GEOPHYSICAL SURVEYS REPORT

FORT RICHARDSON LANDFILL
ANCHORAGE, ALASKA

Ecology and Environment, Inc.
AUGUST 1990

Table of Contents (Cont.)

APPENDICES

TABLE OF CONTENTS

LIST OF FIGURES

1 INTRODUCTION

A geophysical survey, including electromagnetic survey (EM-31, EM-34), magnetic survey and resistivity survey was conducted at the Fort Richardson Landfill during July 1990. The field work was accomplished in accordance with the work plan submitted to U.S. Army Corps of Engineers under Contract No. DA CA85-88-D-0014 and Delivery Order No. 18.

The site is located within the greater Anchorage Area Borough. Detailed histories of the landfills are provided in the work plan pertaining to the subsurface investigation of the site.

1.1 BACKGROUND OF PROJECT

The geophysical investigation was completed as a component of a site subsurface investigation being conducted by Ecology and Environment, Inc. (E & E) for the Fort Richardson landfill in Anchorage, Alaska. The work plan prepared for the site investigation was in compliance with the requirements of the State of Alaska Solid Waste Management Regulation (18A AC60, 1987); 40 CFR Part 124, 257, and 258, subtitle D26418 265 (Draft); and COE guidance for subsurface exploration plan (see Appendix C, section 1.2, Delivery order 190.18, Scope of Work). E & E completed the field work pertinent to the proposed geophysical survey in July 1990. Data reduction, interpretation, and recommendations for the monitoring well locations were completed in August 1990.

The geophysical survey conducted at Fort Richardson better delineated the boundaries of the landfill and identified areas of possible buried metal debris. Portions of the geophysical data were affected by surface cultural features such as fences, railroad, and unidentified buried construction debris. Data gathered from the

geophysical survey may be used to plan additional characterization studies and groundwater monitoring locations.

1.2 APPROACHES AND OBJECTIVES

The geophysical survey consisted of an EM-31 (terrain conductivity survey),an EM-34 (terrain conductivity survey), a magnetic survey, and a resistivity or electrical resistivity sounding survey.

The objectives of the geophysical surveys at Fort Richardson were to:

- Locate the actual landfill boundaries through an EM-31 survey.
- Locate buried conductive wastes using an EM-31 survey in three grids within landfills.
- Locate buried ferromagnetic materials within the three grids and provide confirmation for an EM-31 survey, through magnetic survey.
- Identify subsurface lithology to improve the efficiency of future investigations, such as test pits, soil borings, and groundwater monitoring.
- Identify possible plumes of contaminated groundwater downgradient from the landfills through EM-34 and resistivity surveys.

The following is a summary of geophysical survey areas and the techniques conducted in each area.

Technique(s)	Area(s)
EM-31	landfill boundaries and grids
EM-34	mostly downgradient from landfills
Magnetic	landfill grids
Resistivity	downgradient and upgradient from landfills

1.3 REPORT ORGANIZATION

This document, entitled Geophysical Investigation Report, is structured as follows:

The terrain conductivity surveys (both EM-31 and EM-34) are discussed in section 2. Section 3 contains results of the magnetic survey. Section 4 contains results of resistivity soundings. Section 5 contains conclusions of the geophysical survey and recommendations based on geophysical survey results. Field data were presented on two dimensional profiles and/or contour maps. The raw field data and interpreted profiles were attached as Appendices (where appropriate).

2 TERRAIN CONDUCTIVITY SURVEY

2.1 EM-31 SURVEY

2.1.1 Theory

Terrain conductivity surveys utilize inductive electromagnetic techniques for the measurement of apparent terrain conductivity. The term "apparent conductivity" is used because the measured value is an average of conductivity beneath the measurement point. For convenience throughout this report, apparent terrain conductivity is referred to simply as terrain conductivity.

The EM-31 at the Fort Richardson Landfill was used in both quadrature (operation) and in-phase modes. The magnetic field (secondary magnetic field) produced through electromagnetic techniques has two components. One component of this secondary magnetic field is in quadrature with the primary earth magnetic field which is measured utilizing the operation mode of the instrument. The other component is in-phase with the earth's magnetic field, which can be measured by setting the instrument switch to comp position rather than OPER position. The in-phase component of the magnetic field is significantly more sensitive to large metallic object than the quadrature phase component.

2.1.2 Instrumentation

Portions of terrain conductivity surveying at the Fort Richardson Landfill site were accomplished with an EM-31 terrain conductivity meter manufactured by Geonics, Ltd. The EM-31 is a one-person, portable unit that has two coils separated by a fiberglass pole. The instrument is calibrated by the manufacturer to provide a direct reading of terrain conductivity in millimhos per meter (mmhos/m). The EM-31 is designed for engineering geophysical applications and measures terrain conductivity from the land surface to depths of approximately 20 feet.

2.1.3 Survey Methodology

The EM-31 survey was conducted across the eastern and western landfill boundaries and on 19 parallel traverse lines within 3 separate grids. Traverse lines were located in the field by an E & E field crew. Within grids 1, 2, and 3 traverse lines were oriented northsouth and were separated by 50 feet. Survey traverse lines were perpendicular to the landfill boundaries within the eastern and western landfill boundaries.

The terrain conductivity survey was conducted during the week of July 14, 1990. Conductivity measurements were obtained at stations located on traverse lines. Measurements were conducted from south to north in both quadrature and in-phase modes.

2.1.4 Data Reduction and Interpretation Methodology

Steps used in data reduction and interpretation of terrain conductivity data are as follows:

- o Data collected in the field are checked for correctness.
- o Conductivity values for both quadrature and in-phase modes are plotted and contoured on maps along each traverse line.
- o The terrain conductivity contour map is examined for elevated and/or lowered conductivity values which could not be attributed to known naturally existing or manmade subsurface conditions or cultural features.

2.1.5 Survey Results

The EM-31 survey was intended to define the landfill boundaries and to identify possible buried conductive waste. The results of the EM-31 Survey are presented in the following sections.

2.1.5.1 Landfill Boundaries:

The eastern and western boundaries of the landfills were identified through five traverse lines (W1 through W5; see Figure 2-1) conducted across Landfill No. 6, and 17 traverse lines (E1 through E17) conducted across south and east boundaries of Landfills No. 1 and 3. All traverse lines were conducted perpendicular to the landfill boundaries (where possible).

Terrain conductivity data indicates that the landfill boundaries are marked by a decrease of conductivity from conductivity values greater than 5 to values ranging from 4 to 5 mmhos/m. An isoconductivity line of 4.5 mmhos/m represents approximate landfill boundaries under actual site conditions. The closer the traverse lines, the more accurate the boundary delineation. For the purpose of subsurface investigation of the site, this delineation is sufficient. However, additional data may be necessary for further detailed study or future remediation.

2.1.5.2 Landfill Grid:

Terrain conductivity (EM-31) data collected on landfill grids were incorporated into terrain conductivity contour maps. Contour maps for Grids 1, 2, and 3 are found in Figures 2-2, 2-3, and 2-4 respectively.

For each grid, both quadrature and in-phase data were contoured, with the results described in the following sections:

Grid 1: Three north-south traverse lines were conducted within this grid. Data from both quadrature (operation mode) and in-phase modes were contoured (see Figure 2-2).

Examination of grid 1 terrain conductivity contour map indicates the following:

- An elevated terrain conductivity zone, trending north-northeast, south-southwest was identified within the northern portion of Grid 1. This conductivity zone, marked by a conductivity of 50 mmhos/m or higher, is an indication of buried conductive waste in this area. The main body of the conductive materials causing the anomaly may likely be located by conductivity values greater than 80 mmhos/m.

- Two potential areas of buried pipes and/or drums were identified within this grid: (1) a zone of buried pipe in the central portion of the surveyed area between 100N and 200N and 0E to 100E coordinates, and (2) a less important buried pipe and/or drums zone detected within the northwest portion of the surveyed grid.

- A zone of relatively elevated conductivity was detected in the south and southwest of the grid. The main portion of the conductive materials seems to be located at 80N/25E coordinates. The conductivity contour line of 40 mmhos/m may indicate the areal extent of the identified anomaly.

FTR 0018591

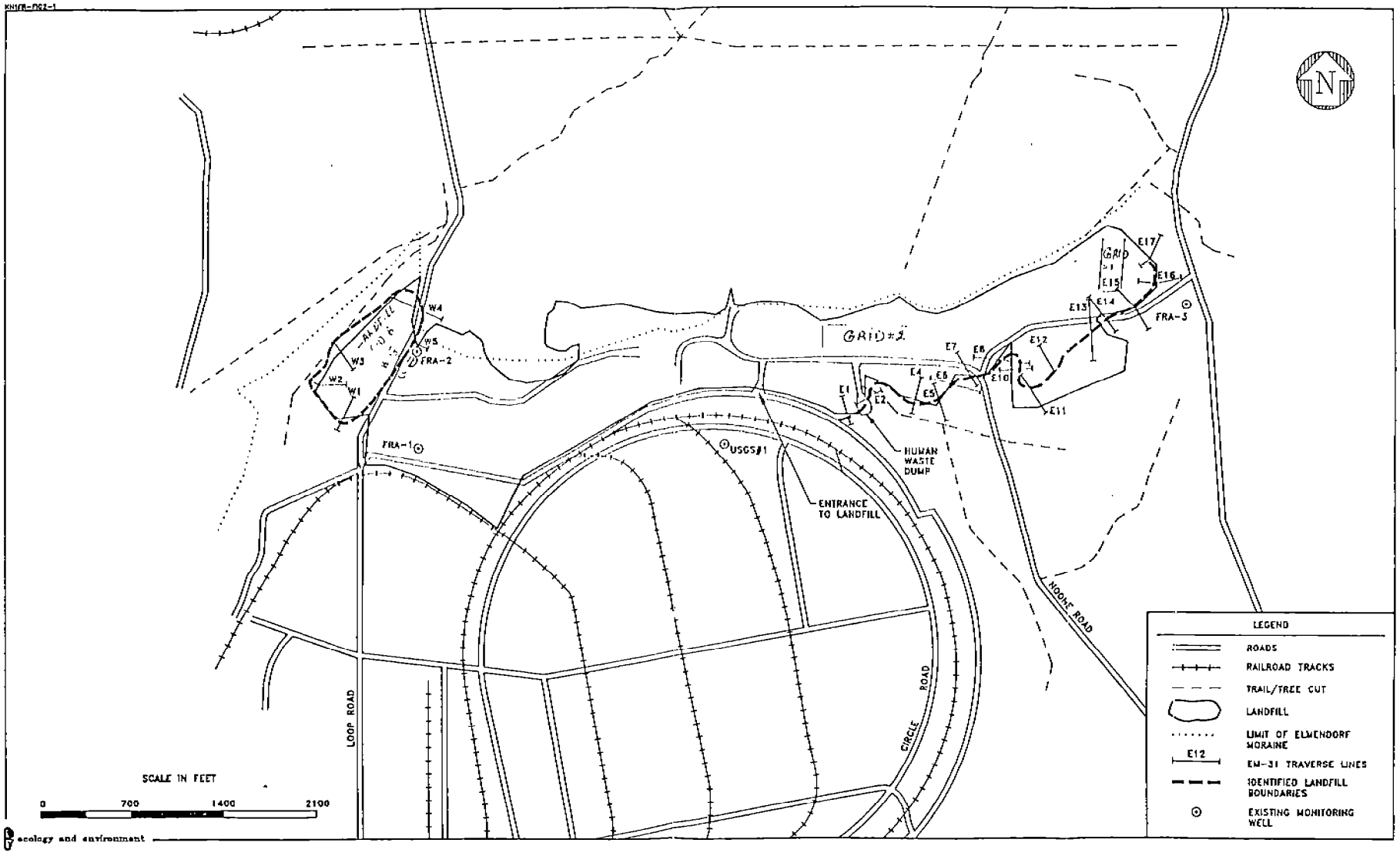


Figure 2-1 FORT RICHARDSON LANDFILL
GEOPHISICAL INVESTIGATION
LANDFILL BOUNDARIES
EM-31 SURVEY

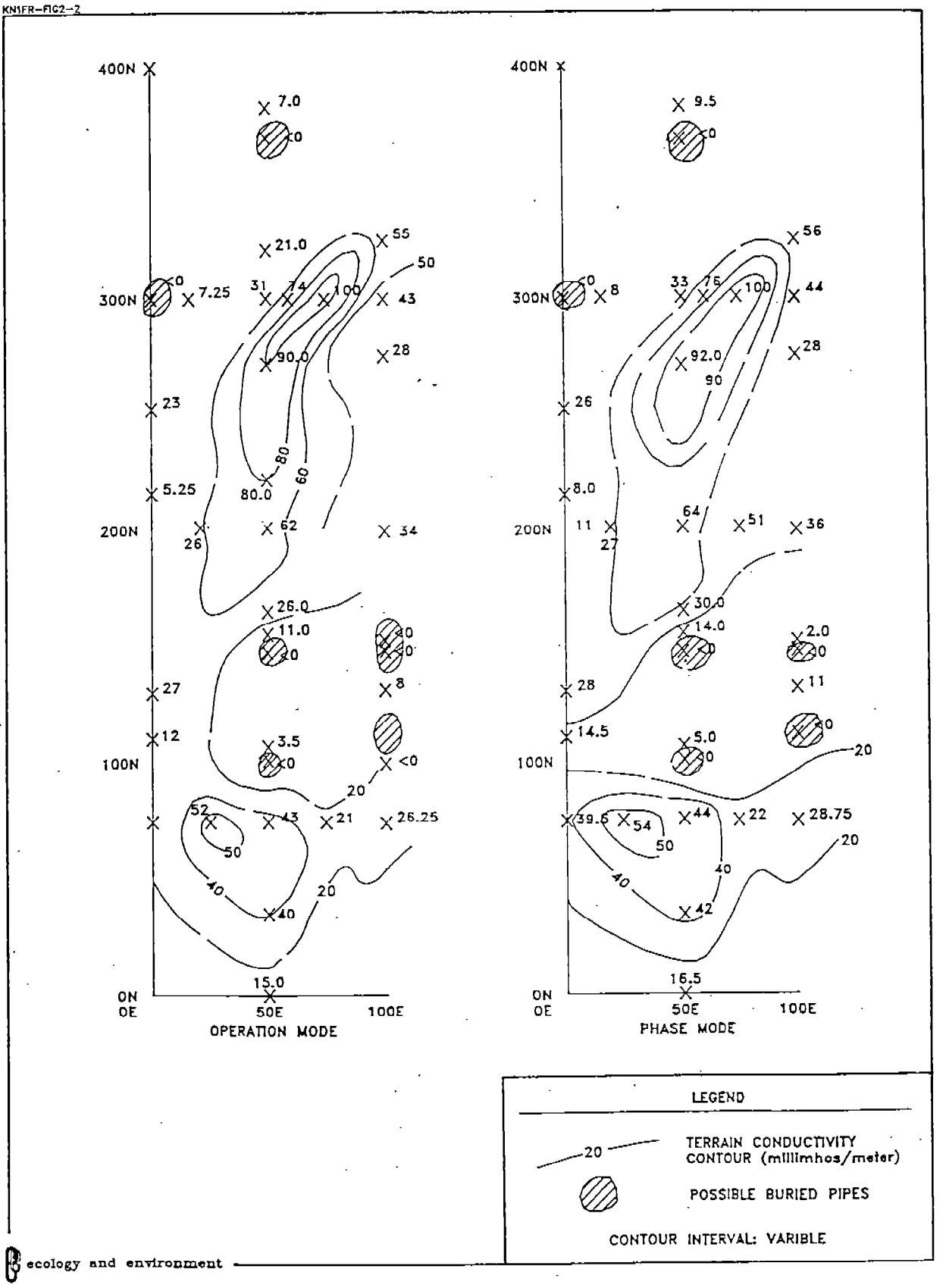
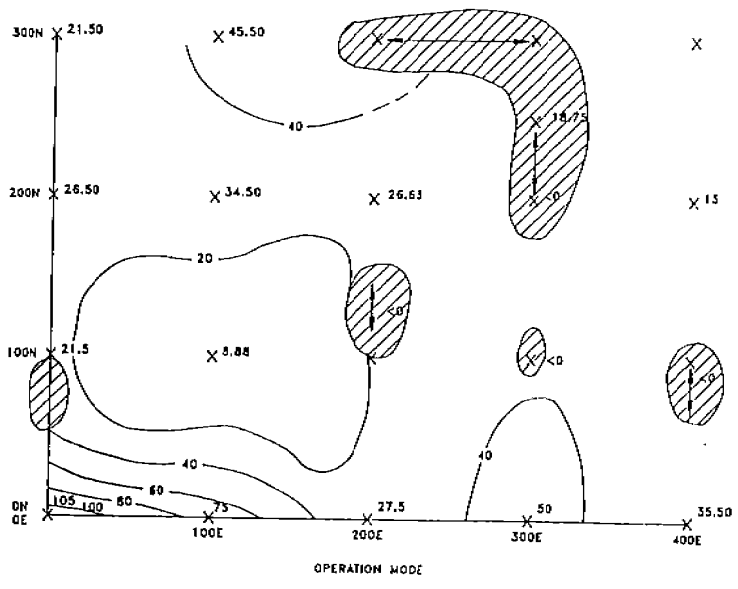
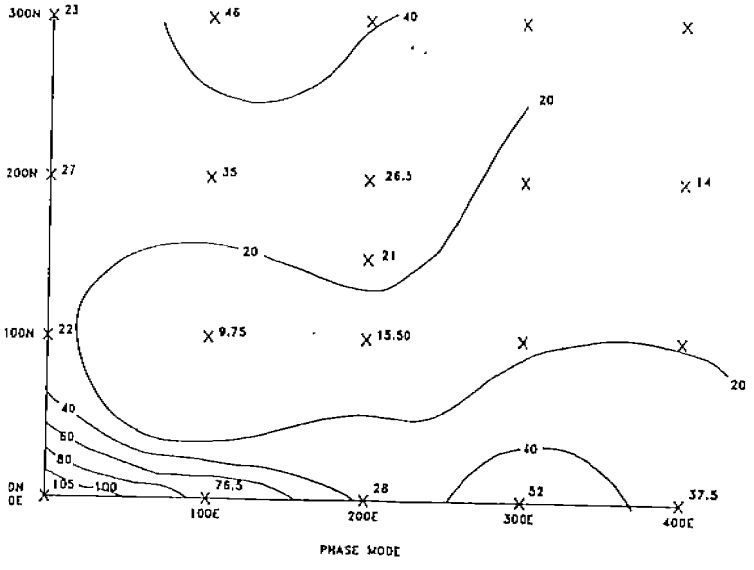
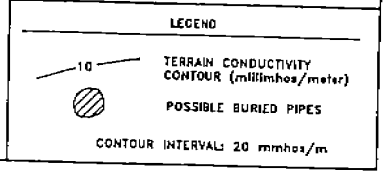


Figure 2-2 FORT RICHARDSON LANDFILLS GEOGRAPHICAL INVESTIGATION EM-31 TERRAIN CONDUCTIVITY CONTOUR MAP: GRID #1

FTR 0018593



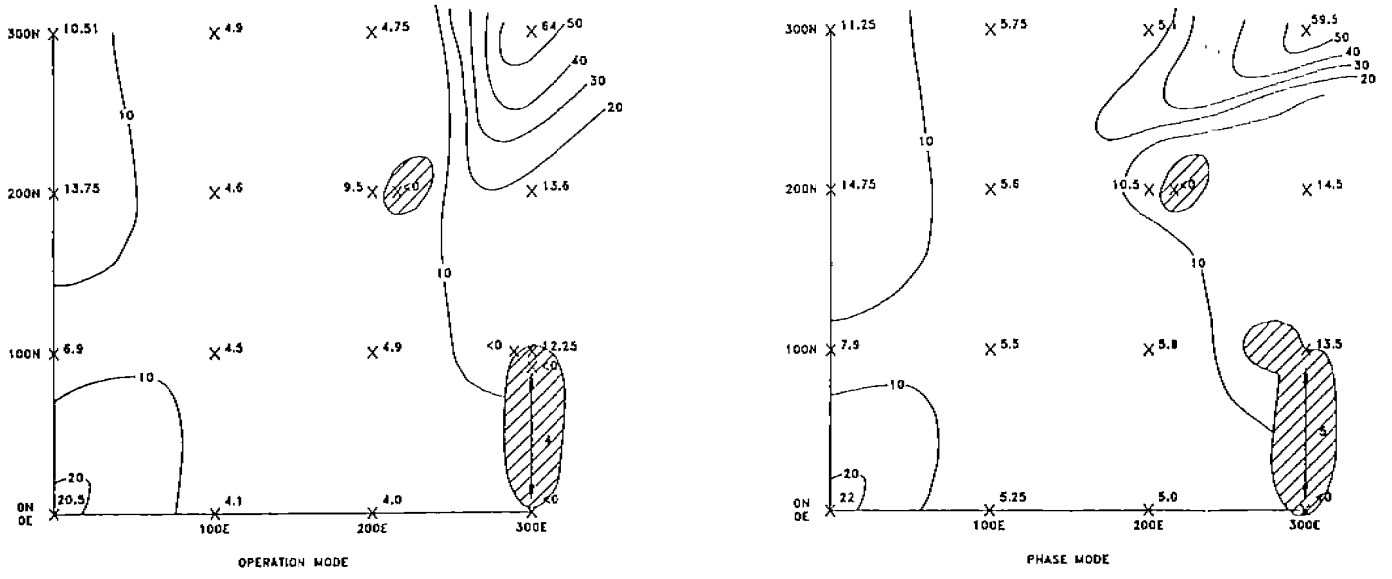




ecology and environment

Figure 2-3 FORT RICHARDSON LANDFILLS
GEOPHYSICAL INVESTIGATION
EM-31 TERRAIN CONDUCTIVITY
CONTOUR MAP: GRID #2

FTR 0018594



ecology and environment

Figure 2-4 FORT RICHARDSON LANDFILL
GEOPHYSICAL INVESTIGATION
EM-31 TERRAIN CONDUCTIVITY
CONTOUR MAPS: GRID #3

Grid 2: Five north-south traverse lines were established within this grid. Data from both quadrature (operation mode) and in-phase modes were contoured (see Figure 2-3).

Examination of Grid 2 terrain conductivity contour maps indicates the following:

- An elevated conductivity zone was detected in the southwest portion of the grid. The extent of this anomaly may be marked by the conductivity contour 40 mmhos/m. This elevated conductivity may be indicative of buried conductive waste, metallic materials, and/or construction debris.

- Two zones with conductivity greater than 40 mmhos/m were identified in south-southeast and north sections of the surveyed grid. These anomalies may represent minor amounts of buried conductive waste or simply surface interferences from metallic debris near the measurement points.

- A series of negative readings, indicative of buried pipes, were detected throughout the survey grid. The major area of buried pipe was identified within the north-northeast portion of the grid.

