# APPENDIX J

Geophysical Surveys

## J1.0 INTRODUCTION

Three non-invasive geophysical techniques were employed in geophysical surveys at Tooele Army Depot, South Area (TEAD-S), ground penetrating radar (GPR), electromagnetic induction (EMI), and magnetics. The geophysical surveys were conducted to detect buried material and aid in borehole and trench placement.

Geophysical investigations at solid waste management unit (SWMU) 30 consisted of EMI and magnetic surveys, and were conducted to map the locations of three waste disposal trenches observed in aerial photographs of the site. The survey was conducted over an approximately 10-acre area.

An EMI geophysical survey was conducted at SWMU 9 to map the location of four or five possible waste disposal trenches observed in aerial photographs of the unit. The survey was conducted over an approximately 15-acre area.

Additionally, GPR was used at SWMU 5 to delineate the areal extent of underground storage tanks (USTs) prior to drilling soil borings adjacent to the tanks.

## J2.0 GEOPHYSICAL METHODOLOGY

### J2.1 MAGNETIC SURVEYS

Magnetic surveys measure the magnitude of the naturally occurring magnetic field of the earth and can detect ferromagnetic metals (metals that can be magnetized). Local anomalies can be interpreted as evidence of concentrations of ferromagnetic material such as iron or steel wastes or containers.

Magnetic data was collected using a GEM Systems GSM 19 gradiometer configured to measure the total magnetic field (TMF) in nanoteslas (nT) and the vertical gradient of the total magnetic field (VMG) in nT per meter (nT/m). A gradiometer measures TMF intensity at each station with the lower sensor on the sensor staff, and again with the upper sensor. The difference between the two readings divided by the sensor separation is the VMG, usually defined in nT/m. VMG measurements may help to resolve composite or complex magnetic anomalies into their individual constituents and they automatically remove the regional magnetic gradient as well as more rapid variations caused by solar flares, magnetic storms, and solar wind. Magnetic data thus generated can be analyzed to provide information on the location of buried ferrous metal.

When the TMF data are used for site analysis, it is necessary to account for diurnal effects (i.e., the daily changes that occur in the earth's magnetic field) which distort the external magnetic field. To account for diurnal effects, a base station is established at an arbitrary position where magnetic readings can be collected periodically throughout the duration of the magnetic survey. Base station data may be collected using a dedicated base station magnetometer, or by returning to the base periodically with the field magnetometer and measuring and recording the TMF at the base. For the TEAD-S geophysical surveys, a GSM 19 magnetometer was used to collect base station data. The diurnal variation that is recorded at the base station is removed from the field data using a time-weighted interpolative process. Once the diurnal effect has been removed from the TMF data, magnetic anomalies at the site can be correctly resolved and interpreted.

## J2.2 ELECTROMAGNETIC INDUCTION (INDUCED GROUND CONDUCTIVITY)

Conductivity contrasts in the earth can be caused by natural phenomena (e.g. lithologic changes), manmade phenomena (e.g. disturbed ground), contaminants in the soil and groundwater, or ferrous and nonferrous metals. EMI surveys are conducted to detect these contrasts.

A geonics Limited Model EM31-DL terrain conductivity meter was used to collect the EMI data. The EMI technique entails transmitting a primary electromagnetic signal that is inductively coupled to the earth. Secondary signals are generated in the subsurface, and both the primary and secondary signals are detected by the EMI receiver. The ratio of the secondary signal to the primary signal is directly related to terrain conductivity under certain constraints. Two components of the resultant EMI field are measured: terrain conductivity as millimhos per meter (mmhos/m) and the in-phase component, which is expressed in parts per thousand (ppt) of the primary signal (a measure of signal strength). Terrain conductivity data may be used to locate trench boundaries by sensing the conductivity contrast between the disturbed and undisturbed soil.

The in-phase mode of the EM31-Dl is particularly sensitive to ferrous and nonferrous metal objects.

