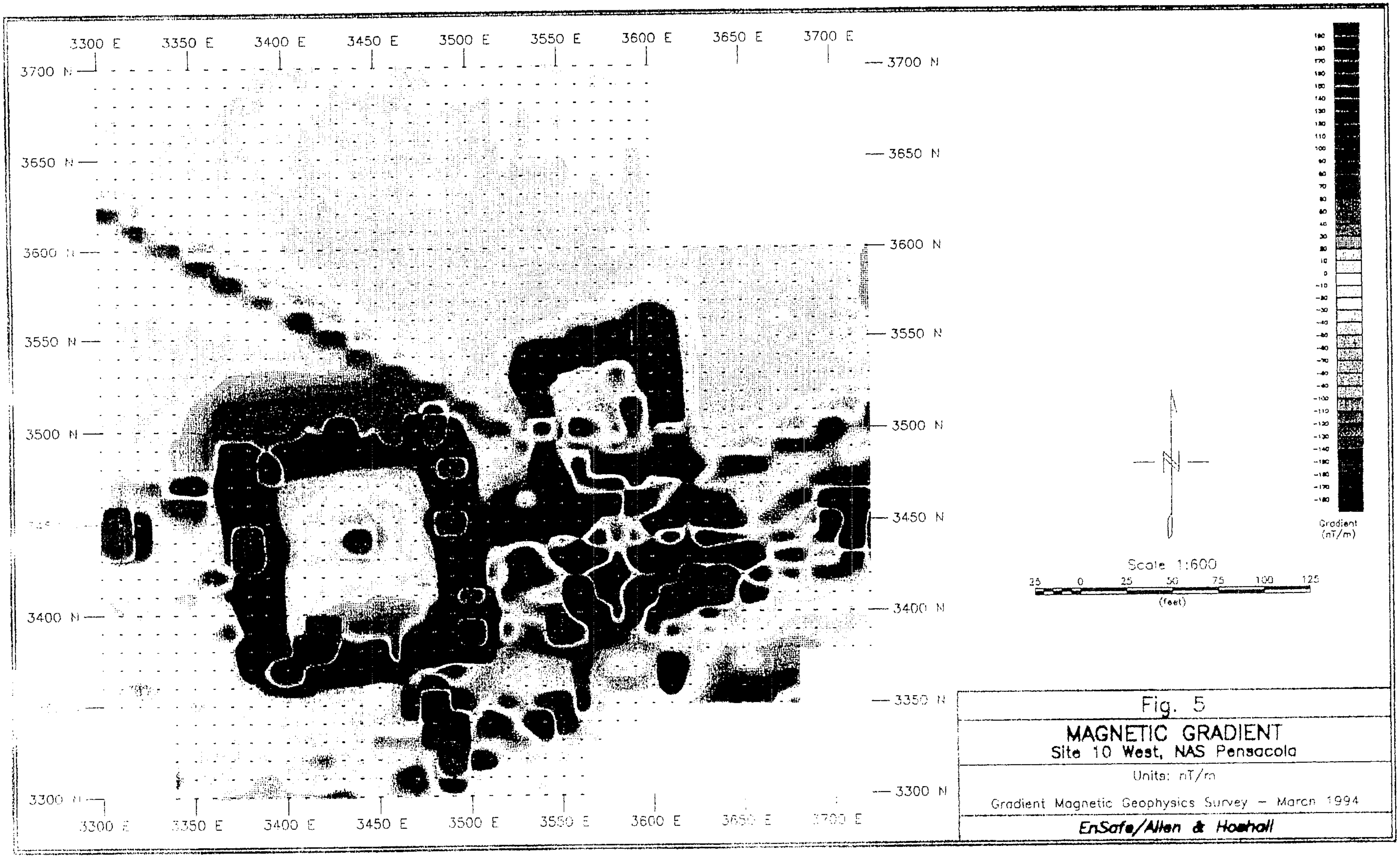

Fig. 5
MAGNETIC GRADIENT
Site 10 West, NAS Pensacola
Units: nT/m
Gradient Magnetic Geophysics Survey – March 1994
EnSafe/Allen & Hoshall

downward slope of the anomaly. A number of strong local anomalies lie along the access road to the south, which has subsurface cables, electric lines, and storm and sewer utilities. Finally, many metal poles, light fixtures, and storm grates produce strong anomalies.

Superposed on these anomalies attributed to culture are subtler anomalies, some of which are believed to be the result of buried metals. Figure 6 shows the interpretation of anomalies not likely to be caused by culture. It is possible that other anomalies have gone unrecognized near heavy culture, especially in the area's southern portion.

Anomalies 1 to 5 lie east of the basketball court; all but Anomaly 1 are strong and well-defined, and a near-surface source is indicated for all of them. Anomaly 4 should be investigated with a shovel or hand tool (see safety note in conclusions section).

Anomalies 6 to 10 are small-amplitude features in a broad area otherwise interpreted to be free of metal drums. These anomalies are smaller than a typical drum anomaly and are likely to be caused by a small piece of shallowly buried metal. However, one of these features should be excavated to confirm this interpretation (Anomaly 10 is the best candidate due to its proximity to the drum enclosure area).

Anomalies 11 to 25 have the amplitude and appearance consistent with buried drums, although it is quite possible that some are caused by other metal debris. Based on the data alone, there is no reason to consider any of these anomalies more likely to be caused by a drum than others. Instead, all of these features are worthy of investigation.