- Areas with terrain conductivity values ranging from 20 to 40 mmhos/m may also be indicative of a relatively conductive shallow subsurface or minor, shallow, buried conductive waste.

Grid 3: Four north-south traverse lines were conducted within this grid. Data from both operation and in-phase modes were contoured (see Figures 2-4).

Examination of Grid 3 conductivity contour map indicates the following:

- Two local elevated conductivity values were recorded in the northeast and southwest corners of the surveyed grid. These elevated conductivities indicate that small, buried, conductive objects may exist at very shallow depths.

- Two locations were marked by negative readings which may indicate buried pipes and/or drums. The zone with significant buried pipes was located in the southeast portion of the grid.

2.2 EM-34 SURVEY

2.2.1 Instrumentation

Portions of the Fort Richardson landfill site were surveyed with an EM-34DLXL, which consists of transmitter and receiver coils and meters connected by several cables. This instrument has a larger transmitter coil in comparison to the standard EM-34-3. The larger transmitter reduces noises and provides better transmission of current. Two persons are required to carry the instrument and record the data. The instrument was used with all available coil spacings and with both vertical (coils parallel to the ground) and horizontal (coils vertical to the ground) dipoles.

2.2.2 Survey Methodology

The EM-34 survey was conducted at preselected locations downgradient from the landfills. The EM-34 measurement points were designated ER-1 through ER-20 (see Figure 2-5). At each measurement point, conductivity was measured with both vertical and horizontal dipoles for 10, 20 and 40 meter coil spacings. In total, from each location, six conductivity measurements were taken.

2.2.3 Data Reduction and Interpretation Methodology

Data collected in the field were subject to the following processing steps:

- Collected data were plotted in individual vertical plots.
- All the vertical plots, or profiles, were assembled on a site profile to allow correlation between the individual measurement points.
- The correlation profiles (see Figure 2-6) were examined for elevated or lowered conductivity, downgradient from the landfills, which could not be attributed to known naturally existing surface conditions or cultural features.

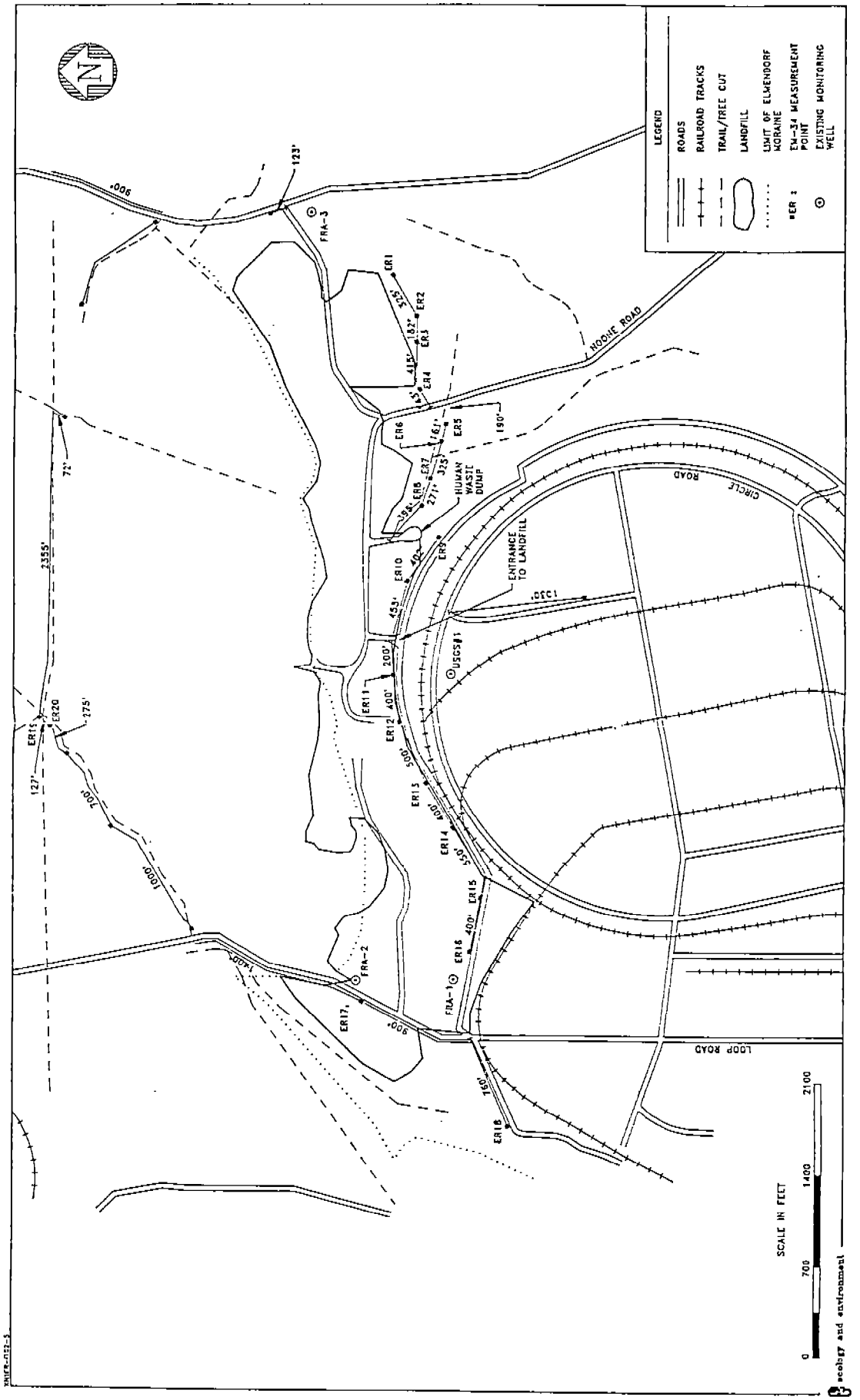


Figure 2-5 FORT RICHARDSON LANDFILL
ANCHORAGE, ALASKA
LOCATIONS OF EM-34
MEASUREMENT POINTS

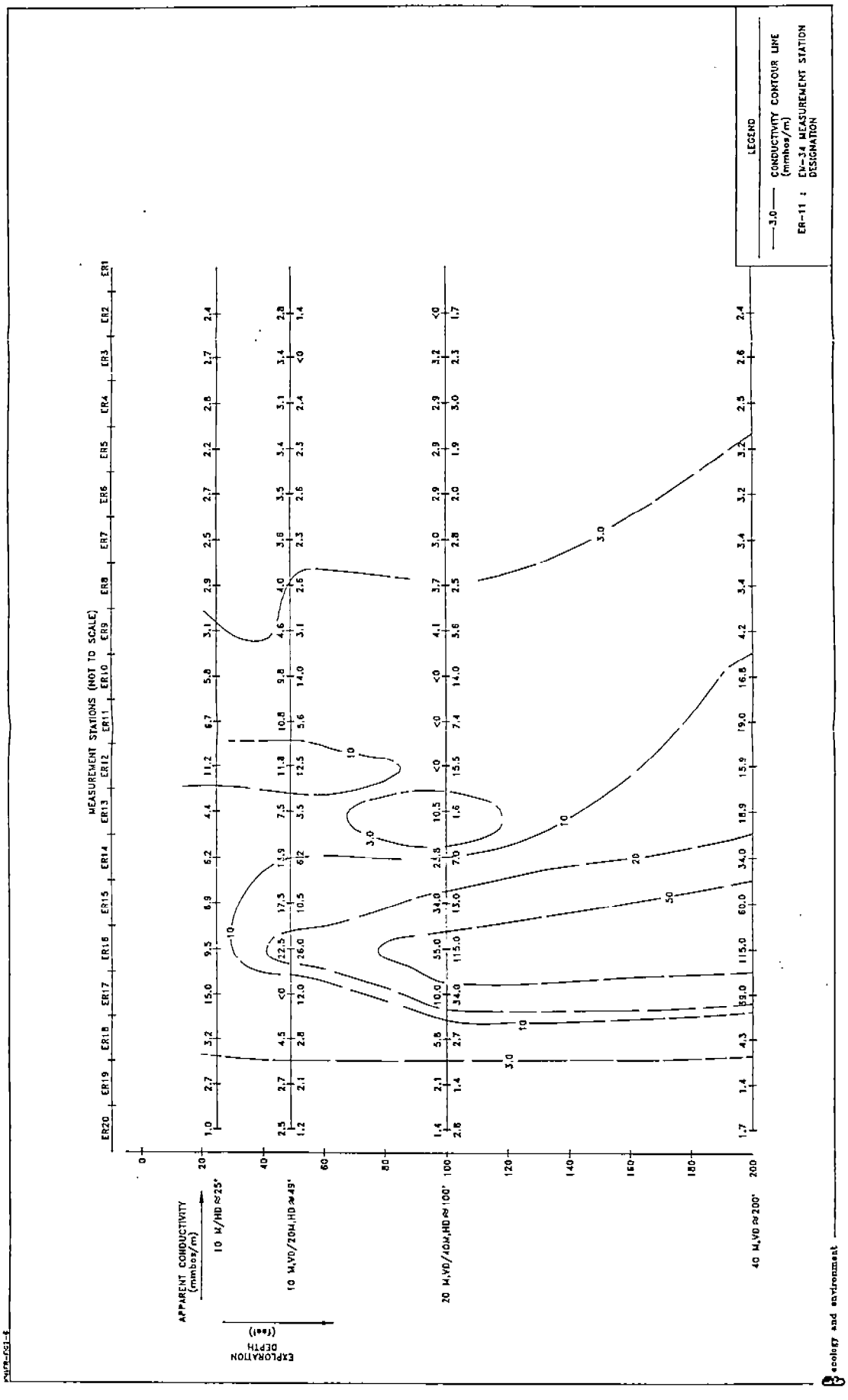


Figure 2-6 FORT RICHARDSON LANDFILL GEOPHYSICAL INVESTIGATION EM-34 PROFILE

- For better correlation to the resistivity sounding data and profiles, the conductivity data were also converted to resistivity, using the following conversion factor:

$$\frac{1000}{\text{Ohm} \times \text{m}} = \frac{\text{mmhos/m}}{\text{m}}$$

$$\text{or Ohm} \times \text{feet} = \frac{3281}{\text{mmhos/m}}$$

2.2.4 Survey Results

Data collected in the field were used to produce the conductivity profile (see Figure 2-6). Examination of the conductivity profile indicates:

- Areas downgradient from the eastern portion of the landfills, measurement point ER-1 through ER-7, indicate a homogeneous lithology, possibly gravel and sandy gravel from surface to a depth of approximately 200 feet below ground surface.

- Approaching the human waste dump, conductivity increases which may be indicative of conductive waste from the shallow subsurface migrating downwards. This zone is marked by conductivity ranging from 3 to 10 mmhos/m. The conductivity measurement taken at ER-9, ER-10, ER-11, and ER-12 may be affected by the presence of a metallic fence along the southern boundary of the landfill.

- An area of elevated conductivity, identified from locations ER-13 to ER-16 measurement locations. This elevated conductivity may indicate buried conductive wastes, and construction materials such as steel pipes and concrete debris.

  The highest conductivity values (115 mmhos/m) were recorded at a depth greater than 50 feet at station ER-15. Any buried object beneath the transmitter or receiver coils may also affect the conductivity measurements; therefore, this elevated conductivity value may be associated with some interferences to the measurements.

- The western portion of the landfill, like the eastern portion, is characterized by a conductivity value smaller than 3 mmhos/m (see ER17 and ER18 locations), which represents the background conductivity of gravel-type lithology.

3 MAGNETIC SURVEY

3.1 THEORY

The objective of a magnetic survey is to identify anomalies in the earth's magnetic field. These variations are caused by the presence of magnetic minerals or manmade objects containing iron or steel in proximity to the magnetometer.

The earth's magnetic field resembles that of a uniformly polarized sphere. The two poles of the sphere are located near the geographical north and south poles. The unit commonly used in magnetic field measurements is the gamma (1 gamma = 10^{-9} webers/m^2). The intensity of this magnetic field varies, being twice as large at the poles as at the equator (60,000 and 30,000 gammas, respectively). The intensity of the magnetic field in the vicinity of the Fort Richardson study area is approximately 55,000 gammas.

A magnetic survey entails conducting a series of measurements of the magnetic field. Measurements are taken at regular intervals along successive, parallel, traverse lines that collectively form a grid. Spatial changes in the magnetic field are identified by two methods: examination of two-dimensional graphs of the magnetic field generated from data obtained along the traverse lines; and examination of a contour map of the magnetic field data produced for the survey grid.

The two-dimensional graphs of total magnetic field intensity disturbances (anomalies) are generally varied in shape and amplitude, and are almost always asymmetrical due to the dipolar nature of the field. Anomaly shape and amplitude may also be affected by the shape of the source and by the orientation of the source in the earth's magnetic field. As a result, anomalies sometimes appear complex, even from simple dipolar sources.

Another significant characteristic of the profile of a magnetic anomaly is the anomaly's variation with depth: the deeper the source,

the larger the period (or the broader the anomaly). This property allows the determination, from interpretation of the profiles, of the approximate depth to the magnetic source.

Methods used for interpretation of magnetic survey data include a qualitative determination of the regions of potential burial of ferromagnetic material and a semi-quantitative determination of the depth of burial of magnetic source objects.

Several interpretation techniques based on curve matching, deconvolution, and other modeling have been developed. These interpretation techniques require rigorous mathematical computation. A graphic interpretation technique described by Vacquier, Steenland, and Henderson (1951) was used in this survey. This method is called "slope estimate" and is based on the fact that the distance from magnetic source to the sensor is proportionally related to the horizontal extent of a straight line drawn parallel to the "straight" portion of the maximum gradient of the anomaly.

The slope estimate technique was applied to each smoothed profile. Estimated depths were correlated with adjacent profiles to ascertain whether a reinterpretation is required, or if the depth to the ferromagnetic material did indeed vary. The depths from the surface to the source were obtained by subtracting the sensor height from the estimated depths.

3.2 INSTRUMENTATION

Magnetic surveying at the Fort Richardson landfill site was accomplished through the use of a proton precession magnetometer (a portable model G-856 magnetometer manufactured by EG&G Geometrics). The mode, in which the magnetometer was used, had a sensitivity capable of measuring the absolute value of the earth's magnetic field to within 0.1 gamma.

This instrument is battery operated, and has a digital LED display and an electronic memory capable of storing 1,000 readings. The memory was transferred electronically to a computer for data processing.

3.3 SURVEY METHODOLOGY

The magnetic survey was only conducted in selected areas of the landfills to provide complementary data for the terrain conductivity survey. The main purpose of the magnetic survey was to identify buried ferromagnetic material.

Magnetic survey traverse lines were assigned unique line numbers. Measurements of the magnetic field were conducted at 10-foot intervals on the traverse lines. To minimize interference caused by surficial magnetic objects, the magnetometer was mounted on an 8-foot staff so that, in effect, measurements were made 8 feet above the ground surface. In addition, the person holding the polarizing coil was free of any ferromagnetic material. This eliminated possible interferences from small ferromagnetic objects in proximity to the polarizing coil.

3.4 DATA REDUCTION AND INTERPRETATION METHODOLOGY

Steps taken in the reduction and interpretation of the data are summarized as follows:

- Data taken in the field were transferred electronically from the magnetometer memory into a microcomputer. As a result, the possibility of transcription errors was eliminated.
- Data from traverse lines were plotted by computer as magnetic field profile lines, with the magnetic field as the y-axis and the distance in feet as the x-axis. Data were also plotted by computer to produce magnetic field contour maps for each grid.
- Anomalies that represented magnetic objects were identified on profiles and the contour map.
- Anomalies caused by surficial objects (such as pipe racks, steel buildings, and iron or steel materials) were identified by reference to the site map and field notes taken during the survey.
- Areas where the magnetic field was disturbed by buried magnetic objects were identified.

3.5 MAGNETIC SURVEY RESULTS

Magnetic surveys were conducted in all three landfill grids. Although the magnetic survey was suggested as optional by the site work

plan, the results of the terrain conductivity survey recommend the use of magnetic survey in all three grids. All three grids were surveyed with north-south traverse lines at 50 feet spacing between traverse lines. Based on the results of the EM-31, a 10-foot interval was selected for measurement points along each traverse line. The interpreted magnetic anomalies were plotted on contour maps. The results or findings of the survey are described below.

Diurnal data for both survey days (August 17 and 18, 1990) were depicted on Figures 3-1 and 3-2. Grid 1: The maximum daily variation being less than 40 gammas; therefore, no diurnal correction were applied.

Grid 1: Examination of magnetic profiles and magnetic contour maps (Figure 3-3) produced for this grid indicated:

- A zone of possible buried ferromagnetic material was identified within three other portions of the survey grid along east-west line E-70. The intensity of the identified magnetic anomaly is approximately 1,300 gammas with an estimated depth of burial of 10 to 33 feet below ground surface.

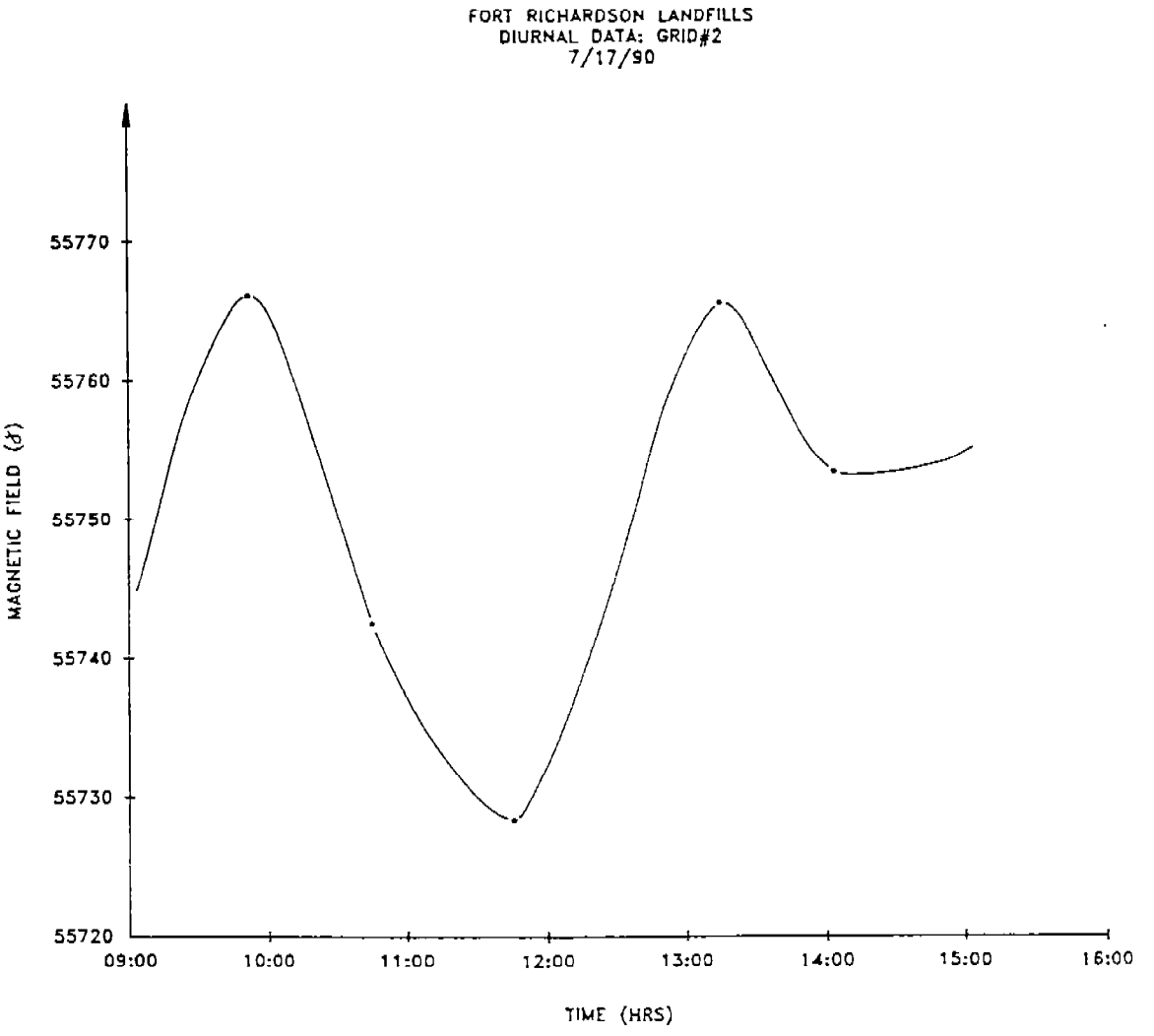
- A small zone of buried metallic materials was detected in the middle portion of the study area. The depth of burial of metallic objects is estimated at 10 to 12 feet below ground surface. The intensity of this anomaly and the depth of source object suggest that a large amount of metallic objects or ferromagnetic material, may be buried in this area.

- Two, east-west trending, magnetic anomalies or anomalous zones were defined within the northern portion of this grid. The estimated depth of burial is 2 to 22 feet. The intensity of magnetic anomalies decreases from east to west. The higher intensity of magnetic fields at depths greater than 10 feet below ground surface, within the eastern portion of the identified zone, is indicative of significant amounts of buried ferromagnetic materials in this area.

Grid 2: Data from all nine traverse lines were used to produce a contour map (Figure 3-4) of the total magnetic field for the Grid 2 survey area. An analysis of this map indicated the following:

- Two major, east-west trending, magnetic anomalies were identified with the southern portion of the Grid 2 survey.