The EMI data were electronically recorded with a digital datalogger attached to the EMI instrument. The EMI processing sequence consisted of transferring the data from the digital data logger into the Geonics Limited DATA 31 computer software program. The program converted the raw EMI field data measured in millivolts (mv) into corresponding values that more readily characterize the conductive properties of the subsurface. The quadrature phase data were converted to ground conductivity values in mmhos/m. The in-phase data are reported in units of ppt.

If a significant variation was noted in the calibration data collected prior to and at the end of each survey, data processing included a correction to remove this effect. The correction is similar to the process used to remove diurnal variations from magnetic data and consists of using a time-weighted interpolative process.

## J2.3 GROUND-PENETRATING RADAR

The GPR technique is based on transmitting short wavelength (high-frequency) electromagnetic waves into the earth and recording the energy scattered back by reflecting objects. In operation, the GPR repetitively transmits short duration (5 to 10 nanosecond) pulses of high frequency electromagnetic energy (80 to 1000 megahertz) through an antenna that is moved along the ground surface at a constant speed. GPR signals are reflected from any interface that corresponds to an abrupt change in dielectric properties across the interface. Therefore, both metallic and nonmetallic objects can be detected by this method. A continuous GPR profile is made that is analogous to a geologic cross-section.

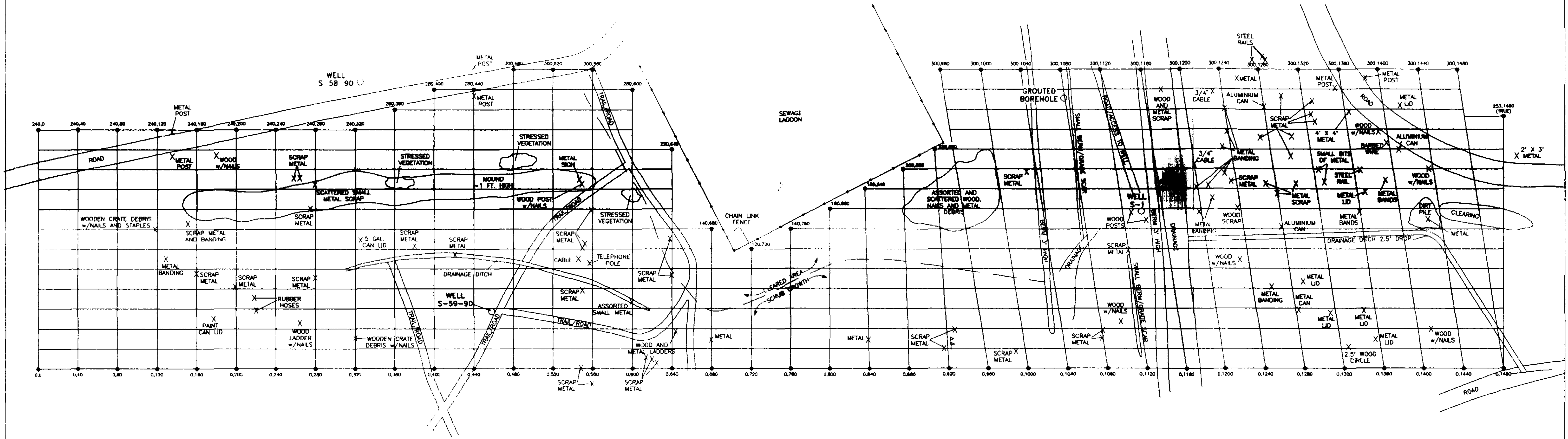
The depth of investigation of GPR instrumentation is dependent upon the frequency of the antenna used and the conductivity of subsurface materials. In general, a low-frequency antenna will provide a greater depth of penetration but have lower resolution than a high-frequency antenna.