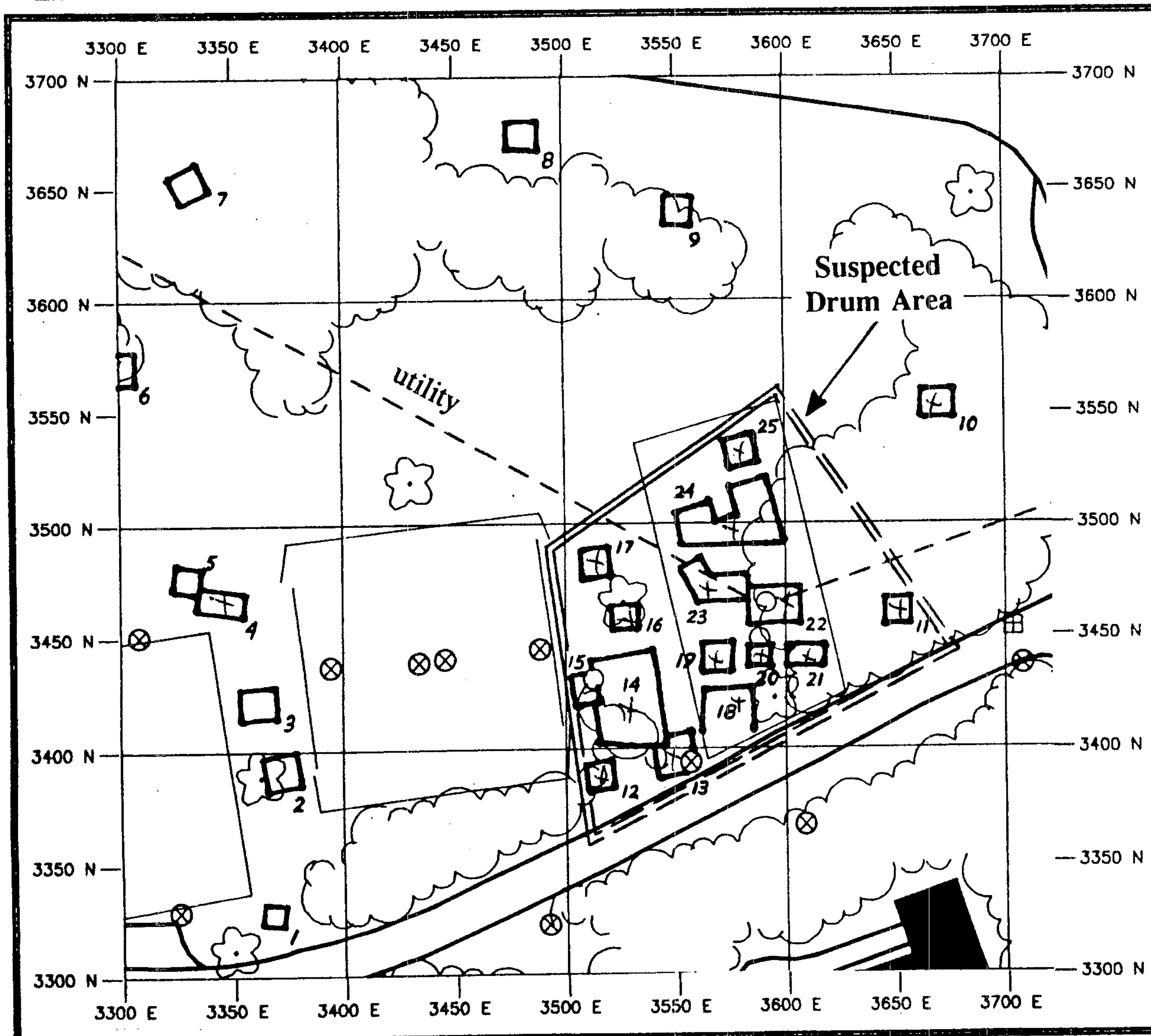

Fig. 6
INTERPRETATION
Site 10 West, NAS Pensacola
Gradient Magnetic Geophysics Survey – March 1994
EnSafe/Allen & Hoshall

Due to the presence of metal debris at the surface and the fusion of some anomalies, it is not possible to estimate the number of drums present. In most cases the causative metal object, whether drum or some other metal object, appears to be fairly shallow. Typical estimated depths are 5 feet or shallower.

Figure 6 shows the interpreted boundary enclosing possible drum anomalies. The east and south sides of this boundary are particularly uncertain due to interference from underground pipes. This area, which measures roughly 100 by 120 feet, is recommended for excavation to 5 feet to search for buried drums. Full excavation or a few well-placed trenches both should suffice to sample this area. Note that the area extends outside the fence.

5.0 CONCLUSIONS

A large section of land on the north half of the surveyed area is interpreted to be free of drums, with the unlikely possibility of drums at anomalies 6 to 10. Although cultural clutter precludes a definitive interpretation, anomalies of the type one might expect of drums are mostly confined to an area about 100 by 120 feet in size. Taken as a whole, the survey suggests this area is not one of systematic and widespread drum disposal, but is limited in areal dimensions and in the number of disposed drums.

The area of possible drums, defined in Figure 6, should be explored by trenching. If drums are found on the south or east parts of the fenced area, the excavation should be extended past the area shown. Caution should be exercised, as the geophysics indicates underground utilities are present in the areas to be dug up.

Although less likely to be drums, anomalies 4 and 10 also should be investigated with shovel or hand tools to confirm a non-drum source. In the unlikely event that a drum is found at one of these anomalies, the data will need to be re-evaluated to identify subtler anomalies that might require investigation.

The fenced drum area gate has no lock on it. Installing one for safety and site security is recommended.