KNIFR-FIG3-4



ecology and environment

Figure 3-1 FORT RICHARDSON LANDFILLS

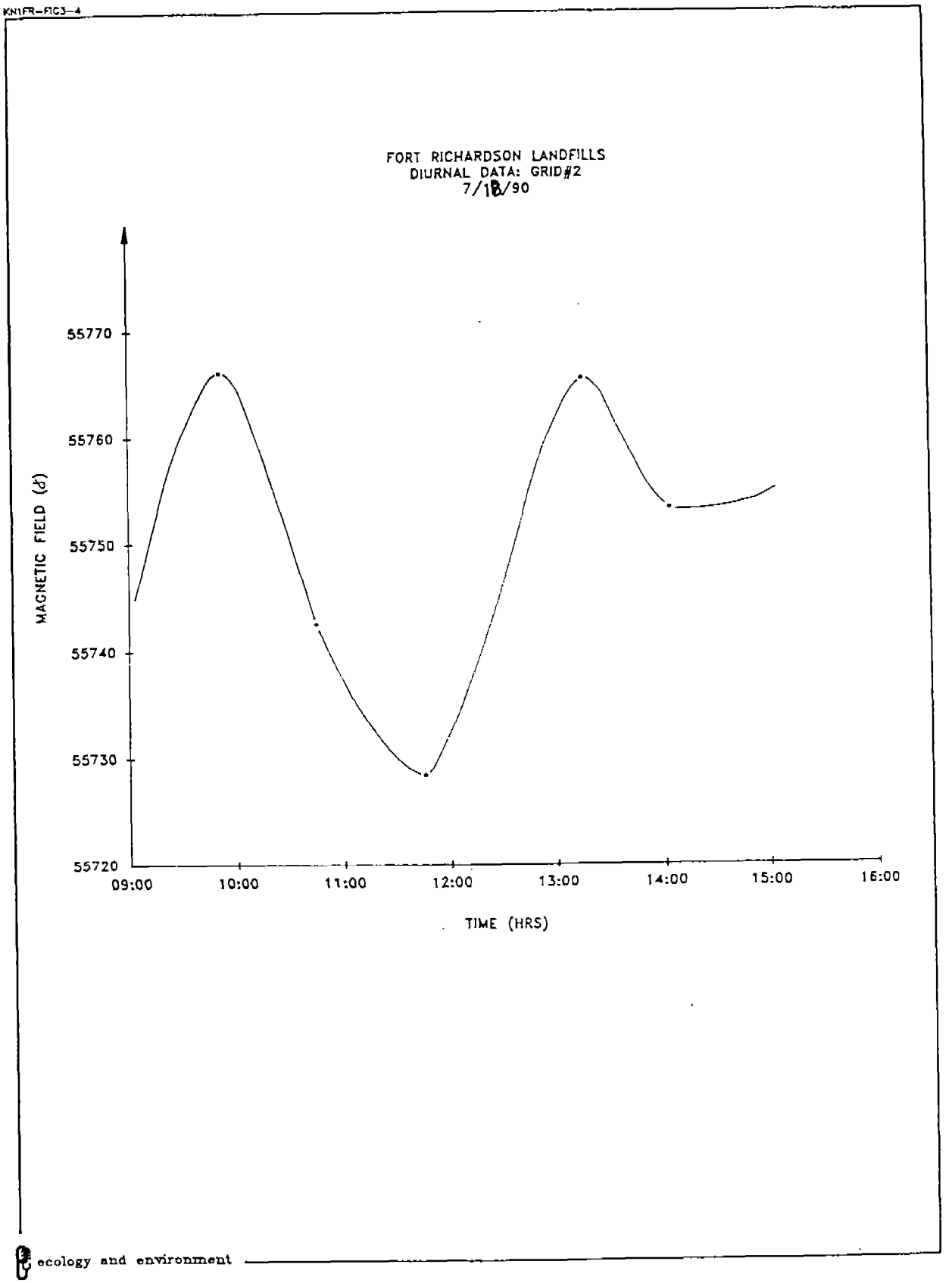


Figure 3-2 FORT RICHARDSON LANDFILLS

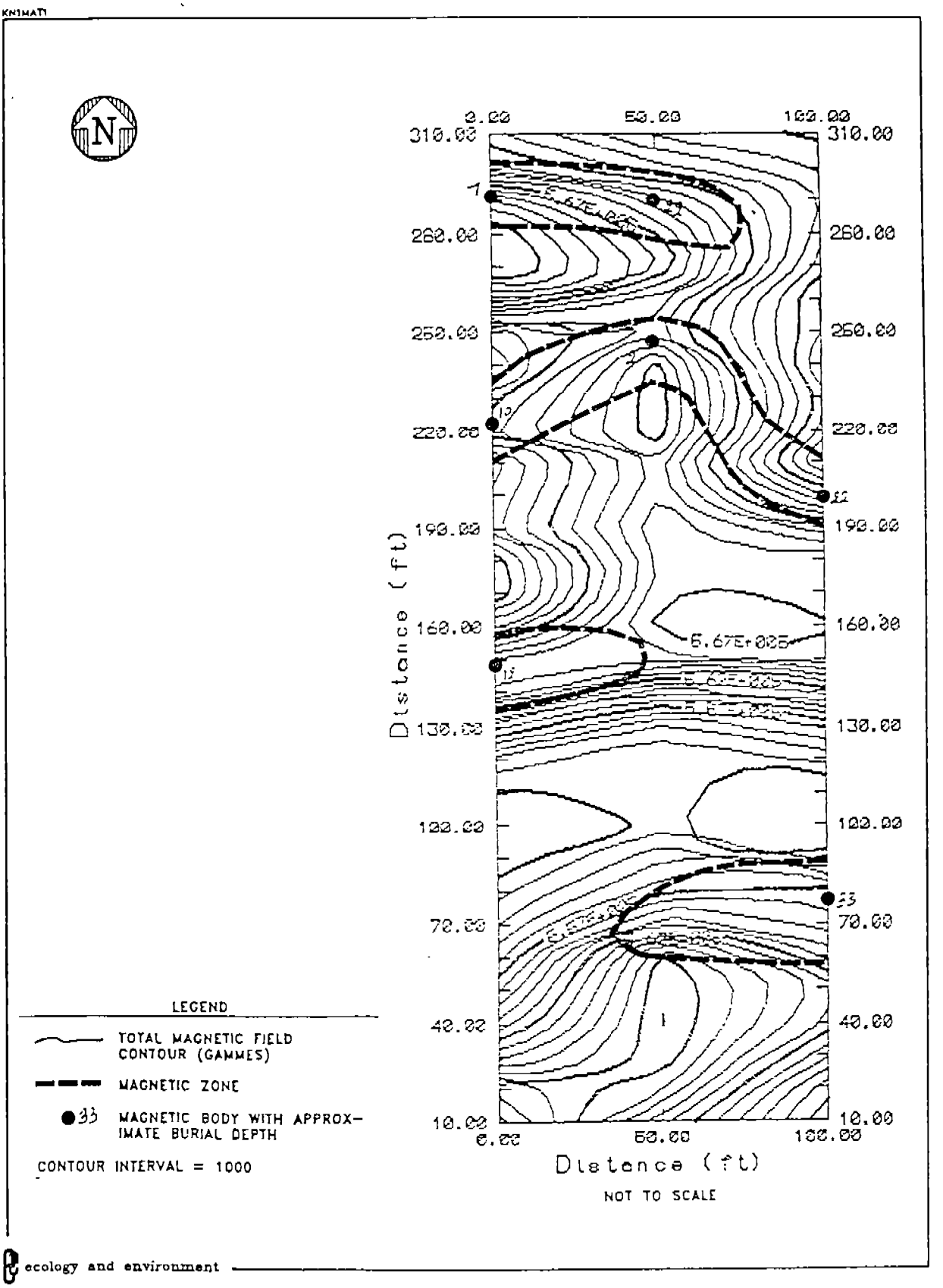


Figure 3-3 FORT RICHARDSON LANDFILLS - GEOPHYSICAL INVESTIGATION
TOTAL MAGNETIC FIELD MAP, GRID 1

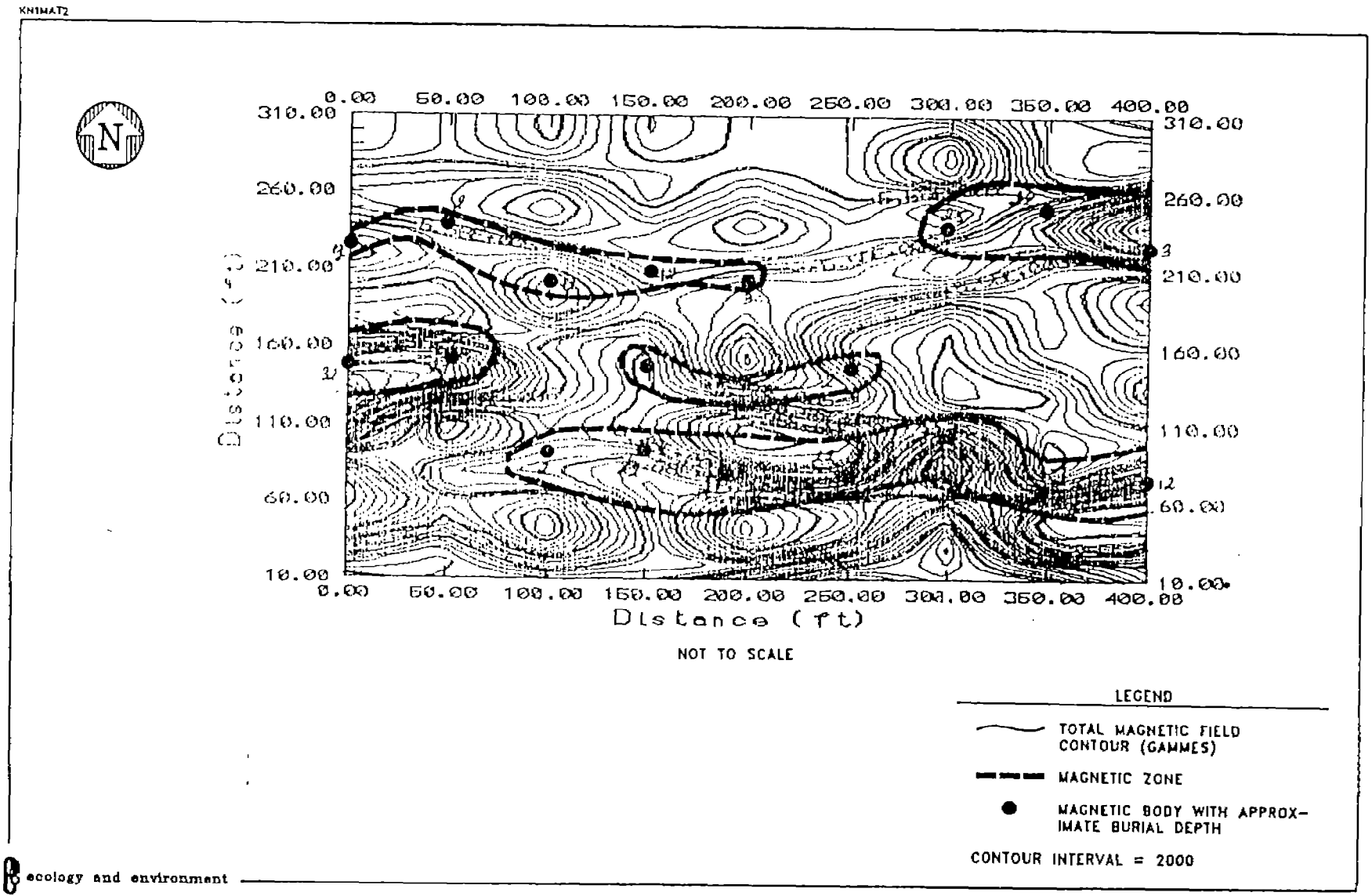


Figure 3-4. FORT RICHARDSON LANDFILLS – GEOPHYSICAL INVESTIGATION
TOTAL MAGNETIC FIELD MAP, GRID 2

FTR 0018607

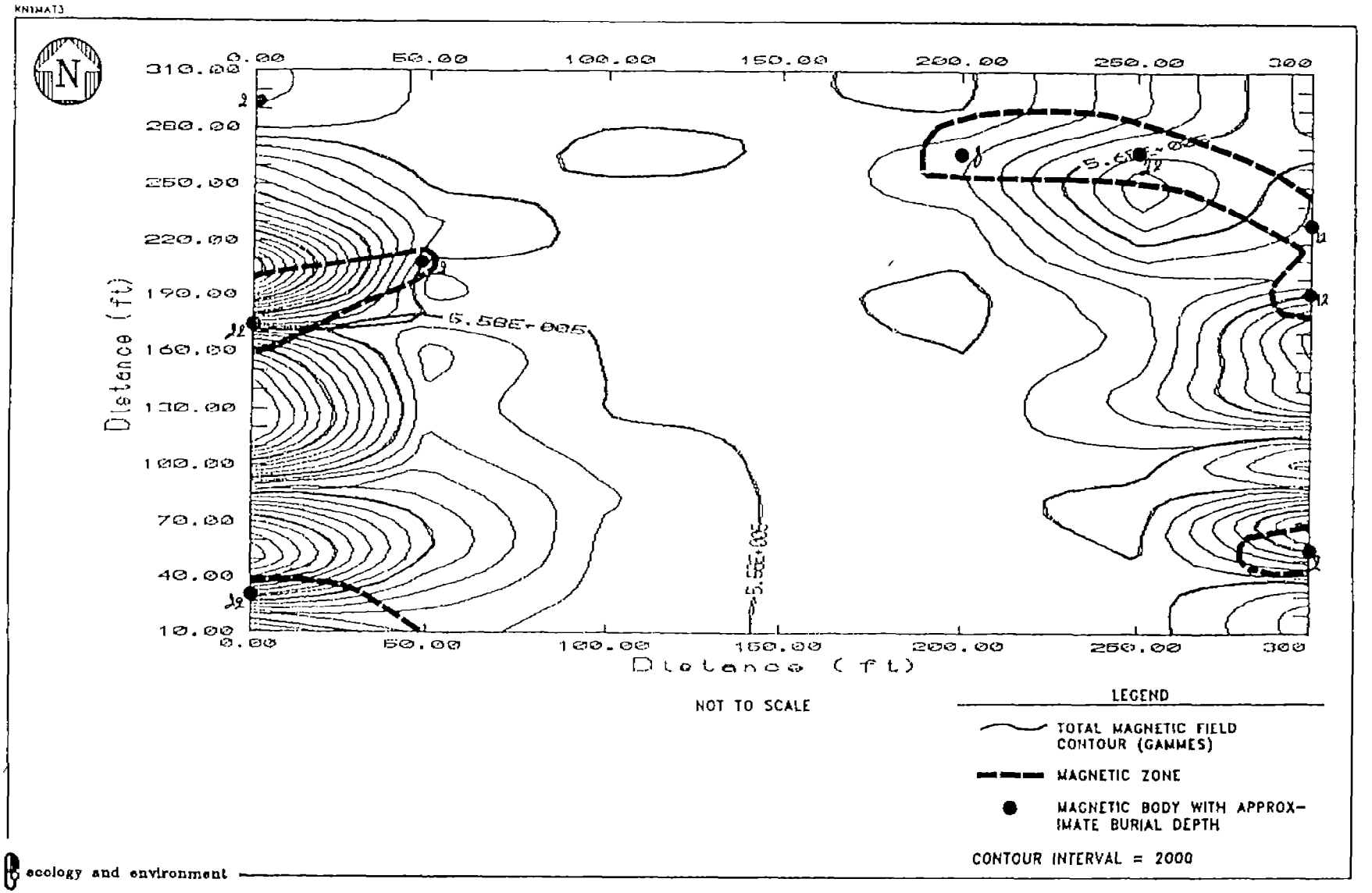


Figure 3-5 FORT RICHARDSON LANDFILLS - GEOPHYSICAL INVESTIGATION
TOTAL MAGNETIC FIELD MAP, GRID 3

FTR 0018608

An east-west trend of a magnetic anomaly along the line N60 or N70, with an intensity of greater than 2,000 gammas and burial depth of 2 to 22 feet indicating presence of significant amount of conductive and/or metallic debris, particularly in the eastern section of the identified trend. Two zones of magnetic anomaly with east-west trend along the line N150. The zone located at 150N/0E and 150N/50E may contain a significant amount of metallic debris and/or objects. The magnetic zone east of the above mentioned magnetic anomaly may indicate lesser amounts of buried metallic objects at shallower depth.

- The northern portion of this grid is characterized by an east-west trend of magnetic zone indicating the presence of buried ferromagnetic materials within this section. Detected magnetic anomalies indicate an intensity of a few hundred to greater than 2,000 gammas with an estimated depth of burial of 2 to 30 feet BGS. The western trend of the identified magnetic anomaly is marked by a shallow, low intensity anomaly which may indicate the presence of minor amounts of buried metallic debris at shallow depth in this area.

- In general, this grid is predominantly characterized by a series of east-west trenches that may contain metallic debris, possibly metallic drums and other types of containers. The maximum amount of burial of ferromagnetic materials was found within the south, southeastern, and southwestern areas of the survey grid.

Grid 3: Field data from all seven traverse lines were incorporated into a magnetic contour map (Figure 3-5) established for this grid. Examination of the Grid 3 magnetic contour indicated:

- Two zones of magnetic anomaly identified within the western portion of this grid survey. A magnetic anomaly detected in the southwest corner of the grid with an intensity greater than 1,000 gammas and an estimated depth of burial of 2 to 22 feet. This anomaly may indicate significant amounts of buried ferromagnetic materials in this area of the survey grid. A second zone of magnetic anomaly was detected at 190N/0E and 190N/50E with an estimated depth of burial of 2 to 22 feet and an intensity of 150 to 1,500 gammas. The main portion of buried metallic debris may be at 190N/0E, with some minor extension to the east.

- The central portion of this survey grid is defined as free of magnetic anomalies. Therefore, it likely does not contain buried iron-rich materials.

- Two magnetic zones identified within the eastern portion of the grid. A local magnetic anomaly indicative of significant amounts of buried iron-rich materials was detected on traverse line 016 at approximately 70N. The estimated depth of burial for this anomaly was 12 feet. The intensity of this anomaly is approximately 1,200 gammas. A second zone of magnetic anomaly was identified further north along the line 270 and 280N. The intensity of the identified anomalies range from 200 to 800 gammas with the estimated depth of burial varying from 8 to 22 feet. This zone may contain construction debris with concrete and rebarr and/or other iron-rich materials buried in a trench extending from E200 to E300 feet coordinates.

4 RESISTIVITY SURVEY

4.1 THEORY

Resistivity (P) is a fundamental property of materials, i.e., the resistance per unit volume. The resistivity of a material depends only on the type of the material, while resistance (R) depends on the material's size and shape. Electrical resistivity surveys for subsurface investigations are useful because various materials differ in their capacity to conduct electricity. Physical properties that affect electrical conductivity include variations in moisture content, density, and chemical composition.

Subsurface resistivity is determined by placing four electrodes along the ground in a straight line. An electrical current is then, introduced into the ground by two outer (current) electrodes, and the potential difference between the two inner (potential) electrodes is recorded. There are a number of different electrode arrangements. The Wenner arrangement consists of placing all four electrodes at an equal distance. In the Schlumberger arrangement, which was used at Fort Richardson, the spacing between the potential electrode is much smaller than that of the current electrode; only current electrodes are moved, and potential electrode spacing is changed only at selected exploration depths and/or when large potential is needed.

Resistivity is calculated using the current, potential differences, and the geometry of the electrode arrangement. Since subsurface materials are not made up of homogenous and isotropic materials, the resistivity calculated is referred to as the apparent resistivity. Apparent resistivity is a complex function of the geologic materials present, and their structure, geometry, moisture content, and thickness. The unit of resistivity used in this report is the Ohm-meter (Ohm-m).

4.2 INSTRUMENTATION

The resistivity survey at the Fort Richardson Landfill site was conducted using an ABEM-300C resistivity meter manufactured by Atlas Copco ABEM. The ABEM-300C is a portable unit that provides resistance (in Ohms or kilo Ohms) of subsurface materials. The instrument is capable of measuring resistance to a depth of greater than 1,000 feet. The terrameter SAS-300C is a complete transmitter/receiver system combined with a measuring voltage of 160 volts.

4.3 SURVEY METHODOLOGY

Deep vertical electrical soundings (VES) in the Schlumberger set up were used at the Fort Richardson site to define the vertical distribution of the electrical characteristics at selected locations. The overall objective of the resistivity survey at Fort Richardson was to provide further information on the vertical distribution of resistivities which could also assist in the interpretation of lateral changes in conductivity identified by the terrain conductivity survey. In the VES method, a series of measurements, centered on a single location, are made. The depth of penetration of a VES is a function of the spacing between the electrodes. Generally, the wider the spacing between the electrodes, the greater the depth of investigation. Electrode spacings were selected based on the type of strata expected at the Fort Richardson site and the compatibility of data with resistivity modeling programs used for data reduction.

4.4 DATA REDUCTION AND INTERPRETATION

A computer program was used to calculate the average soil resistivity at each sounding location. Program outputs are included in Appendix C.

Steps used in data reduction and interpretation of resistivity data are summarized as follows:

- Data collected in the field were entered into a microcomputer for resistivity computation.
- Data were interpreted and printed using an inverse-forvard program written by Interplex Limited. This program

tabulates the actual resistivity of a series of horizontal layers from measurements of apparent resistivity.

- o Interpreted resistivities from the inverse program were correlated with the terrain conductivity and assumed lithological units at each sounding location.

- o Interpreted resistivities and depths were then correlated to each other at each area, and the resulting average resistivity of each layer was attributed to a given lithological unit and/or to a conductive or possibly contaminated layer.

4.5 RESISTIVITY SURVEY RESULTS

Data from sensitivity soundings were incorporated into two profiles or geoelectric cross sections. Examination of these sections indicates:

- o The geoelectric cross section (Figure 4-2) established across the background of the site through soundings R6, R7, R8, R10, R11, R12 and R13 (Figure 4-2) shows a very heterogeneous lithology with significant discontinuities and interfingering of lithologic units. This is common to glacial deposits. However, the top portion of each sounding is marked by a resistive geoelectrical layer with resistivity value greater than 1,000 ohm x feet reflecting a dry or semidry gravelous lithologic unit. The depth of this layer ranges from 140 to greater than 400 feet bgs. A conductive geoelectric layer with resistivity lower than 500 ohm feet was detected in R6, R7, R10 and R11 at various depths. This low resistivity layer may indicate the presence of a clayey layer and/or conductive groundwater beneath these sounding location. Major lithologic changes were inferred from R8 and R10, which showed a geoelectric layer with resistivity values ranging from 500 to 1,000 Ohm x feet. This layer may indicate a sandy gravel with some minor amounts of silt and clay. A marshy type of surface soil existed at R10. A very conductive layer was detected at a depth greater than 345 feet.