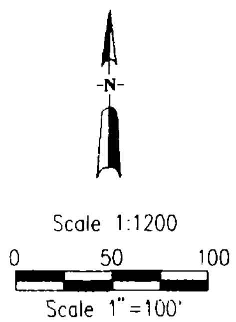
## J3.0 SWMU 30 GEOPHYSICS

The area chosen for geophysical surveys at SWMU 30 consists of a series of three covered burn trenches in use from the mid 1950s to the early 1970s for wood burning and dunnage disposal. The burn trenches are visible on aerial photographs taken in 1959 and 1966, however, they are not discernable on more modern aerial photographs. Further, although there is a small mound south of groundwater monitor well S-58-90, the locations of the burn trenches are not obvious based on surface features. An area at SWMU 30 was selected for the geophysical survey by locating road intersections, drainage ditches, and other landmarks observed on aerial photographs. A grid measuring 1,400 feet in the east-west direction and 300 feet in the north-south direction was flagged at 40-foot intervals in the east-west direction and 20- foot intervals in the north-south direction. The grid as laid out encompassed the southern portion of a sewage lagoon that had been constructed as part of the CAMDS facility. No data were acquired within the fence surrounding the sewage lagoon.

Profile lines were oriented perpendicular to the predominant orientation of the trenches as observed on the aerial photographs. EMI and magnetic data were obtained along north-south profile lines spaced in 20-foot intervals (one line on the flagged stations and one line between the flags). Magnetic data were collected at a station spacing of 20 feet along each line. EMI data were collected continuously at 0.6 second intervals as each line was traversed at a constant speed. The 0.6 second interval equates to a data point every 2 to 2.5 feet along each line. These data were recorded by a digital electronic data logger.

Concurrent with the geophysical survey, a surface features map was developed to document the location of surface scrap metal, groundwater monitor wells, roads, topography, vegetation, and other items observed at the site. The surface features map (Figure J3.0-1) shows that there is an abundance of metal debris and surface disturbances at this site. The surface features information was used at the data-interpretation stage to determine which geophysical anomalies were caused by surface debris. Figure J3.0-1 is presented at the same scale as the geophysical data so that a direct correlation between maps can be made.



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Aberdeen, Maryland

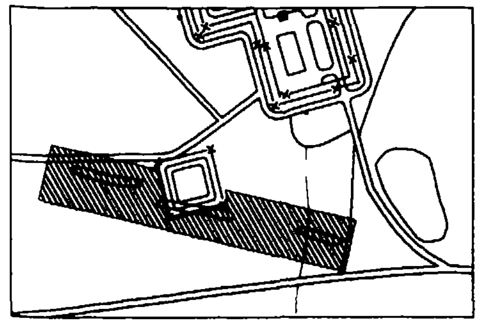
Figure J3.0-1

Surface Features Map at SWMU 30

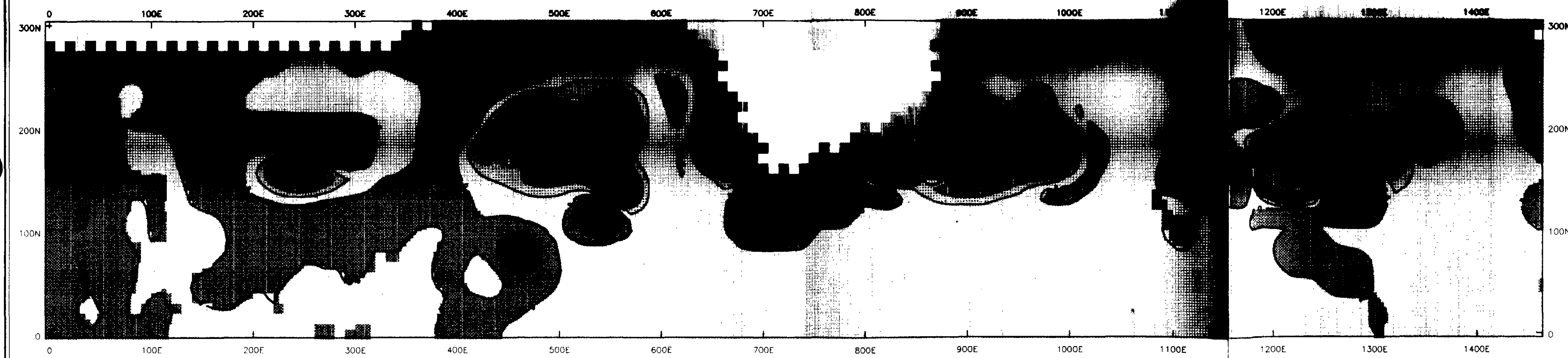
Prepared by:
Ebasco Services Incorporated