- o The geoelectric cross (Figure 4-3) section established downgradient from the landfill, through R1, R2, R14, R4M, R3, R4NM and R5, indicates variable lithology across the profile. The eastern section of the profile is characterized by predominantly gravel type lithologic unit with resistivity value greater than 1,000 ohm feet (R1, R2, R14, and R4M). The western portion of the profile (R3, R4NM and R5) shows some conductive layers at shallow depth. It should be noted that R1 and R2 are the most representative sounding with little or no interferences. Other soundings were subject of various degrees of interferences from fences, landfills, roads, overhead power lines. The depth to the groundwater varies from 90 to 150

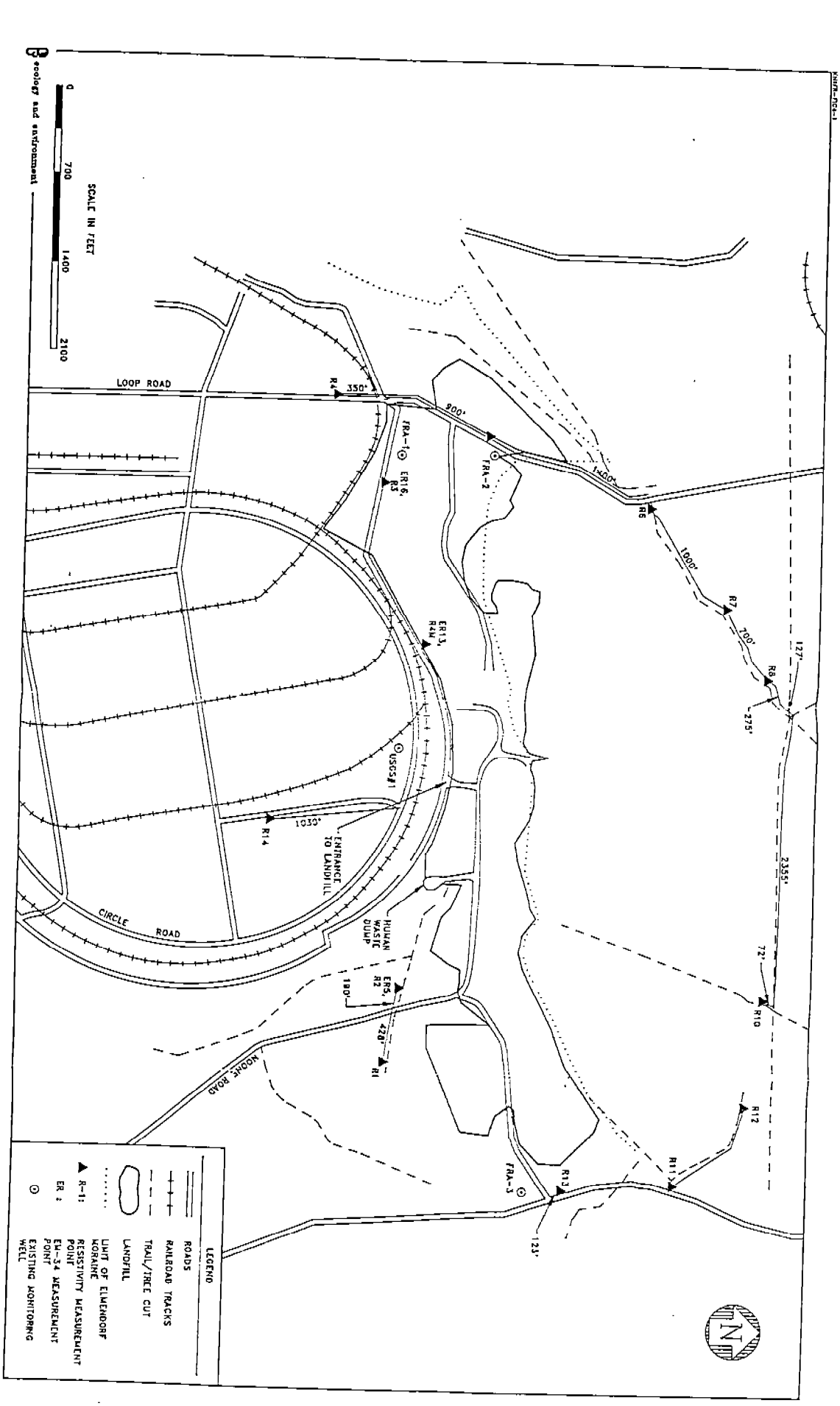


Figure 4-1 FORT RICHARDSON LANDFILL
ANCHORAGE, ALASKA
RESISTIVITY SOUNDING
LOCATION MAP

FTR 0018615

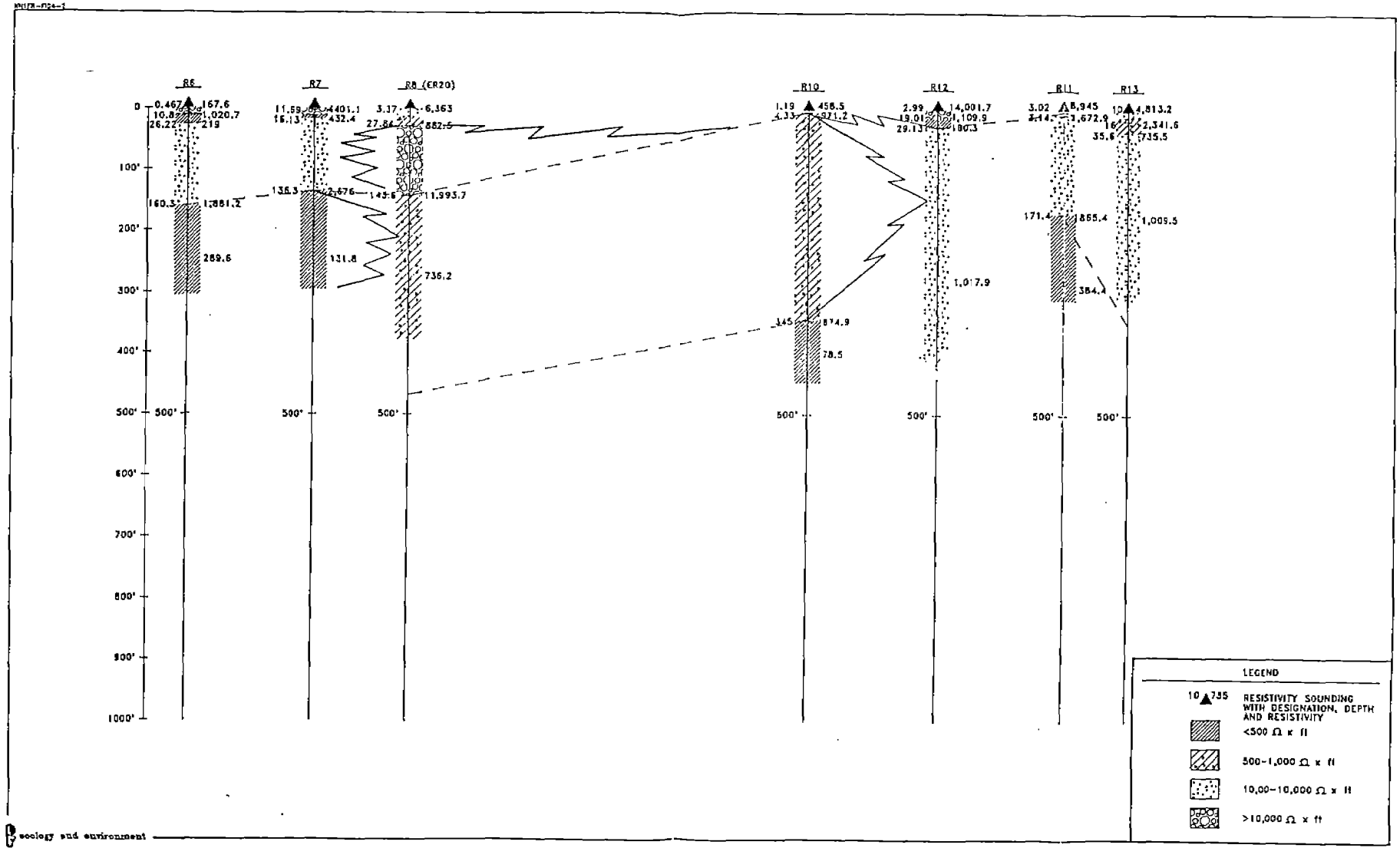
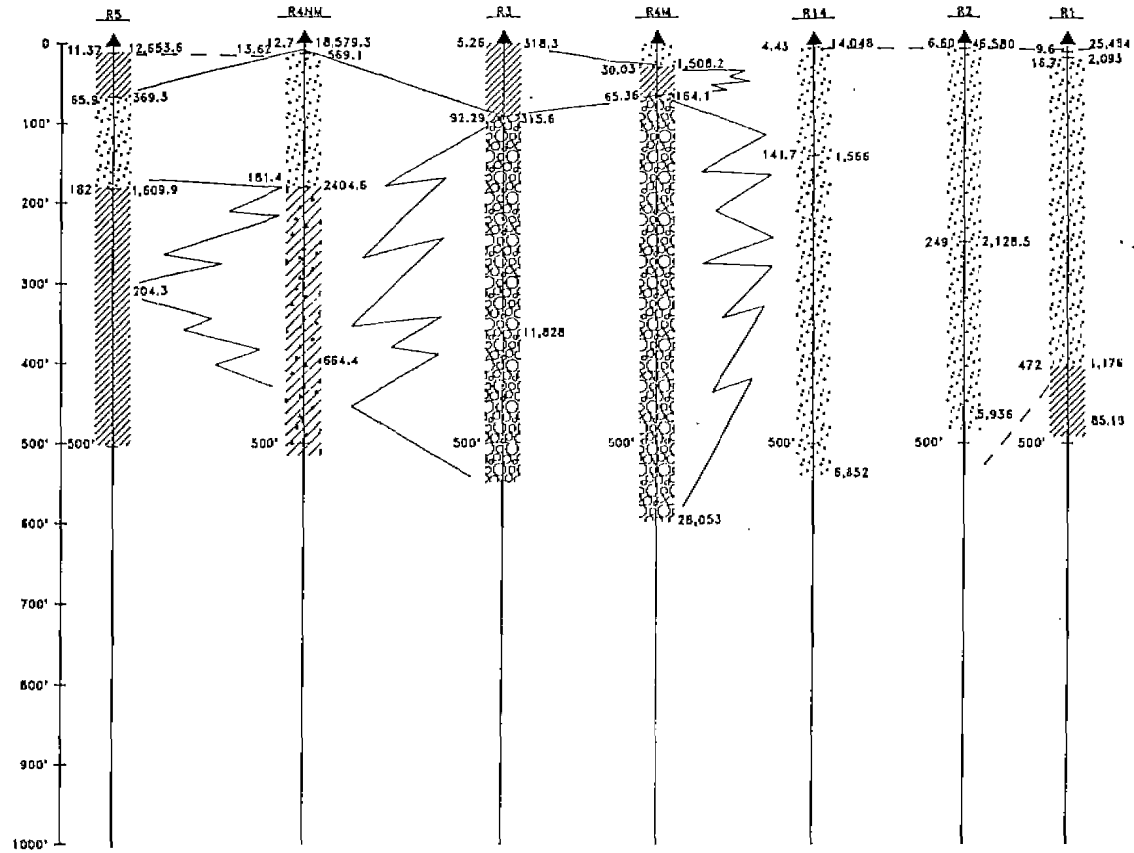


Figure 4-2 FORT RICHARDSON LANDFILL GEOPHYSICAL INVESTIGATION GEOELECTRIC PROFILES OF VES

FTR 0018616



ecology and environment

Figure 4–3 FORT RICHARDSON LANDFILL
GEOPHYSICAL INVESTIGATION
GEOELECTRIC PROFILES
OF VES

feet. The water level is generally indicated by a slight decrease in resistivity values from the top gravel and dry soil. A conductive layer, that could represent the confining clay layer beneath the first water table, was identified at 350 to 400 feet in both R1 and R2. Conductive layers with resistivity values less than 500 Ohm-feet, identified at R4M, R3, and R5, at shallow depth were associated with buried conductive materials and some surface interferences.

5 CONCLUSIONS AND RECOMMENDATIONS

5.1 CONCLUSIONS

Shallow and deep geophysical surveys were conducted at Fort Richardson Landfill. The investigation used three different geophysical techniques: EM-31 and EM-34 terrain conductivity, magnetometry, and deep vertical electrical sounding (VES).

The principal conclusions of the geophysical surveys, with respect to the potential environmental impacts are:

- The eastern and western boundaries of the landfills were identified through EM-31 survey. The actual boundaries of the landfill are marked by the isoconductivity line 4.5 mmhos/m.

- Selected areas of landfill (Grid 1, 2, and 3) surveyed through EM-31 and magnetometry indicated the presence of a significant amount of buried waste. Grids 1 and 2 contain significant amounts of buried metallic materials (metallic objects, construction debris with rebarr, metal wires. and possibly metallic containers such as steel drums and/or buckets). In each grid area, the EM-31 delineated several zones of buried conductive waste and magnetometry provided confirmation of the EM-31 results and detected areas of buried metals within the EM-31 anomalous zones. Grid 3 did not indicate a significant amount of buried waste, with the exception of minor burial of conductive waste and ferromagnetic materials along the eastern and western boundaries of this grid.

- The EM-34 survey results did not identify any major conductivity contrast within the subsurface in the surveyed area, that may be associated with a possible groundwater contaminant leachate. The EM-34 data suggests homogeneous lithology from surface to the maximum depth of exploration. An area of potential deep and shallow buried conductive waste was identified at ER14, ER15, and ER16 locations. This area may contain various types of wastes such as construction debris and possibly metallic containers. The subsurface conductivity increased near the human waste area.

- The electrical soundings, while providing detailed information on subsurface lithology downgradient and upgradient from the landfill, did not identify evidence of groundwater leachate. The most abundant lithology underlying the site is resistive gravel units with some underlying layers of increased conductivity (sandy and clayey) at depths 250 to 400 feet below the ground surface. Variations from this general lithology were observed on some soundings displaying lithological units with intermediate resistivity values (e.g., sand and gravel).

5.2 RECOMMENDATIONS

Based on the results of geophysical investigation conducted at Fort Richardson Landfill, E & E recommends the following:

- The findings of the terrain conductivity survey on the eastern and western boundaries of the landfill may be conducted should the need for remediation be identified through a test pit excavation program. If a clean up is required for the site, this test may become mandatory and very cost efficient for remediation.

- Similar to the findings of EM-31 on landfill boundaries, the grids surveyed with both EM-31 and magnetometry detected numerous areas of buried conductive wastes that need to be further studied through test pit and soil borings. If these results need to be field proved, a comprehensive exploration program through excavation and soil boring will be proposed. However, this should not be performed prior to groundwater testing.

- The principal goal of deep geophysical surveys (EM-34 and deep resistivity) was to provide the best suited and most cost efficient monitoring well locations to promptly monitor the groundwater beneath the landfill. Due to the lack of clear evidence for groundwater contamination and/or highly contrasted plume of leachate, E & E proposes four monitoring wells instead of the initial six wells, in the downgradient area from the landfill and one, instead of two, monitoring wells in the area upgradient from the landfill. The proposed locations of monitoring wells (figure 5-1) were based on the results of geophysical surveys conducted at the site. To verify the depth of the clay confining unit, at least one boring should be drilled to deeper than 200 feet below the ground surface.

FTR 0018620

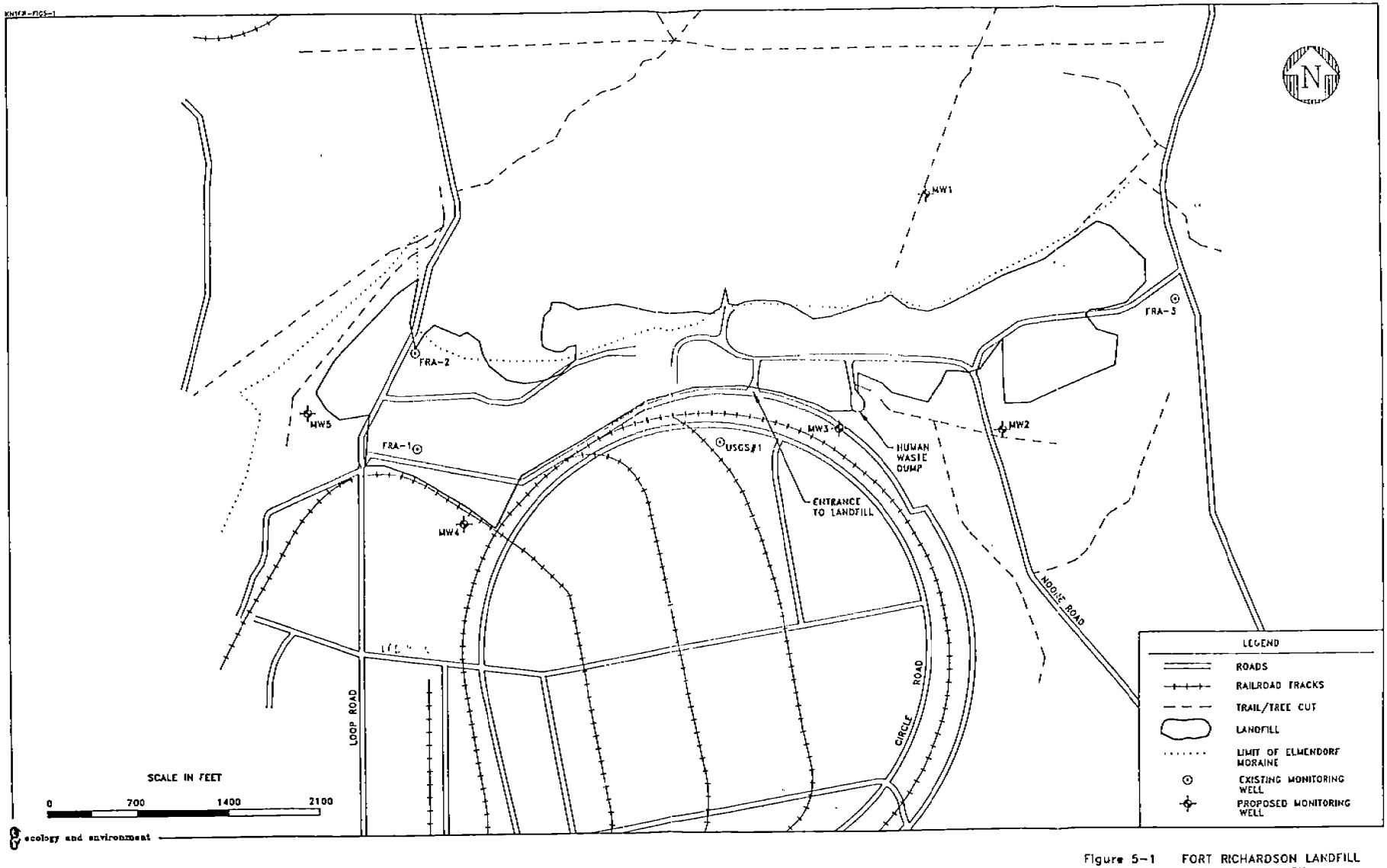


Figure 5-1 FORT RICHARDSON LANDFILL ANCHORAGE, ALASKA MONITORING WELL LOCATION MAP

The proposed monitoring wells will provide the confirmation of the potential groundwater contamination from the landfill. If approved, additional monitoring well and aquifer testing may be recommended.

APPENDIX A

TERRAIN CONDUCTIVITY DATA

TERRAIN CONDUCTIVITY SURVEY

DATA SHEET

Instrument EM-34DLXL

Coil Separation 10,20 & 40m

Dipole Configuration Vertical & Horizontal

Remarks Calibration line

Project No. KN1080

Client C.E.O

Location Anchorage ALASKA

Date

Personnel AA/M.S

Line	Station	Orientation: VD Conductivity (millimhos/meter)	Orientation: HD Conductivity (millimhos/meter)	Remarks
		2.82	1.90	10m sp.
		<0	1.50	20m sp.
		3.3	1.60	40m sp.

TERRAIN CONDUCTIVITY SURVEY

DATA SHEET

Instrument EM-34 DL XL
Coil Separation 10,20&40m
Dipole Configuration VD & HD
Remarks

Project No. KN1080
Client C.D.E
Location Anchorage ALASKA
Date 7/17/1990
[redacted] Personnel A.A / M.S

Line	Station	Orientation: VD Conductivity (millimhos/meter)	Orientation: HD Conductivity (millimhos/meter)	Remarks
	ER-1	2.80	2.40	10m sp.
		40	1.40	20m sp.
		2.40	1.70	40m sp
	ER-2	3.40	2.70	
		3.20	40	
		2.55	2.30	
	ER-3	3.10	2.80	
		2.98	2.40	
		2.50	3.00	
	ER-4	3.40	2.20	
		2.97	2.30	
		3.20	1.9	
	ER-5	3.50	2.70	10m sp.
		2.98	2.60	20m sp.

TERRAIN CONDUCTIVITY SURVEY

DATA SHEET

Instrument EM34 DL XL
Coil Separation 10,20&40m
Dipole Configuration VD & HD
Remarks _____

Project No. KN1080
Client C.O.E
Location Anchorage ALASKA
Date 7/17/90
[redacted] Personnel A.A / H.S

Line	Station	Orientation: VD Conductivity (millimhos/meter)	Orientation: HD Conductivity (millimhos/meter)	Remarks
		3.20	2.00	40m sp.
	ER-6	3.60	2.50	10m sp. } in I
		3.00	2.30	20m sp. } wooded
		3.40	2.80	40m sp. } area
	ER-7	4.00	2.90	
		3.70	2.60	
		3.40	2.50	
	ER-8	4.60	3.10	
		4.10	3.10	
		4.20	3.60	
	ER-9	9.80	5.80	
		<0	14.00	Close to R fence
		16.80	14.00	// to fence

TERRAIN CONDUCTIVITY SURVEY

DATA SHEET

Instrument EM-34 DL XL
Coil Separation 10, 20 & 40m
Dipole Configuration VD & HD
Remarks _____

Project No. KN1080
Client C.O.E
Location Anchorage Alaska
Date 7/17/90
Personnel A.A/M.S.

Line	Station	Orientation: VD Conductivity (millimhos/meter)	Orientation: HD Conductivity (millimhos/meter)	Remarks
	ER-10	10.80	6.65	10m (20-25' from fence)
		<10 NF	5.50 NF	≠ 2cm sp. (Needle
		19.80	17.40	40m sp. Fluctuation =NF)
	ER11	11.80	11.20	11 (20-25') from
		<10 NF	12.50	Fence
		15.90	15.50	
	ER-12	7.45	4.40	
		10.50	3.50	40-45' from Fence
		18.90	1.60	
	ER-13	13.90	6.20	3 metal pipes on
		23.80	6.20	slop
		34.00	7.00	

TERRAIN CONDUCTIVITY SURVEY

DATA SHEET

Instrument EM-34DLXL
Coil Separation 10,20,40m
Dipole Configuration VD & HD
Remarks

Project No. KN1080
Client C.O.E
Location Anchorage ALASKA
Date 7/17/90
[redacted] Personnel AA/H.S.

Line	Station	Orientation: VD Conductivity (millimhos/meter)	Orientation: HD Conductivity (millimhos/meter)	Remarks
	ER14	17.50	8.90	10m sp. gentle slop
		34.00	10.50	20m sp.
		60.00	13.00	40m sp.

U

TERRAIN CONDUCTIVITY SURVEY

DATA SHEET

Instrument EM-34 BL AL
Coil Separation 10, 20 84m
Dipole Configuration VD & HD
Remarks Calibration Line

Project No. KN1080
Client C.O.E
Location Anchorage ALASKA
Date 1/18/90
[redacted] Personnel A.A/M.S/B.

Line	Station	Orientation: VD Conductivity (millimhos/meter)	Orientation: HD Conductivity (millimhos/meter)	Remarks
		2.82	1.80	10m sp.
		2.0	1.58	20m sp.
		3.38	1.66	40m sp.

U

TERRAIN CONDUCTIVITY SURVEY

DATA SHEET

Instrument EM-34 DL xL

Coil Separation 10, 20 & 40m

Dipole Configuration VD & HD

Remarks _____

_____

Project No. KN1080

Client C.O.E

Location Anchorage ALASKA

Date 7/18/90

[redacted] Personnel AA/H.S/B

Line	Station	Orientation: VD Conductivity (millimhos/meter)	Orientation: HD Conductivity (millimhos/meter)	Remarks
	ER-19	6.50	45.00	10m sp.
		<0, NF	<0 NF	20m sp.
		<0 NF	44.00	40m sp.
	ER-20	2.50	1.65	
		1.40	1.20	
		1.70	2.80	

TERRAIN CONDUCTIVITY SURVEY

DATA SHEET

Instrument EM-34DLXL
Coil Separation 10,20,40m
Dipole Configuration VD & HD
Remarks

Project No. KN10.80
Client C.O.E
Location Anchorage ALASKA
Date 7/18/90
Personnel AA / M.S / B

Line	Station	Orientation: VD Conductivity (millimhos/meter)	Orientation: HD Conductivity (millimhos/meter)	Remarks
	ER-15	22.50	9.50	10m SP 2o.2[illegible] Gravel Fan
		55.00	26.00	20m SP Fill +
		115.00	115.00	40m SP Concrete
	ER-16	20	15.00	
		10.00	12.00	
		39.00	34.00	
	ER-17	4.50	3.15	
		5.80	2.80	
		4.30	2.70	
	ER-18	2.70	2.65	
		2.10	2.10	
		1.38	1.38	

APPENDIX B

MAGNETIC DATA

ECOLOGY & ENVIRONMENT, INC.

FORT RICHARDSON LANDFILL
MAGNETIC SURVEY DATA

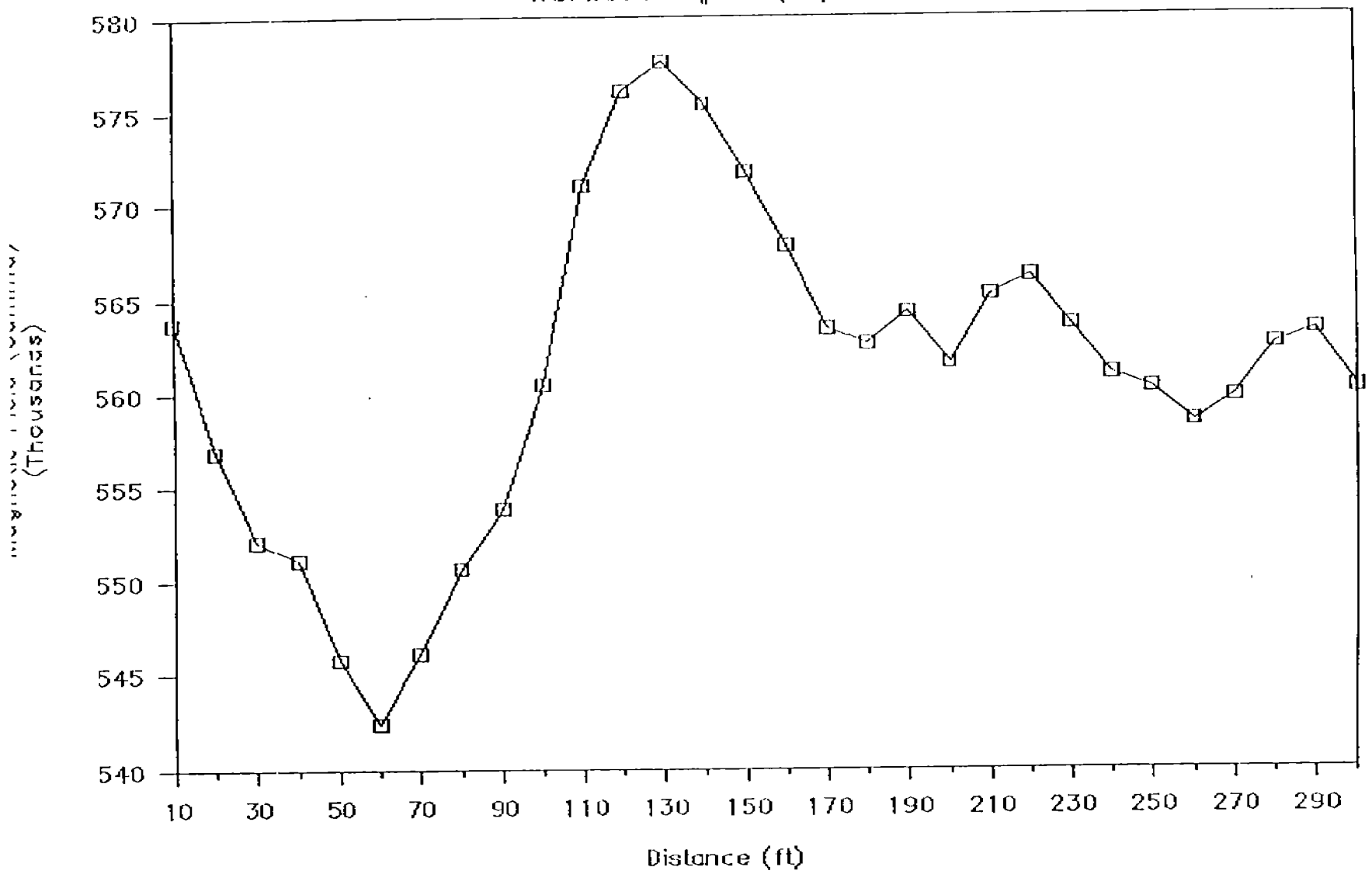
TRAVERSE LINE # 002/001

LINE #	SITE #	FEET	TIME	GAMMAS
002/710	0	0	09:09:56	56374.3
002/710	1	10	09:11:02	55688.7
002/710	2	20	09:11:18	55209.5
002/710	3	30	09:11:29	55119.3
002/710	4	40	09:11:42	54576.5
002/710	5	50	09:11:56	54237.7
002/710	6	60	09:12:07	54609.0
002/710	7	70	09:12:26	55064.2
002/710	8	80	09:12:30	55379.1
002/710	9	90	09:13:11	5604..9
002/710	10	100	09:13:35	57094.5
002/710	11	110	09:13:51	57610.6
002/710	12	120	09:16:47	57763.0
002/710	13	130	09:17:00	57535.1
002/710	14	140	09:17:12	57166.3
002/710	15	150	09:17:24	56779.6
002/710	16	160	09:17:35	56339.4
002/710	17	170	09:18:17	56257.7
002/710	18	180	09:18:31	56438.4
002/710	19	190	09:18:52	56198.7
002/710	20	200	09:19:09	55513.3
002/710	21	210	09:19:55	56635.7
002/710	22	220	09:20:12	56361.6
002/710	23	230	09:20:26	56090.5
002/710	24	240	09:20:52	56014.7
002/710	25	250	09:21:05	55833.7
002/710	27	260	09:21:34	55966.7
002/710	28	270	09:21:48	56248.6
002/710	29	280	09:22:01	56325.7
002/710	30	290	09:22:16	56069.7

FTR 0018633

Fort Richardson Landfill

Traverse line #001 (G2)



ECOLOGY & ENVIRONMENT, INC.

PORT RICHMOND LANDFILL
MAGNETIC SURVEY DATA

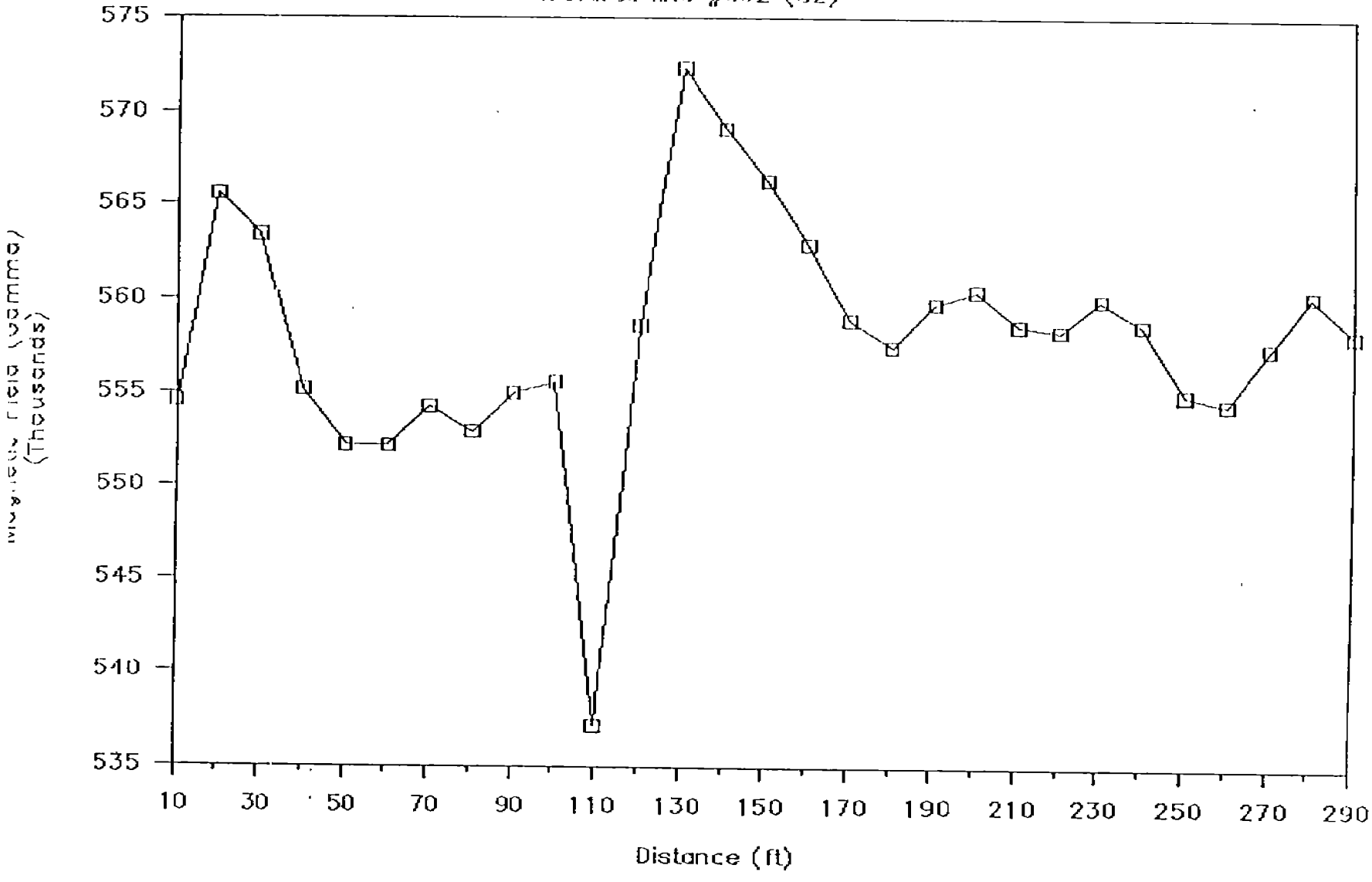
TRAVERSE LINE # 002/ 2

LINE #	SITE #	FEET	TIME	GAMMAS
002/ 2	31	0	09:29:33	55454.8
002/ 2	32	10	09:31:20	56555.4
002/ 2	33	20	09:32:16	56389.0
002/ 2	34	30	09:32:54	55516.8
002/ 2	35	40	09:33:15	55218.2
002/ 2	36	50	09:33:34	55316.4
002/ 2	37	60	09:33:51	55426.6
002/ 2	38	70	09:34:07	55390.5
002/ 2	40	90	09:36:15	55497.2
002/ 2	41	90	09:38:58	56557.1
002/ 2	42	100	09:39:44	55716.5
002/ 2	44	110	09:40:18	55859.7
002/ 2	45	120	09:40:50	57835.5
002/ 2	46	130	09:41:11	56911.4
002/ 2	47	140	09:41:31	56617.4
002/ 2	48	150	09:41:48	56388.6
002/ 2	49	160	09:42:10	55851.1
002/ 2	50	170	09:42:24	55943.7
002/ 2	51	180	09:42:42	55970.4
002/ 2	52	190	09:43:02	56048.1
002/ 2	53	200	09:43:21	55851.1
002/ 2	54	210	09:43:44	55809.4
002/ 2	55	220	09:44:03	55999.7
002/ 2	56	230	09:44:23	55861.1
002/ 2	57	240	09:44:39	55486.9
002/ 2	58	250	09:45:02	55449.1
002/ 2	59	260	09:45:18	55729.4
002/ 2	60	270	09:45:36	56022.5
002/ 2	61	280	09:45:56	55810.9

FTR 0018635

Fort Richardson Landfill

Traverse line #002 (G2)



ECOLOGY & ENVIRONMENT, INC.

FORT RICHARDSON LANDFILL
MAGNETIC SURVEY DATA

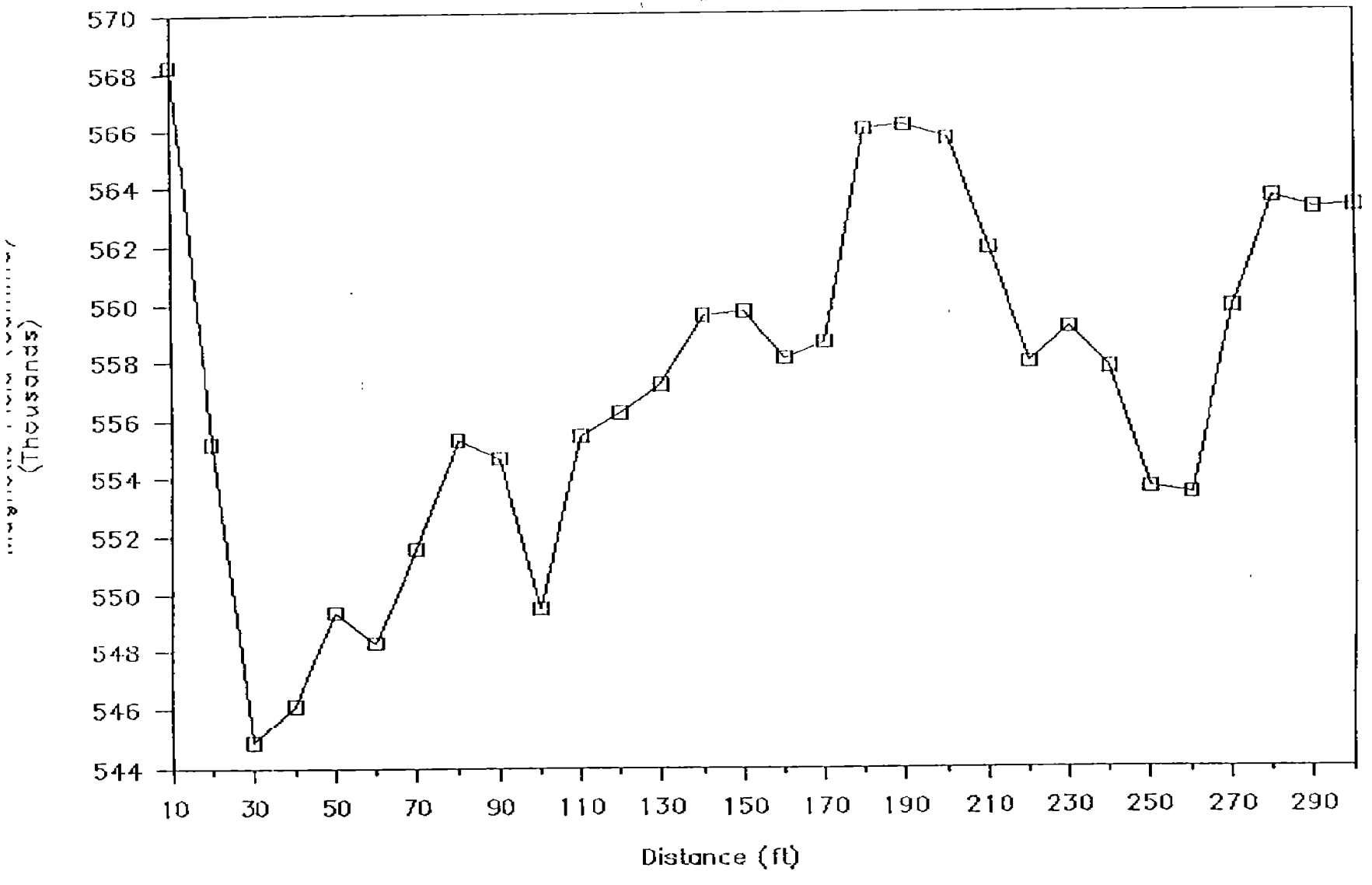
TRAVERSE LINE # 002/ 3

LINE #	SITE #	FEET	TIME	GAMMAS
002/ 3	72	0	10:08:00	54949.7
002/ 3	73	10	10:08:14	55544.2
002/ 3	74	20	10:09:31	55622.4
002/ 3	75	30	10:09:47	55719.5
002/ 3	76	40	10:10:01	55957.1
002/ 3	77	50	10:10:15	55969.6
002/ 3	78	60	10:10:30	55807.3
002/ 3	79	70	10:10:45	55861.6
002/ 3	81	80	10:12:06	56597.8
002/ 3	82	90	10:12:23	56611.2
002 3	83	100	10:12:43	56565.1
002 3	84	110	10:13:08	56187.6
002 3	85	120	10:13:25	55730.3
002 3	86	130	10:13:51	55913.9
002/ 3	87	140	10:14:05	55771.7
002/ 3	88	150	10:14:20	55356.8
002/ 3	89	160	10:14:47	55238.4
002/ 3	90	170	10:15:02	55551.4
002/ 3	91	180	10:15:23	56058.7
002 3	92	190	10:15:47	56317.3
002/ 3	93	200	10:16:08	56113.9

FTR 0018637

Fort Richardson Landfill

Traverse line #003 (G2)



ECOLOGY & ENVIRONMENT, INC.

FORT RICHARDSON LANDFILL
MAGNETIC SURVEY DATA

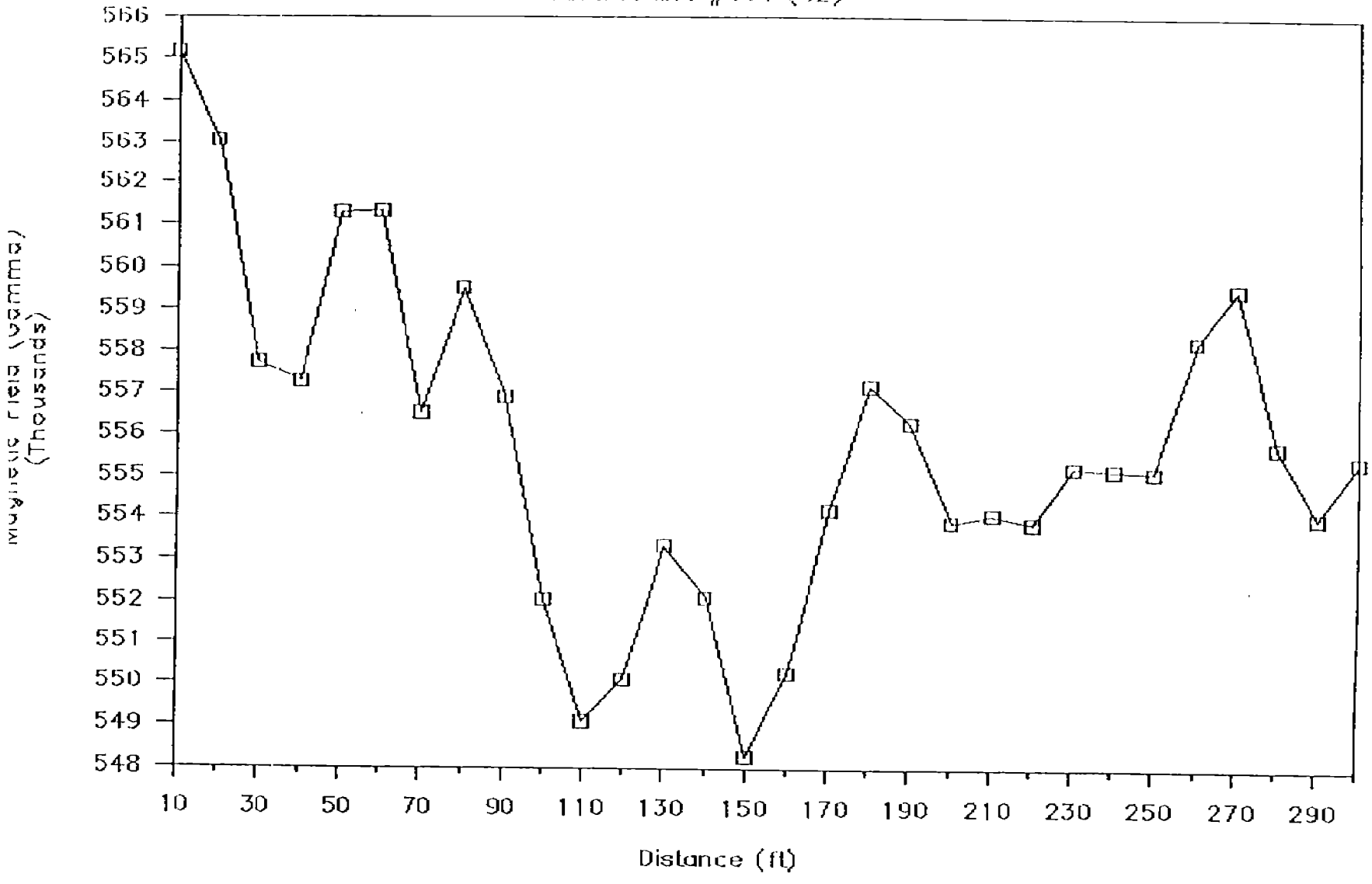
TRAVERSE LINE # 002/ 4

LINE #	SITE #	FEET	TIME	GAMMAS
002/ 4	94	0	10:28:03	56515.8
002/ 4	95	10	10:28:50	56305.0
002/ 4	96	20	10:29:07	55772.6
002/ 4	97	30	10:29:26	55726.2
002/ 4	98	40	10:29:41	56129.2
002/ 4	99	50	10:30:00	56132.1
002/ 4	100	60	10:30:20	55651.6
002/ 4	101	70	10:30:40	55951.2
002/ 4	102	80	10:30:54	55689.5
002/ 4	103	90	10:31:15	55205.0
002/ 4	104	100	10:31:41	54909.5
002/ 4	105	110	10:32:27	55005.4
002 4	106	120	10:33:20	55534.0
002/ 4	107	130	10:33:38	55210.1
002/ 4	108	140	10:34:02	54806.8
002/ 4	109	150	10:34:32	55004.9
002/ 4	110	160	10:34:55	55418.6
002/ 4	111	170	10:36:02	55715.4
002/ 4	112	180	10:35:22	55627.1
002/ 4	113	190	10:36:39	55358.6
002/ 4	114	200	10:36:57	55406.7
002/ 4	115	210	10:38:58	55385.1
002 4	116	220	10:39:53	55519.1
002/ 4	117	230	10:40:16	55514.1
002/ 4	118	240	10:40:35	55508.4
002/ 4	119	250	10:41:11	55823.3
002/ 4	120	260	10:42:19	55949.9
002/ 4	121	270	10:42:39	55568.9
002/ 4	122	280	10:43:01	55399.6
002/ 4	123	290	10:43:15	55534.7

FTR 0018639

Fort Richardson Landfill

Traverse line #004 (G2)



ECOLOGY & ENVIRONMENT, INC.