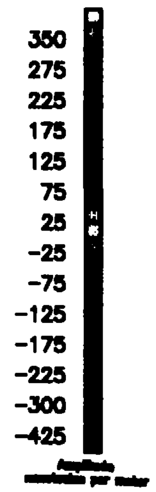
The magnetic data are displayed in Figures J3.0-2 and J3.0-3. Figure J3.0-2 is a contour map of the VMG data while Figure J3.0-3 is a contour map of the TMF data. Both maps display similar features. Magnetic high values (red-toned colors) and magnetic low values (blue-toned colors) indicate magnetic anomalies on both maps. The anomalous areas around the sewage lagoon located approximately at stations 600E to 900E on lines 150N to 300N are probably caused by a chain link fence surrounding the sewage lagoon and therefore may not indicate the presence of buried material. The large anomaly just east of the sewage lagoon, approximately located on lines 105N to 200N at stations 850E to 975E, may be caused by an abundance of metal debris as the surface, however, the character of this anomaly suggests that it may correspond to buried material. The small anomaly located approximately on line 75N at station 450E is caused by the metal surface casing of groundwater monitor well S-59-90. The small anomaly located approximately on line 250N at station 125E corresponds to metal posts at the ground surface. Three large anomalies that are probably caused by buried material within the burn pits are located within the grid on lines 125N to 200N at stations 200E to 350E, lines 100N to 250N at stations 375E to 575E, and lines 100N to 225N at stations 1100E to 1350E.

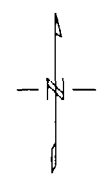
EMI data are displayed on Figures J3.0-4 and J3.0-5. Figure J3.0-4 is a contour map of the EMI in-phase response while Figure J3.0-5 is a contour map of the EMI quadrature phase response. Although both maps show similar characteristics, the in-phase response shows the anomalies more clearly. Four anomalies on the EMI data may indicate the presence of the burn pits. The first anomaly is located approximately between stations 150N to 200N on lines 200E through 300E. The second anomaly is located approximately between stations 150N to 200N on lines 425E through 500E. Both these anomalies are located on a small mound at the surface and correspond to magnetic anomalies. It is not known if these two anomalies represent different types of buried material at two places in one long pit or if they represent two shorter pits. The third anomaly is located approximately between stations 150N to 200N on lines 875E to 950E. This anomaly is not associated with any surface features other than scattered scrap metal. Because of the character of this anomaly and because it corresponds with a marginal magnetic anomaly, this EMI anomaly may indicate the presence of a burn pit extending inside the fenced area at the sewage



Index Map of Survey Area (Hachured)



Scale 1:1200

50 0 50

(feet)

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**Figure J3.0-2**

**Vertical Gradient Magnetic Response at SWMU 30**

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lagoon. The fourth anomaly is located approximately at stations 150N to 200N on lines 1150E through 1350E. This linear anomaly is located between groundwater monitor well S-1 to the west and a mound of soil to the east. This anomaly corresponds to a large magnetic anomaly and is most likely indicative of a covered burn pit.

## J4.0 SWMU 5 GEOPHYSICS

SWMU 5 consists of concrete building foundations, an earthen drainage pond, a ditch and several peripheral structures. High explosive and chemical munitions were renovated in the main building (Building 600) at SWMU 5. Two standpipes were observed near building foundations which indicated the possible presence of underground storage tanks (USTs) at SWMU 5. One standpipe is located at the southeast corner of building 600. The other is located on the east side of Cross Street near the shower facility building foundation.

GPR was used to determine the size and orientation of the suspected USTs and to locate soil borings close to USTs without encountering them (Figure J4.0-1). No maps of the GPR data were made. The GPR profiles were evaluated and the locations picked at the time of the survey.

The UST at Building 600 was found to be oriented with its long axis parallel to the concrete building foundation. A location for a soil boring was chosen on the east side of the UST.

The GPR survey at the standpipe near the shower facility foundation revealed no indication of a UST. A location was chosen for a soil boring near the standpipe.

## J5.0 SWMU 9 GEOPHYSICS

SWMU 9 was used as a chemical munitions storage area. Although munitions were maintained and valves were changed at SWMU 9, leaking chemical agent canisters were removed to SWMU 3 for renovation. Several chemical spills have been documented within the storage area.

A 1974 aerial photograph revealed ground scars that were interpreted to be burn trenches in an area southeast of the chemical storage area.

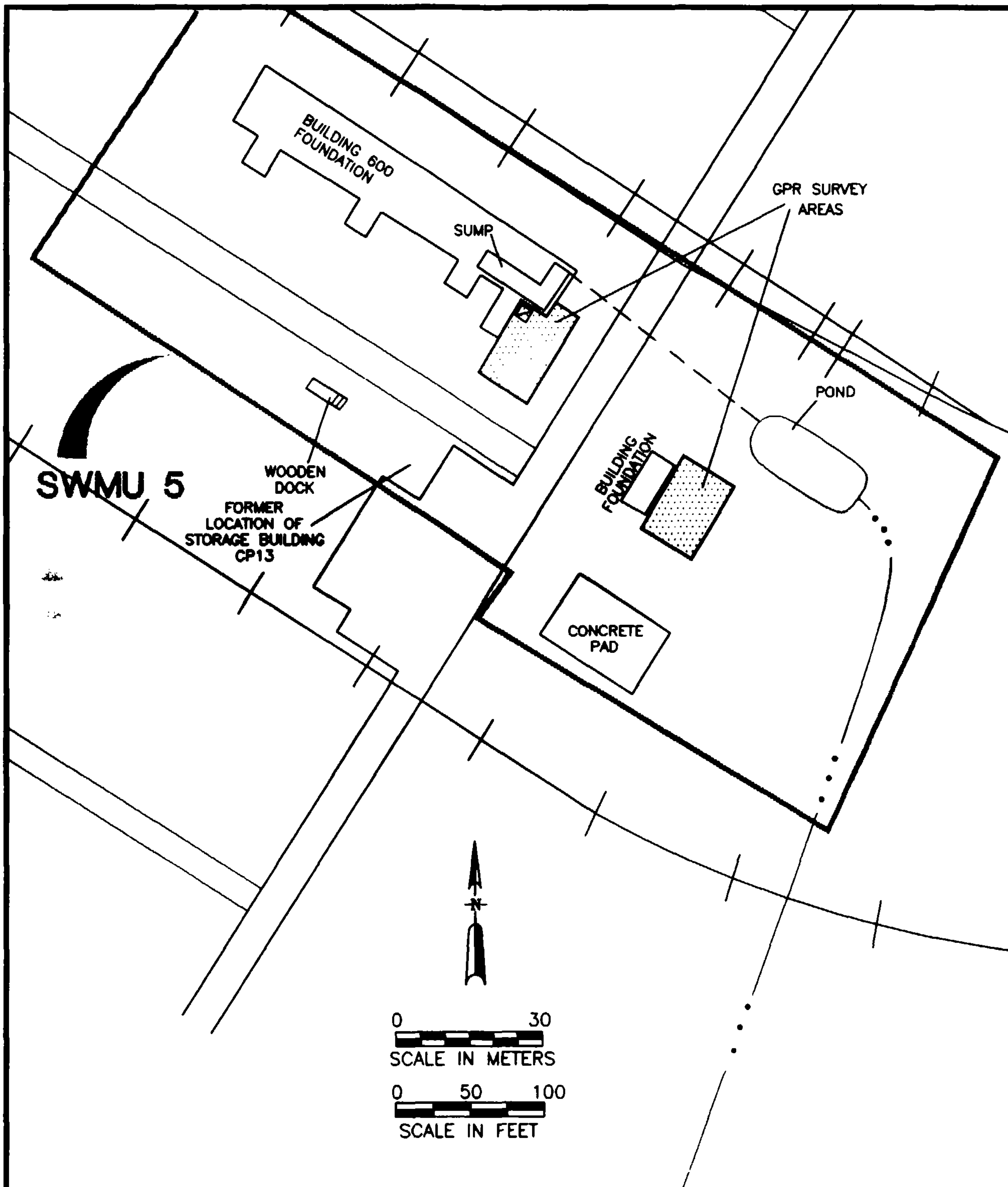
A geophysical survey consisting of EMI was conducted in the suspected burn trench area to determine the presence of debris and materials below ground surface in the trenches. The area chosen for the geophysical survey encompassed five potential burn trenches as observed on the aerial photograph. A grid was established measuring 2000 feet by 360 feet. The grid was staked every 100 feet in the east-west direction and very 50 feet in the north-south direction.