FORT RICHARDSON LANDFILL
MAGNETIC SURVEY DATA

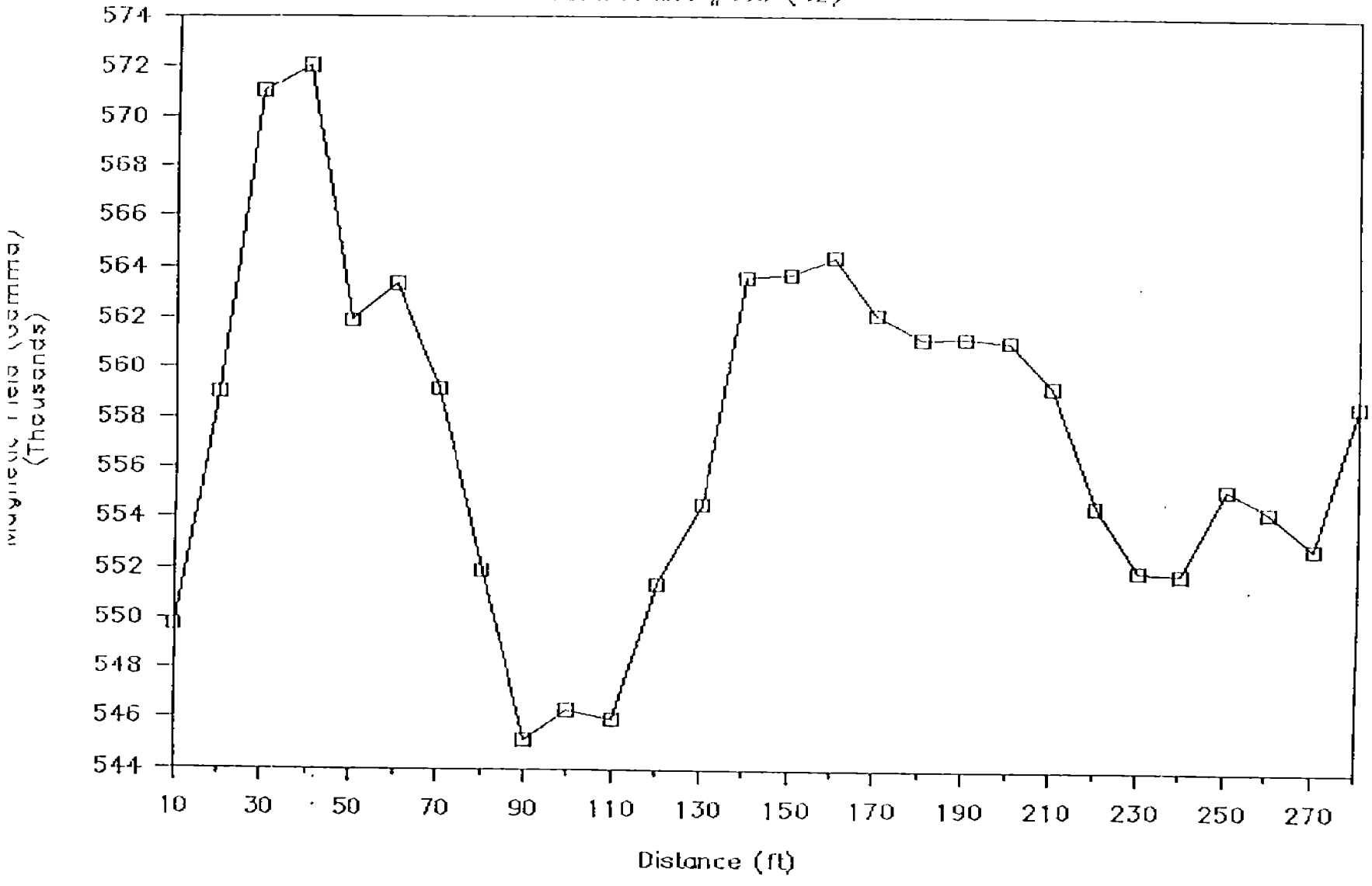
TRANSECT LINE # 002/ 5

LINE #	SITE #	FEET	TIME	GAMMAS
002/ 5	125	0	11:02:53	54977.7
002/ 5	126	10	11:03:36	55899.4
002/ 5	127	20	11:03:50	57105.6
002/ 5	128	30	11:04:03	57204.5
002/ 5	130	40	11:04:32	56192.2
002/ 5	131	50	11:04:55	56338.8
002/ 5	132	60	11:05:19	55916.2
002/ 5	133	70	11:05:38	55193.9
002/ 5	135	80	11:06:02	54514.9
002 5	136	90	11:06:25	54531.5
002/ 5	137	100	11:06:45	54594.3
002/ 5	138	110	11:07:02	55141.4
002/ 5	139	120	11:07:24	55458.9
002/ 5	141	130	11:09:42	56362.9
002/ 5	142	140	11:10:07	56394.7
002/ 5	143	150	11:10:27	56442.5
002/ 5	144	160	11:10:47	56217.5
002 5	145	170	11:11:09	56120.9
002 5	146	180	11:11:33	56122.4
002/ 5	147	190	11:12:07	56111.0
002/ 5	148	200	11:12:48	55934.5
002/ 5	149	210	11:13:06	55448.5
002/ 5	150	220	11:13:31	55198.0
002/ 5	151	230	11:13:44	55157.1
002/ 5	152	240	11:14:06	55818.7
002/ 5	153	250	11:14:20	55481.8
002/ 5	154	260	11:14:35	55385.4
002/ 5	155	270	11:14:49	55356.1

FTR 0018641

Fort Richardson Landfill

Traverse line #0005 (G2)



ECOLOGY & ENVIRON-ENT, INC.

PORT RICHARDSON LANDFILL
MAGNETIC SURVEY DATA

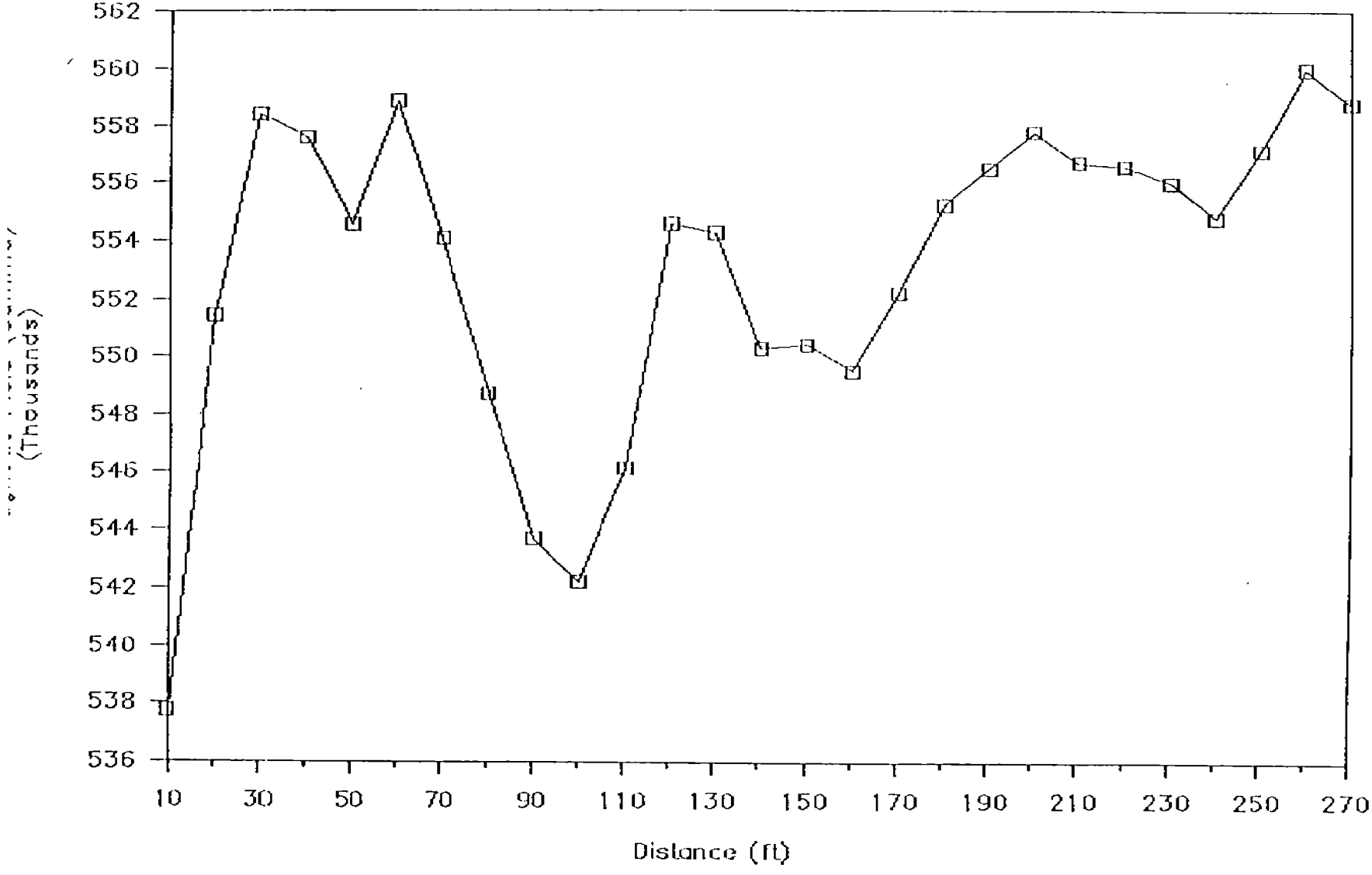
TRAVERSE LINE # 002 6

LINE #	SITE #	FEET	TIME	GAMMAS
002/ 6	156	0	11:25:58	53773.5
002/ 6	157	10	11:27:02	55143.9
002/ 6	158	20	11:27:16	55843.7
002/ 6	159	30	11:27:29	55762.2
002/ 6	160	40	11:27:44	55456.6
002/ 6	162	50	11:28:11	55889.6
002/ 6	163	60	11:28:46	55411.2
002/ 6	164	70	11:29:00	54870.6
002/ 6	166	80	11:29:55	54367.3
002 6	167	90	11:31:11	54221.6
002 6	168	100	11:31:59	54613.1
002 6	169	110	11:32:34	55458.9
002 6	170	120	11:33:11	55439.0
002 6	173	130	11:34:32	55039.1
002 6	174	140	11:35:15	55040.3
002 6	175	150	11:35:38	54948.7
002 6	176	160	11:36:57	55239.5
002 6	177	170	11:36:25	55534.3
002 6	178	180	11:36:42	55549.9
002 6	179	190	11:37:07	55739.9
002 6	180	200	11:37:21	55671.7
002 6	181	210	11:37:54	55656.8
002 6	182	220	11:37:37	55600.0
002/ 6	183	230	11:38:32	55479.2
002/ 6	184	240	11:39:01	55715.3
002/ 6	185	250	11:39:21	56009.9
002/ 6	186	260	11:39:37	55882.7

FTR 0018643

Fort Richardson Landfill

Traverse line #DD5 (C2)



ECOLOGY & ENVIRONMENT, INC.

FORT RICHARDSON LANDFILL
MAGNETIC SURVEY DATA

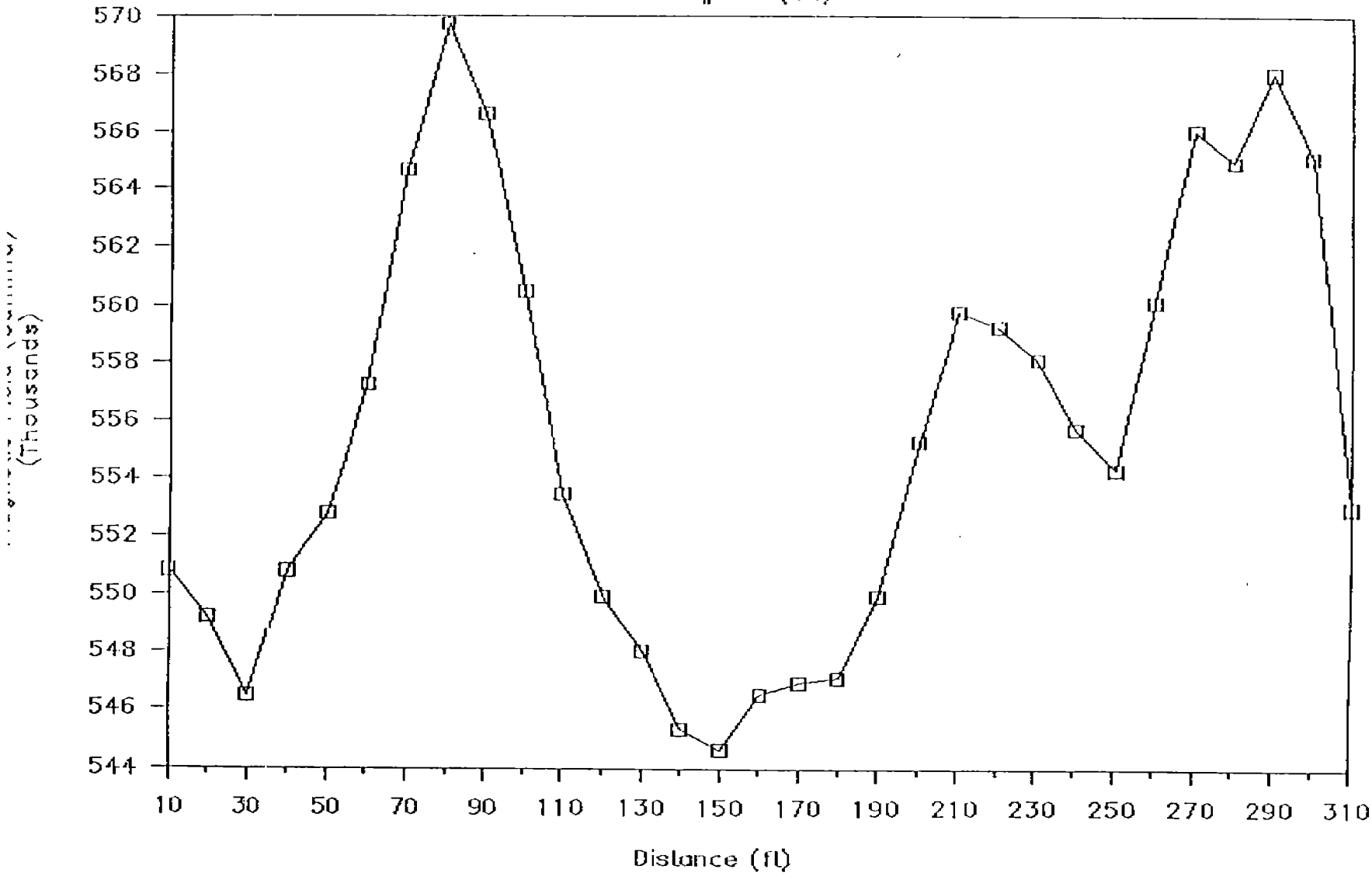
TRAVERSE LINE # 002- 7

LINE #	SITE #	FEET	TIME	GAMMAS
002/ 7	187	0	13:22:05	55084.2
002/ 7	188	10	13:22:36	54923.5
002/ 7	189	20	13:23:37	54643.9
002/ 7	190	30	13:23:52	55080.5
002/ 7	191	40	13:24:05	55277.0
002/ 7	192	50	13:24:18	55723.5
002/ 7	193	60	13:25:07	56464.3
002/ 7	194	70	13:25:30	56971.7
002/ 7	195	80	13:25:45	56663.7
002/ 7	196	90	13:25:58	56051.9
002 7	197	100	13:26:12	55342.4
002 7	198	110	13:26:29	54991.5
002 7	199	120	13:27:01	54798.4
002/ 7	200	130	13:27:47	54923.6
002/ 7	201	140	13:28:00	54468.1
002/ 7	202	150	13:28:32	54645.7
002/ 7	203	160	13:28:50	54839.5
002/ 7	204	170	13:29:04	54796.9
002 7	205	180	13:29:25	54990.9
002 7	206	190	13:29:38	55505.4
002 7	207	200	13:29:52	55979.6
002/ 7	208	210	13:30:43	55525.5
002 7	209	220	13:31:21	55810.5
002/ 7	210	230	13:31:41	55568.0
002/ 7	211	240	13:31:54	55423.2
002/ 7	212	250	13:32:08	56011.6
002 7	213	260	13:32:37	56606.9
002/ 7	214	270	13:32:47	56491.5
002/ 7	215	280	13:33:00	56604.4
002/ 7	216	290	13:33:14	56511.3
002/ 7	217	300	13:33:28	55294.8

FTR 0018645

Fort Richardson Landfill

Traverse line #007 (G2)



BECKLEY & ENVIRONMENTAL, INC.

PORT RICHARDSON LANDFILL
MAGNETIC SURVEY DATA

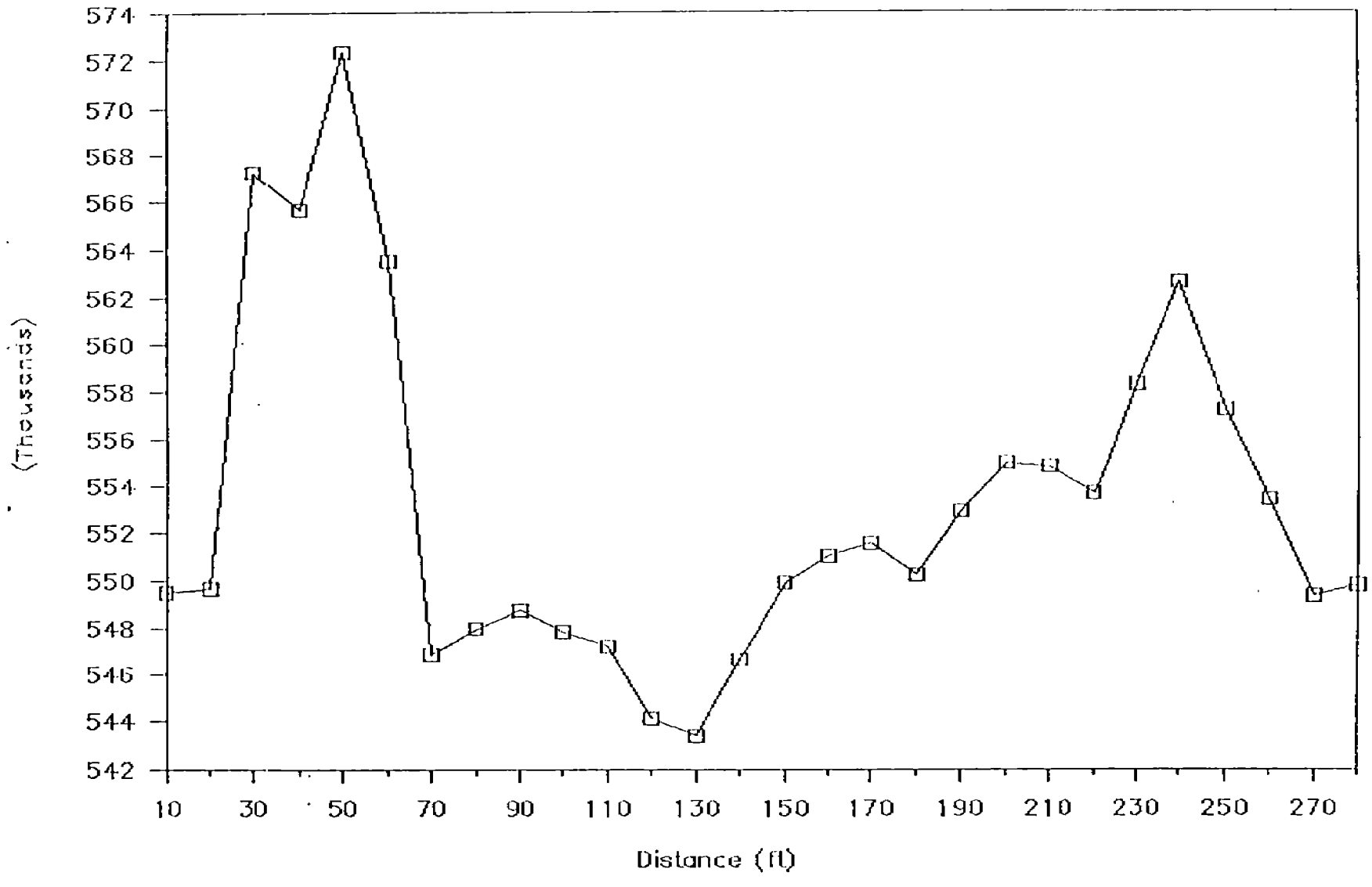
TRANSPOSE LINE # 002/ 8

LINE #	SITE #	FEET	TIME	GAMMAS
002/ 8	218	0	13:45:04	54951.2
002/ 8	219	10	13:45:42	54967.8
002/ 8	220	20	13:45:56	56724.1
002/ 8	221	30	13:46:11	56565.9
002/ 8	222	40	13:46:24	57231.9
002/ 8	223	50	13:46:40	56354.0
002/ 8	224	60	13:46:53	54687.7
002/ 8	226	70	13:49:17	54799.5
002/ 8	227	80	13:49:50	54577.8
002/ 8	228	90	13:49:06	54782.7
002/ 8	229	100	13:49:42	54728.5
002/ 8	230	110	13:50:00	54431.8
002/ 8	231	120	13:50:14	54340.6
002/ 8	232	130	13:50:32	54668.2
002/ 8	233	140	13:50:48	54590.9
002/ 8	234	150	13:51:01	55100.5
002/ 8	235	160	13:51:19	55154.8
002/ 8	236	170	13:51:59	55123.1
002/ 8	237	180	13:52:34	55137.5
002/ 8	238	190	13:52:00	55495.0
002/ 8	239	200	13:53:41	55477.5
002/ 8	240	210	13:54:04	55361.5
002/ 8	241	220	13:54:2?	55326.8
002/ 8	242	230	13:54:47	56260.7
002/ 8	244	240	13:55:18	55729.2
002/ 8	245	250	13:55:33	55835.7
002/ 8	246	260	13:55:49	54936.0
002/ 8	248	270	13:56:36	54979.5

FTR 0018647

Fort Richardson Landfill

Traverse line #008 (C2)



ECOLOGY & ENVIRONMENT, INC.

PORT RICHARDSON LANDFILL
MAGNETIC SURVEY DATA

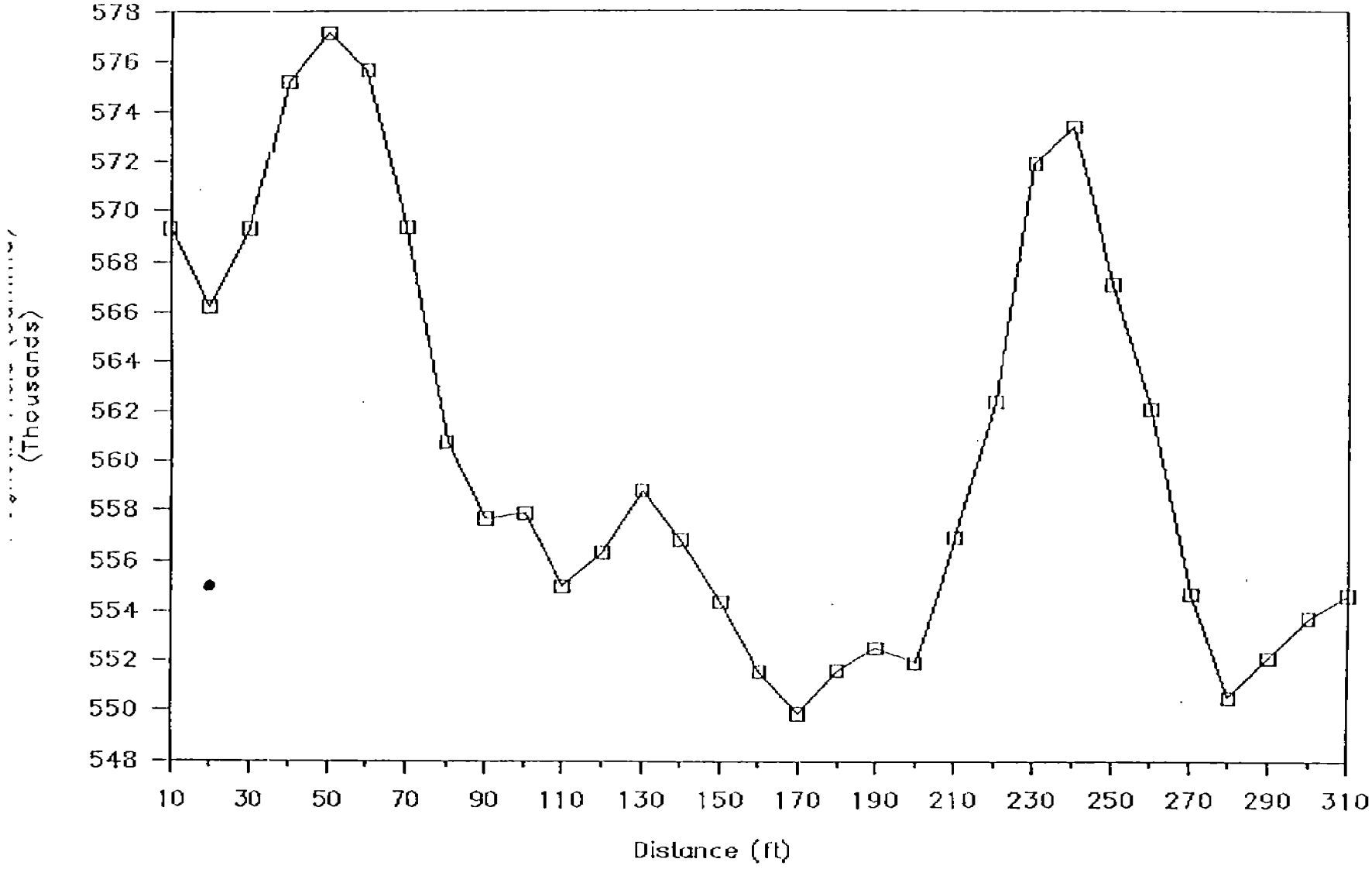
TRAVERSE LINE # 002/ 9

LINE #	SITE #	FEET	TIME	GAMMAS
002/ 9	249	0	14:10:37	56928.7
002/ 9	250	10	14:11:22	56623.3
002/ 9	251	20	14:11:40	56929.0
002/ 9	252	30	14:11:57	57518.0
002/ 9	253	40	14:12:12	57711.3
002/ 9	254	50	14:12:25	57563.6
002/ 9	255	60	14:12:40	56934.7
002/ 9	256	70	14:12:59	56076.2
002/ 9	257	80	14:13:14	55754.0
002/ 9	258	90	14:13:27	55786.1
002/ 9	259	100	14:13:41	55593.1
002/ 9	260	110	14:14:07	55631.7
002/ 9	261	120	14:14:31	55877.7
002/ 9	262	130	14:14:51	55681.7
002/ 9	263	140	14:15:01	55437.6
002/ 9	264	150	14:15:31	55151.9
002/ 9	265	160	14:15:45	54984.8
002/ 9	266	170	14:16:02	55154.9
002/ 9	267	180	14:16:48	55248.7
002/ 9	268	190	14:17:10	55186.7
002/ 9	269	200	14:13:09	55589.7
002/ 9	270	210	14:19:49	56126.5
002/ 9	271	220	14:20:06	57197.4
002/ 9	272	230	14:20:21	57340.1
002/ 9	273	240	14:20:35	56710.7
002/ 9	274	250	14:20:48	56206.1
002/ 9	275	260	14:21:07	55486.9
002/ 9	276	270	14:21:37	55049.8
002/ 9	277	280	14:22:04	55206.9
002/ 9	278	290	14:22:31	55371.1
002/ 9	279	300	14:22:47	55462.0

FTR 0018649

Fort Richardson Landfill

Traverse line #009 (C2)



ECOLOGY & ENVIRONMENT, INC.

FORT RICHARDSON LANDFILL
MAGNETIC SURVEY DATA

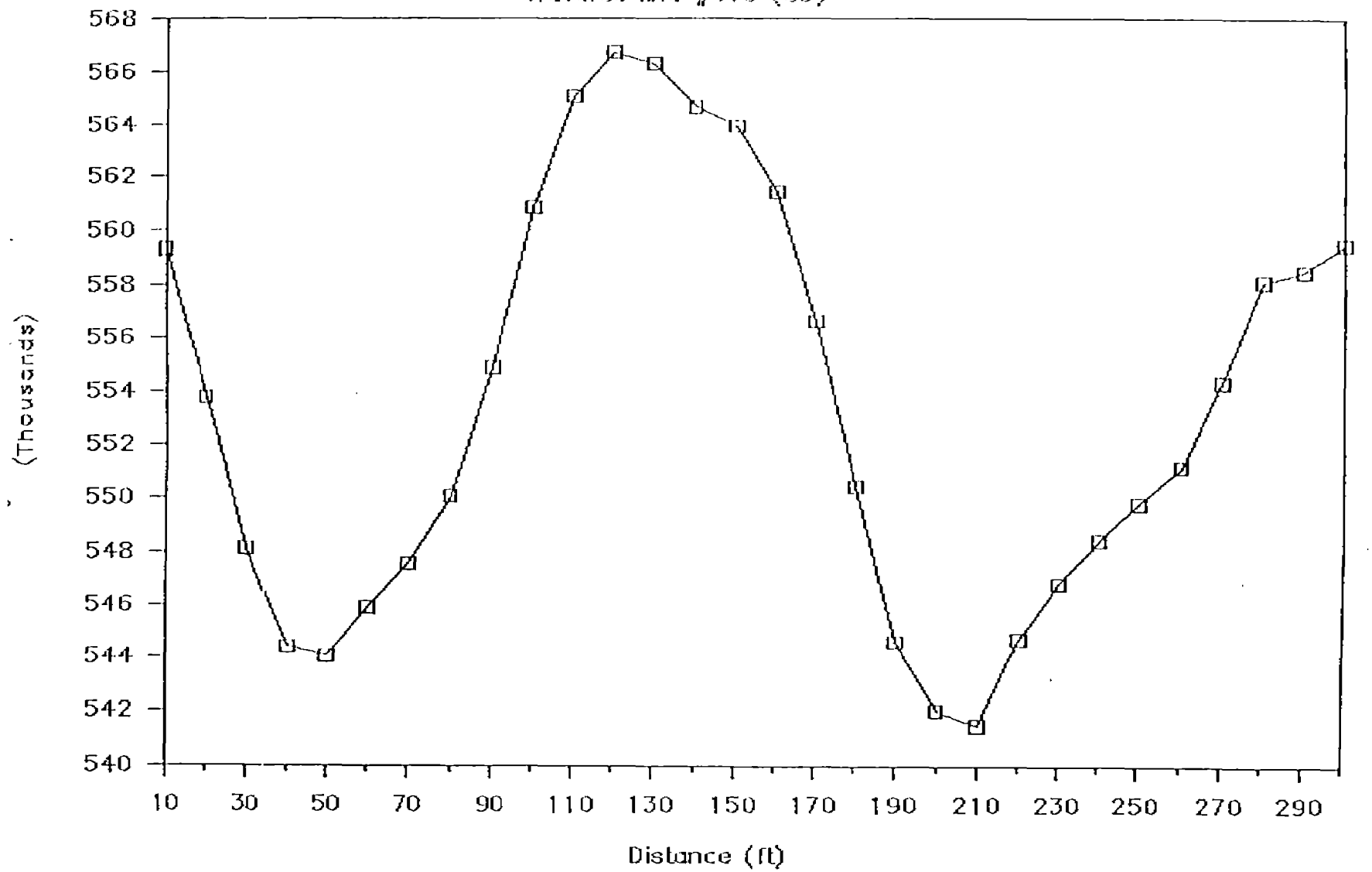
TRAVERSE LINE # 003/ 10

LINE #	SITE #	FEET	TIME	GAMMAS
003/ 10	280	0	09:34:39	55932.8
003/ 10	281	10	09:35:11	55877.1
003/ 10	282	20	09:35:27	54812.6
003/ 10	283	30	09:36:35	54439.2
003/ 10	284	40	09:36:50	54404.7
003/ 10	285	50	09:37:04	54591.4
003/ 10	286	60	09:37:21	54756.3
003/ 10	287	70	09:37:44	55005.3
003/ 10	288	80	09:38:04	55488.2
003/ 10	289	90	09:38:23	56084.3
003/ 10	290	100	09:38:43	56509.5
003/ 10	291	110	09:39:20	56671.8
003/ 10	292	120	09:39:46	56629.4
003/ 10	293	130	09:40:01	56468.8
003/ 10	294	140	09:40:19	56295.4
003/ 10	295	150	09:40:33	56140.5
003/ 10	297	160	09:41:11	55663.9
003/ 10	298	170	09:41:31	55040.6
003/ 10	299	180	09:41:45	54450.5
003/ 10	300	190	09:42:02	54262.2
003/ 10	301	200	09:42:20	54145.1
003/ 10	302	210	09:42:47	54410.0
003/ 10	303	220	09:44:05	54660.9
003/ 10	304	230	09:44:39	54839.5
003/ 10	305	240	09:45:20	54976.0
003/ 10	306	250	09:45:54	55113.6
003/ 10	307	260	09:46:10	55431.2
003/ 10	308	270	09:46:37	55811.7
003/ 10	309	280	09:47:02	55949.4
003/ 10	310	290	09:47:25	55949.6

FTR 0018651

Fort Richardson Landfill

Traverse line #010 (G3)



[illegible] & ENVIRONMENT, INC.

FORT RICHARDSON LANDFILL
MAGNETIC SURVEY DATA

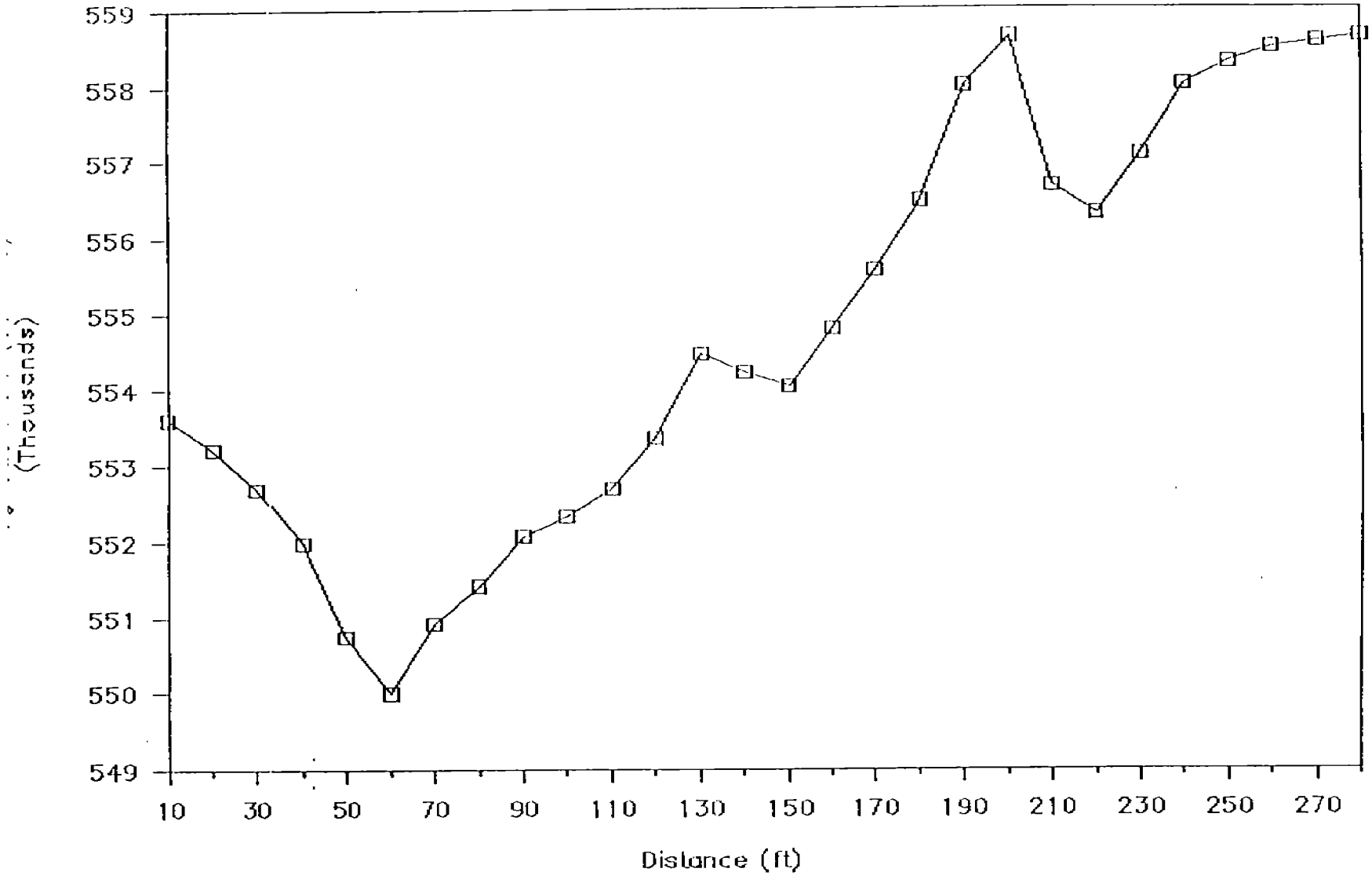
TRAVERSE LINE # 003/ 11

LINE #	SITE #	FEET	TIME	GAMMAS
003/ 11	311	0	10:02:26	55360.0
003/ 11	312	10	10:02:57	55321.2
003/ 11	313	20	10:03:24	55267.8
003/ 11	314	30	10:03:44	55198.2
003/ 11	315	40	10:04:12	55074.0
003/ 11	316	50	10:04:34	54998.6
003/ 11	317	60	10:04:51	55092.0
003/ 11	318	70	10:05:09	55142.5
003/ 11	319	80	10:05:24	55206.5
003/ 11	320	90	10:05:40	55232.2
003/ 11	321	100	10:06:07	55287.9
003/ 11	322	110	10:06:48	55325.2
003/ 11	323	120	10:07:02	55444.7
003/ 11	324	130	10:07:23	55420.6
003/ 11	325	140	10:07:43	55403.8
003/ 11	326	150	10:08:00	55479.2
003/ 11	327	160	10:08:19	55556.6
003/ 11	328	170	10:08:38	55646.4
003/ 11	329	180	10:08:59	55570.7
003/ 11	330	190	10:09:56	55862.6
003/ 11	331	200	10:10:44	55861.1
003/ 11	334	210	10:11:17	55830.6
003/ 11	335	220	10:11:37	55705.0
003/ 11	337	230	10:12:09	55692.1
003/ 11	338	240	10:12:31	55681.0
003/ 11	339	250	10:12:52	55645.7
003/ 11	340	260	10:13:13	55553.6
003/ 11	341	270	10:13:28	55601.9

FTR 0018653

Fort Richardson Landfill

Traverse line #011 (E3)



ECOLOGY & ENVIRONMENT, INC.

FORT PICKAPOOSA LANDFILL
MAGNETIC SURVEY DATA

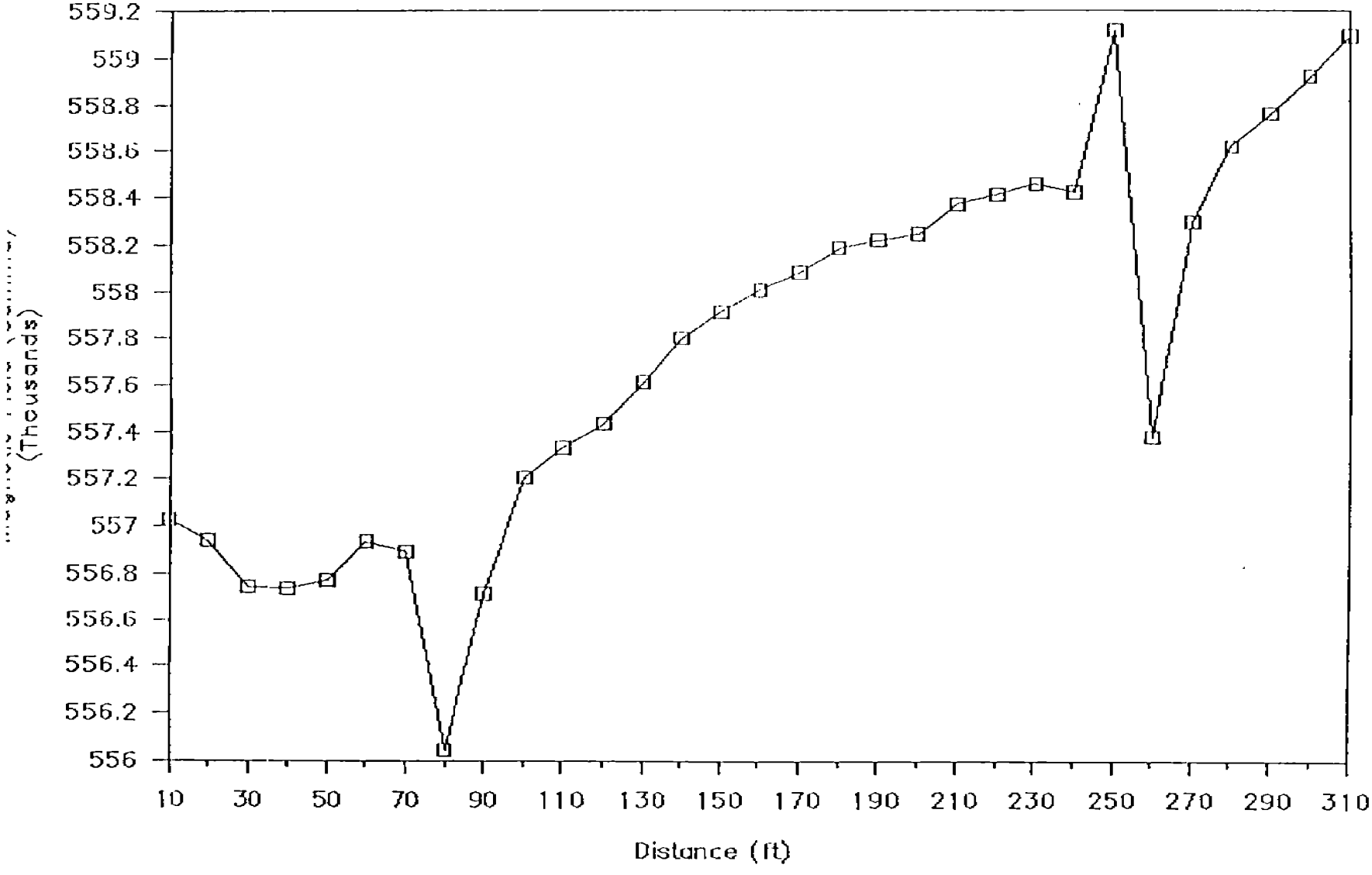
TRAVERSE LINE # 003/ 12

LINE #	SITE #	FEET	TIME	GAMMAS
003/ 12	342	0	10:28:08	55702.7
003/ 12	343	10	10:28:56	55694.1
003/ 12	344	20	10:29:16	55674.4
003/ 12	345	30	10:29:42	55673.8
003/ 12	346	40	10:29:57	55677.3
003/ 12	347	50	10:30:11	55693.7
003/ 12	348	60	10:30:26	55689.3
003/ 12	349	70	10:30:42	55604.5
003/ 12	350	80	10:30:56	55671.6
003/ 12	351	90	10:31:10	55720.2
003/ 12	352	100	10:31:24	55705.1
003/ 12	353	110	10:32:39	55743.2
003/ 12	354	120	10:32:51	55761.0
003/ 12	355	130	10:33:15	55780.0
003/ 12	356	140	10:33:28	55791.5
003/ 12	357	150	10:33:38	55801.9
003/ 12	358	160	10:33:51	55808.6
003/ 12	359	170	10:34:07	55819.1
003/ 12	360	180	10:34:17	55822.3
003/ 12	361	190	10:34:49	55815.6
003/ 12	362	200	10:34:55	55807.5
003/ 12	363	210	10:43:07	55841.7
003/ 12	364	220	10:43:31	55848.1
003/ 12	365	230	10:43:44	55840.9
003/ 12	366	240	10:43:55	55811.6
003/ 12	367	250	10:44:56	55737.1
003/ 12	368	260	10:45:25	55690.1
003/ 12	369	270	10:45:42	55662.5
003/ 12	370	280	10:45:58	55678.9
003/ 12	371	290	10:46:11	55691.9
003/ 12	372	300	10:46:28	55509.4

FTR 0018655

Fort Richardson Landfill

Traverse line #012 (C3)



ECOLOGY & ENVIRONMENT, INC.