A surface features map (Figure J5.0-1) was made for the gridded area. The surface features map documents the topography, vegetation, metallic and non-metallic objects and debris on the ground surface that may effect the geophysical data. Figure J5.0-1 shows that there is an abundance of corrugated sheet metal and other debris in the survey area.

Lines of EMI data were acquired in the east-west direction every 25 feet in order to be perpendicular to the suspected burn pits. Data were gathered continuously along each line at 0.6 second intervals which equates to a sampling station at approximately every 2.5 feet along the line.

The EMI data are presented in Figures J5.0-2 and J5.0-3. Figure J5.0-2 is a contour map of the in-phase response while Figure J5.0-3 is a contour map of the quadrature phase response. The in-phase map (Figure J5.0-2) shows numerous small anomalies scattered throughout the survey area. A comparison of the in-phase data with the surface features map (Figure J5.0-1) reveals that virtually all of these small anomalies can be attributed to metal on the ground surface. It cannot be determined from the in-phase data that buried materials exist at this site.

The quadrature phase response map (Figure J5.0-3) also displays the effects of surface features. Drainage ditches can be seen trending across the data from north to south at approximately stations 1150W to 825W, 900W to 700W, and 240W to 125W. Areas that appear on the aerial photographs as potential burn trenches show up on the quadrature data approximately at stations 1400W, 1100W, 700W, 400W, and 100W. These subtle anomalies are most likely caused by slight depressions or mounding of soil. The quadrature data do not indicate the presence of buried materials at the potential trench locations.

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EXPLANATION

- Approximate Surface Drainage
- Buried Drain Pipe
- Major Access Road
- Railroad Tracks
- Underground Storage Tank
- Approximate SWMU Boundary

Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

**Figure J4.0-1**

**SWMU 5 Location of GPR Surveys**

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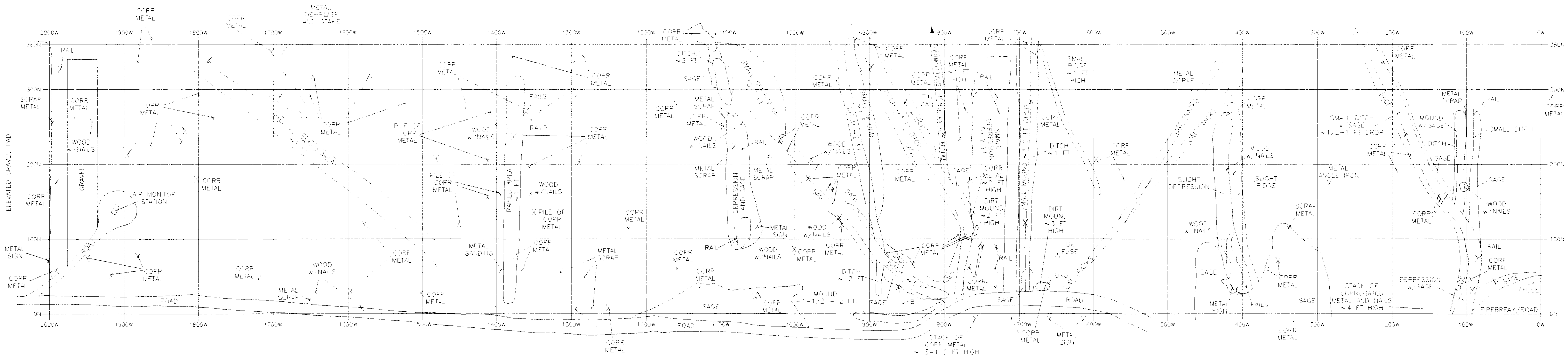
Ebasco Services Incorporated Revised: 2/22/96



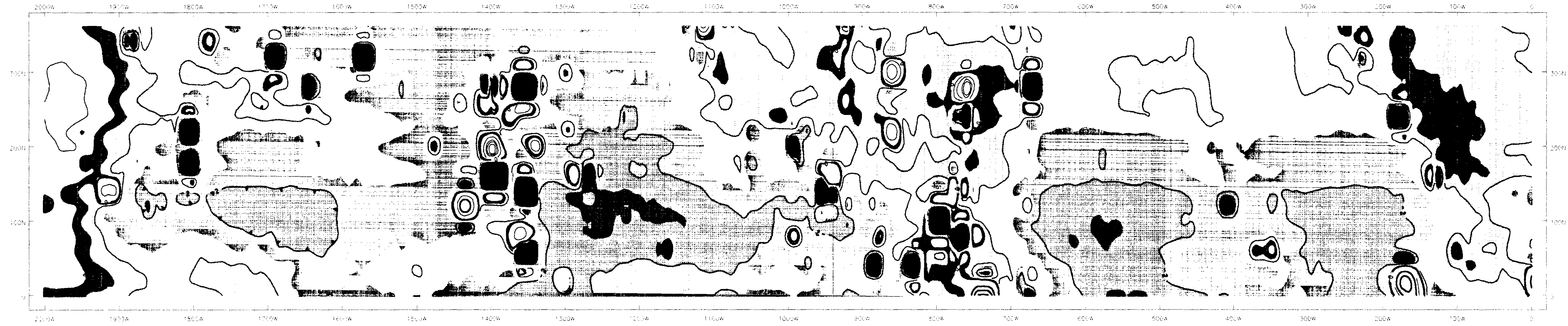


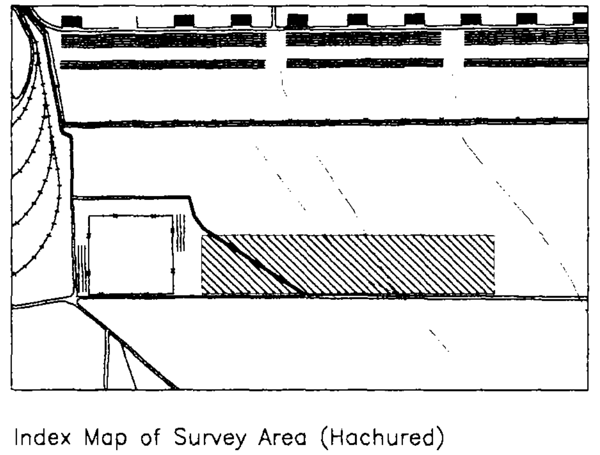
Prepared For
U.S. Army Environmental Center
Aberdeen, Maryland

Figure J5.0-1

Surface Features Map at SWMU 9

Prepared by
Ebasco Services Incorporated



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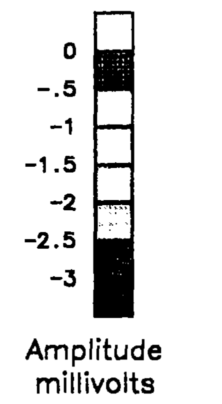


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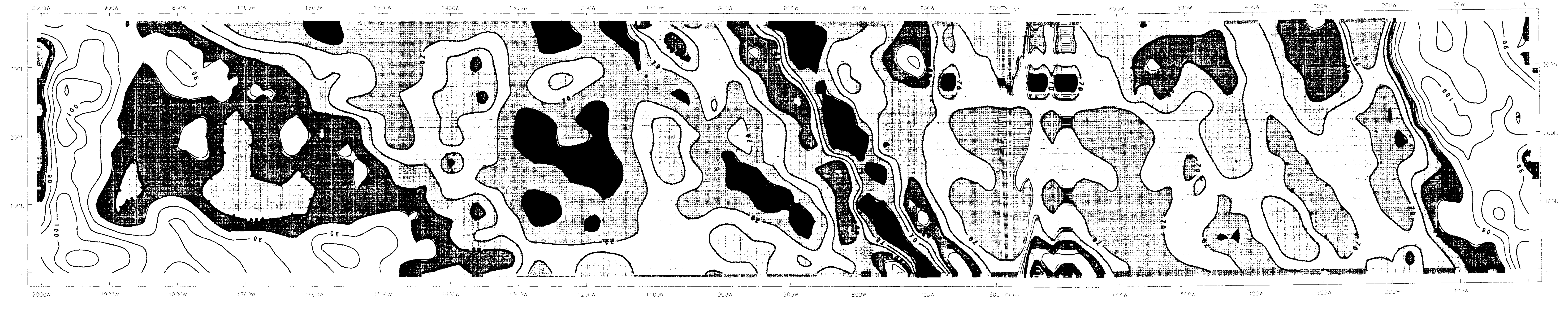
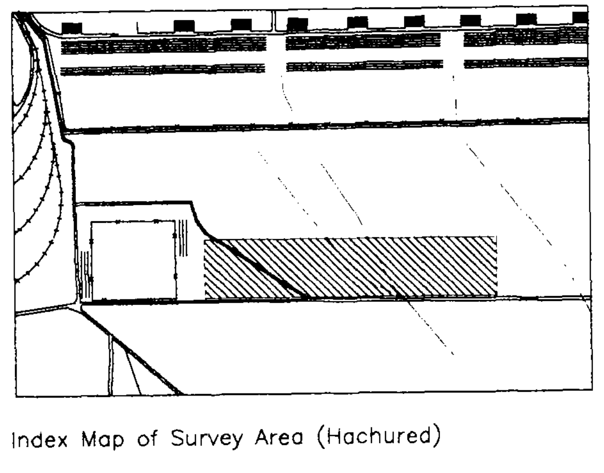
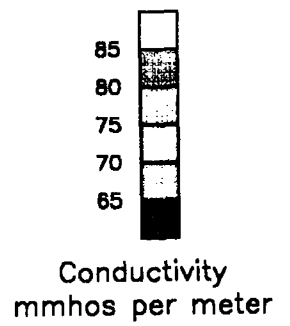
**Figure J5.0-2**
EMI In Phase Response at SWMU 9

Prepared by
Ebasco Services Incorporated






Scale 1:1200
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| Prepared For: United States Army Environmental Center |
| **Figure J5.0-3**<br>EMI Quadrature Phase Response at SWMU 9 |
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