PORT RICHARDSON LANDFILL
MAGNETIC SURVEY DATA

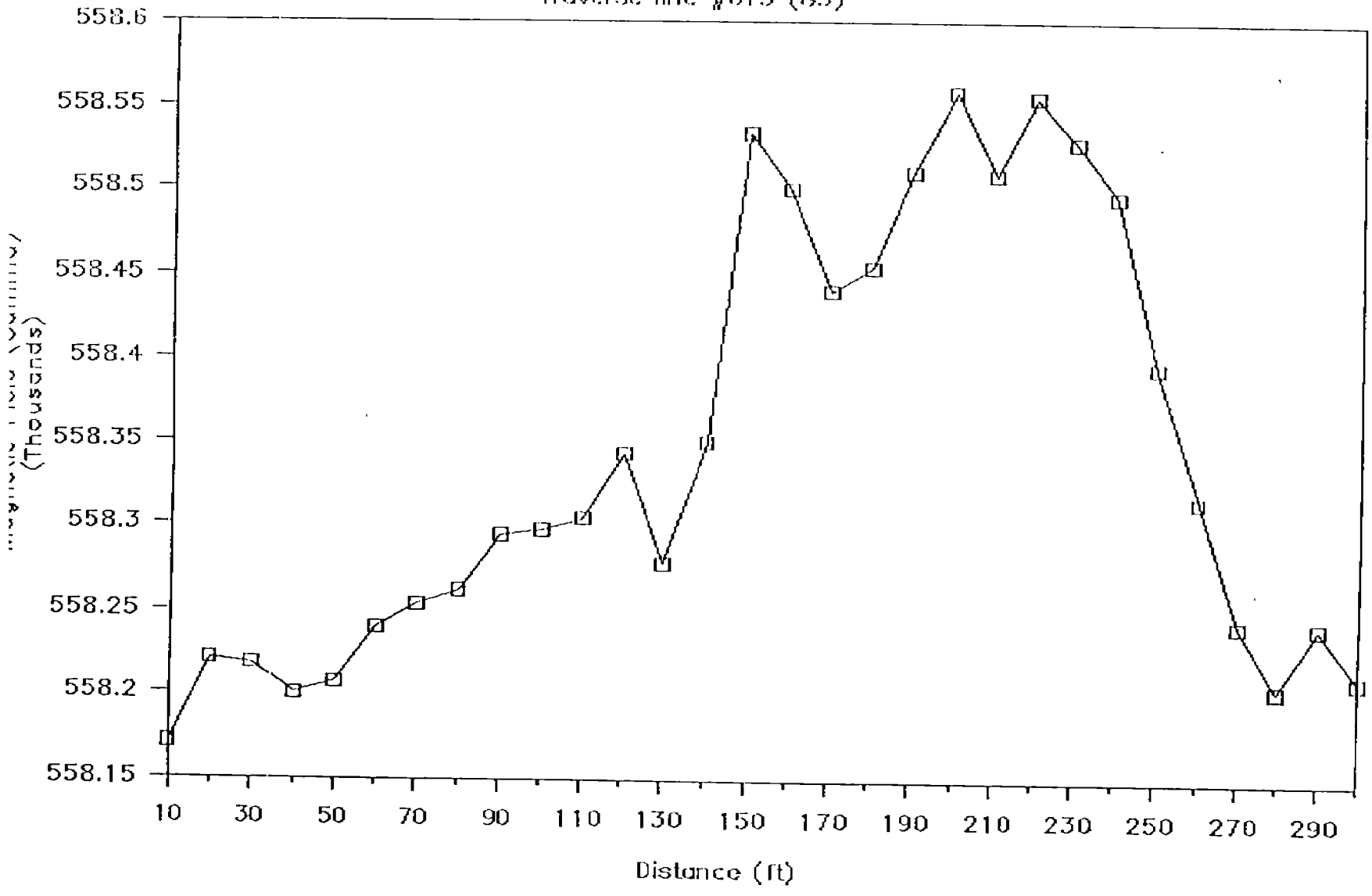
TRAVERSE LINE # 003/ 13

LINE #	SITE #	FEET	TIME	GAMMAS
003/ 13	373	0	10:57:40	55817.1
003/ 13	374	10	10:58:19	55822.1
003/ 13	375	20	10:58:34	55821.8
003/ 13	376	30	10:58:54	55820.0
003/ 13	377	40	10:59:09	55820.7
003/ 13	378	50	10:59:23	55824.0
003/ 13	379	60	10:59:37	55825.4
003/ 13	380	70	10:59:52	55826.2
003/ 13	381	80	11:00:05	55829.4
003/ 13	382	90	11:00:18	55829.7
003/ 13	383	100	11:00:37	55830.4
003/ 13	384	110	11:01:10	55834.2
003/ 13	386	120	11:01:40	55837.8
003/ 13	387	130	11:01:55	55835.2
003/ 13	388	140	11:02:08	55853.4
003/ 13	389	150	11:02:24	55850.6
003/ 13	390	160	11:02:37	55844.1
003/ 13	391	170	11:02:51	55845.5
003/ 13	392	180	11:03:08	55851.1
003/ 13	393	190	11:03:23	55855.9
003/ 13	394	200	11:03:47	55858.9
003/ 13	395	210	11:03:59	55855.6
003/ 13	396	220	11:04:16	55852.9
003/ 13	397	230	11:04:50	55849.6
003/ 13	398	240	11:05:10	55839.5
003/ 13	399	250	11:05:27	55831.5
003/ 13	400	260	11:05:45	55824.3
003/ 13	401	270	11:06:05	55820.4
003/ 13	402	280	11:06:19	55824.3
003/ 13	403	290	11:06:32	55831.0

FTR 0018657

Fort Richardson Landfill

Traverse line #013 (E-S)



BIOLOGY & ENVIRONMENT, INC.

FORT RICHARDSON LANDFILL
MAGNETIC SURVEY DATA

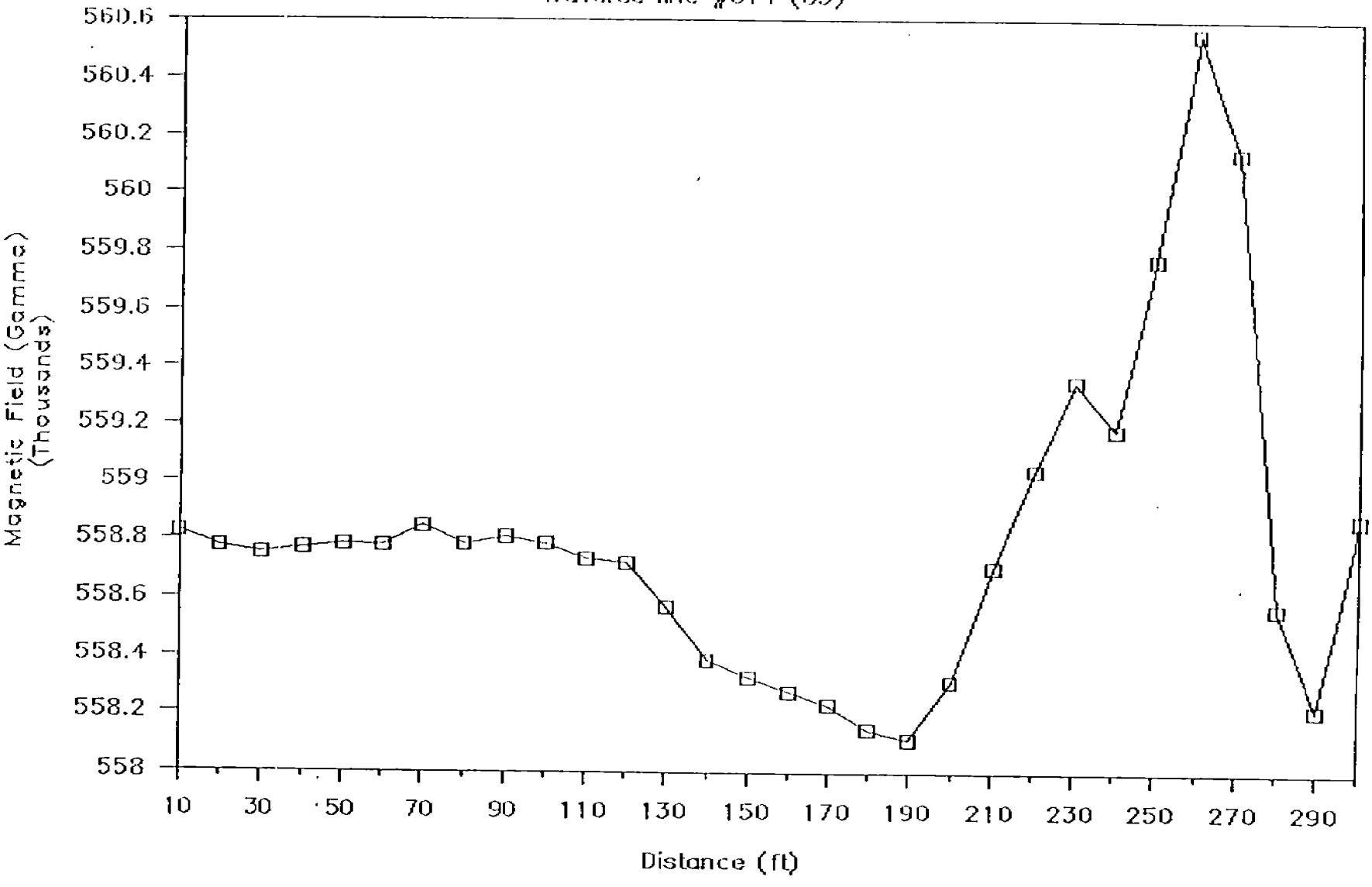
TRAVERSE LINE # 003/ 14

LINE #	SITE #	FEET	TIME	GAMMAS
003/ 14	404	0	11:19:37	55882.5
003/ 14	405	10	11:20:39	55877.4
003/ 14	406	20	11:21:27	55875.2
003/ 14	407	30	11:21:43	55877.0
003/ 14	408	40	11:22:15	55878.2
003/ 14	409	50	11:22:31	55877.9
003/ 14	410	60	11:22:57	55884.5
003/ 14	411	70	11:23:18	55878.1
003/ 14	412	80	11:23:31	55880.6
003/ 14	413	90	11:24:31	55878.4
003/ 14	414	100	11:25:06	55873.2
003/ 14	415	110	11:25:28	55871.9
003/ 14	416	120	11:25:58	55856.8
003/ 14	417	130	11:26:31	55838.2
003/ 14	419	140	11:26:45	55833.1
003/ 14	420	150	11:27:01	55827.1
003/ 14	421	160	11:27:38	55808.8
003/ 14	422	170	11:28:09	55814.4
003/ 14	423	180	11:28:34	55811.1
003/ 14	424	190	11:28:45	55830.2
003/ 14	425	200	11:29:26	55870.4
003/ 14	426	210	11:29:43	55903.8
003/ 14	427	220	11:30:02	55934.7
003/ 14	428	230	11:30:15	55917.9
003/ 14	429	240	11:30:33	55977.3
003/ 14	430	250	11:30:51	56055.1
003/ 14	431	260	11:31:14	56014.1
003/ 14	432	270	11:31:30	55855.6
003/ 14	433	280	11:31:50	55821.5
003/ 14	434	290	11:32:16	55886.9

FTR 0018659

Fort Richardson Landfill

Traverse line #014 (03)

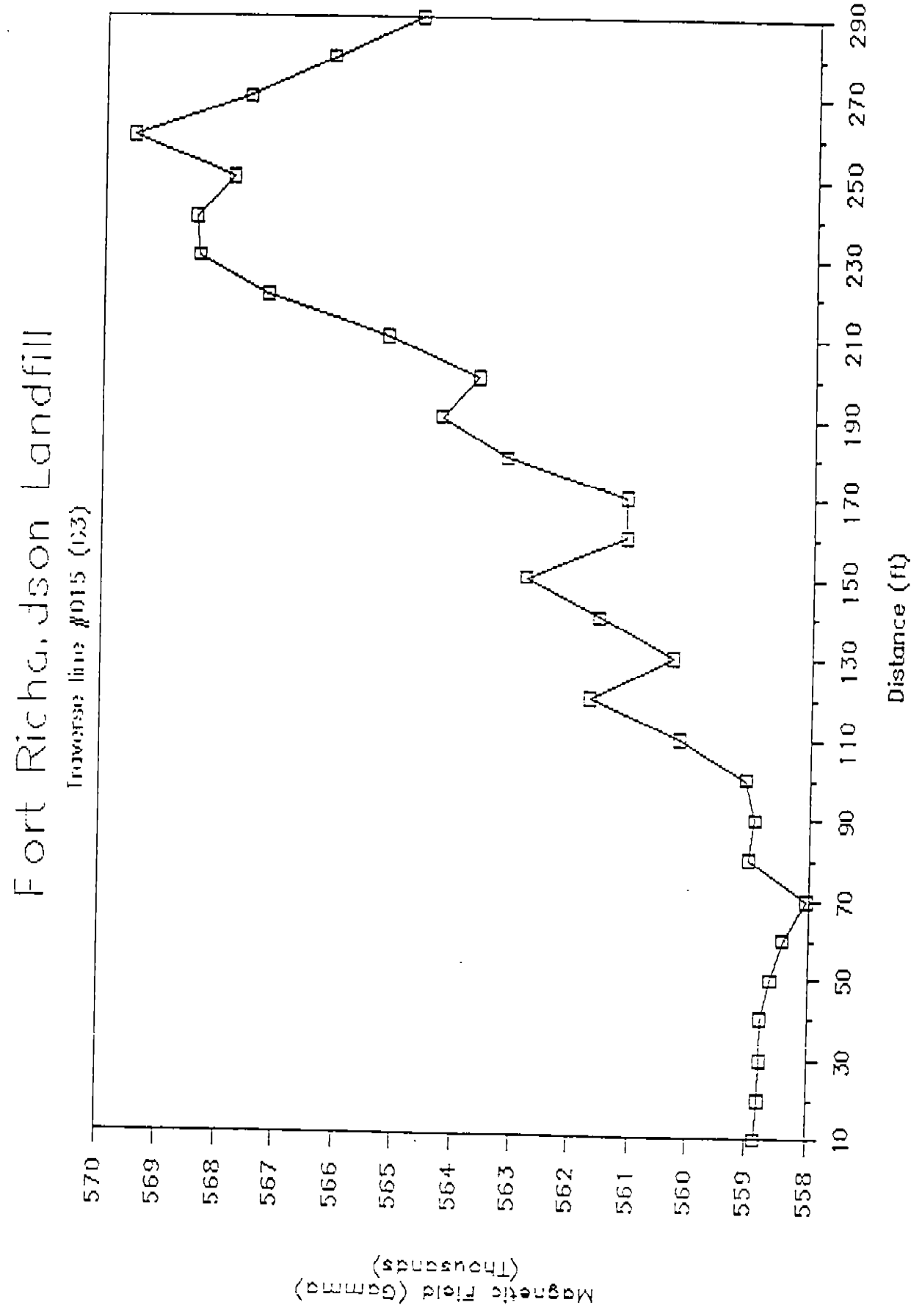


ECOLOGY & ENVIRONMENT, INC.

PORT RICHARDSON LANDFILL
MAGNETIC SURVEY DATA

TRAVERSE LINE # 003/ 15

LINE #	SITE #	FEET	TIME	GAMMAS
003/ 15	435	0	12:52:55	55885.3
003/ 15	436	10	12:53:58	55880.0
003/ 15	437	20	12:54:13	55878.4
003/ 15	438	30	12:54:26	55877.3
003/ 15	440	40	12:54:57	55862.2
003/ 15	441	50	12:55:14	55842.3
003/ 15	442	60	12:55:32	55804.2
003/ 15	443	70	12:55:47	55899.7
003/ 15	444	80	12:56:06	55890.0
003/ 15	445	90	12:56:39	55865.5
003/ 15	446	100	12:57:15	56019.3
003/ 15	447	110	12:57:29	56179.6
003/ 15	448	120	12:57:45	56081.9
003/ 15	449	130	12:58:01	56157.8
003/ 15	450	140	12:58:14	56280.6
003/ 15	451	150	12:58:32	56113.4
003/ 15	452	160	12:58:46	56113.9
003/ 15	453	170	12:59:08	56019.6
003/ 15	454	180	12:59:25	55429.7
003/ 15	455	190	12:59:40	55365.9
003/ 15	457	200	13:00:19	55515.1
003/ 15	458	210	13:00:31	55733.6
003/ 15	459	220	13:00:43	55848.5
003/ 15	460	230	13:01:01	56847.4
003/ 15	461	241	13:01:16	56783.7
003/ 15	462	250	13:01:30	56951.9
003/ 15	463	260	13:01:44	56755.8
003/ 15	464	270	13:01:55	56817.6
003/ 15	465	280	13:02:19	56467.4


Fort Richardson Landfill
Traverse line #015 (03)
Magnetic Field (Gamma)
(Thousands)
570
569
568
567
566
565
564
563
562
561
560
559
558
10
30
50
70
90
110
130
150
170
190
210
230
250
270
290
Distance (ft)

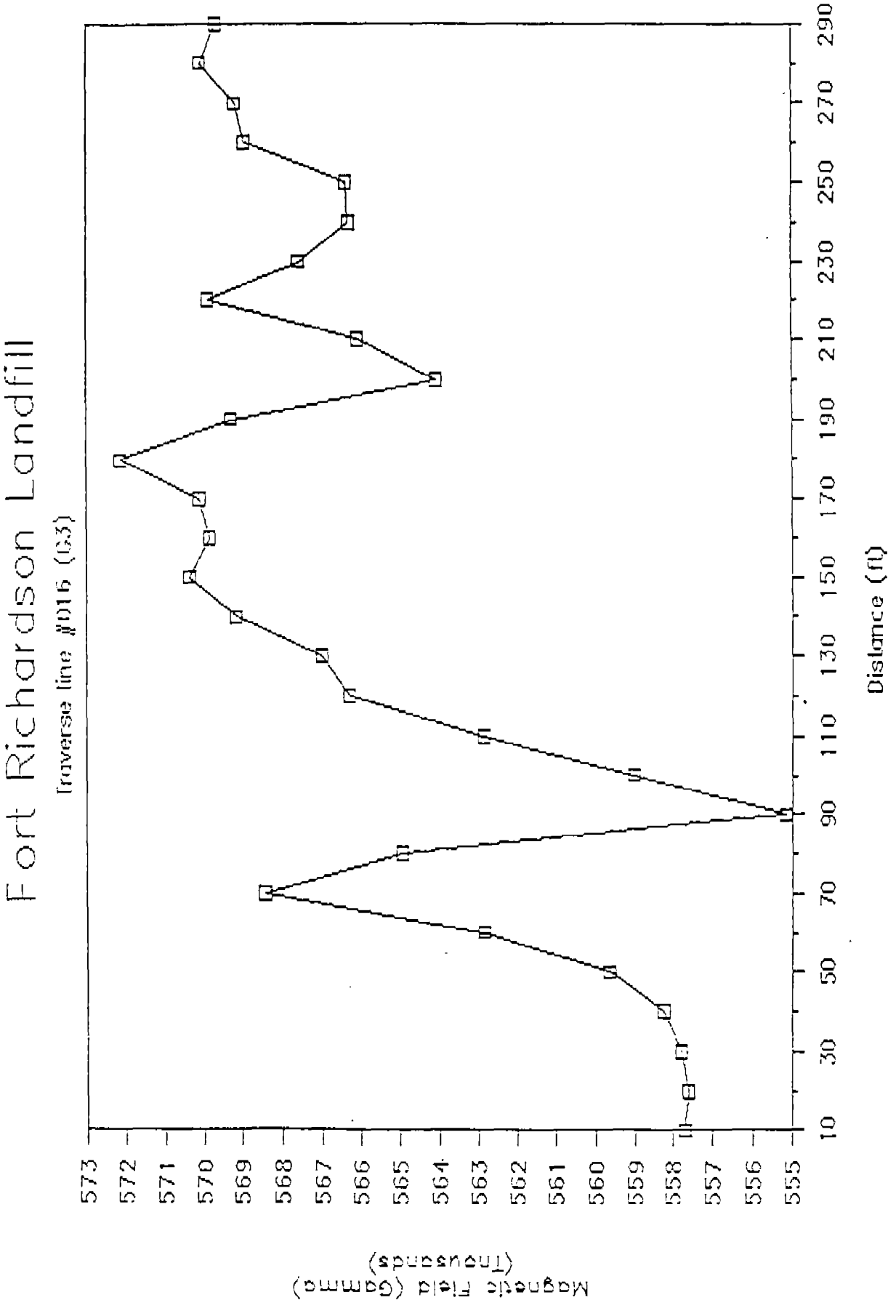
BIOLOGY & ENVIRONMENT, INC.

PORT RICHARDSON LANDFILL
MAGNETIC SURVEY DATA

TRAVERSE LINE # 003/ 16

LINE #	SITE #	FEET	TIME	GAMMAS
003/ 16	466	0	13:13:00	55771.4
003/ 16	467	10	13:13:33	55761.0
003/ 16	468	20	13:13:50	55778.8
003/ 16	469	30	13:14:06	55824.8
003/ 16	470	40	13:14:22	55965.7
003/ 16	471	50	13:14:36	56285.7
003/ 16	472	60	13:14:48	56844.4
003/ 16	473	70	13:15:02	56493.9
003/ 16	474	80	13:15:34	55518.8
003/ 16	475	90	13:15:52	55900.1
003/ 16	477	100	13:16:16	56286.7
003/ 16	478	110	13:16:41	56629.3
003/ 16	479	120	13:16:57	56701.3
003/ 16	480	130	13:17:13	56915.6
003/ 16	481	140	13:17:29	57036.3
003/ 16	482	150	13:18:13	56124.8
003/ 16	483	160	13:18:29	57016.3
003/ 16	484	170	13:18:39	57213.8
003/ 16	485	180	13:19:12	56929.1
003/ 16	486	190	13:19:39	56407.1
003/ 16	487	200	13:19:52	56609.7
003/ 16	489	210	13:20:35	56988.4
003/ 16	490	220	13:20:53	56760.0
003/ 16	491	230	13:21:09	56632.8
003/ 16	492	240	13:21:23	56638.2
003/ 16	493	250	13:21:37	56894.9
003/ 16	494	260	13:21:51	5692[illegible].2
003/ 16	495	270	13:22:03	57009.5
003/ 16	496	280	13:23:16	56968.9

FTR 001866


Fort Richardson Landfill
Traverse line #016 (G3)
Magnetic Field (Gamma)
(Thousands)
573
572
571
570
569
568
567
566
565
564
563
562
561
560
559
558
557
556
555
10
30
50
70
90
110
130
150
170
190
210
230
250
270
290
Distance (ft)

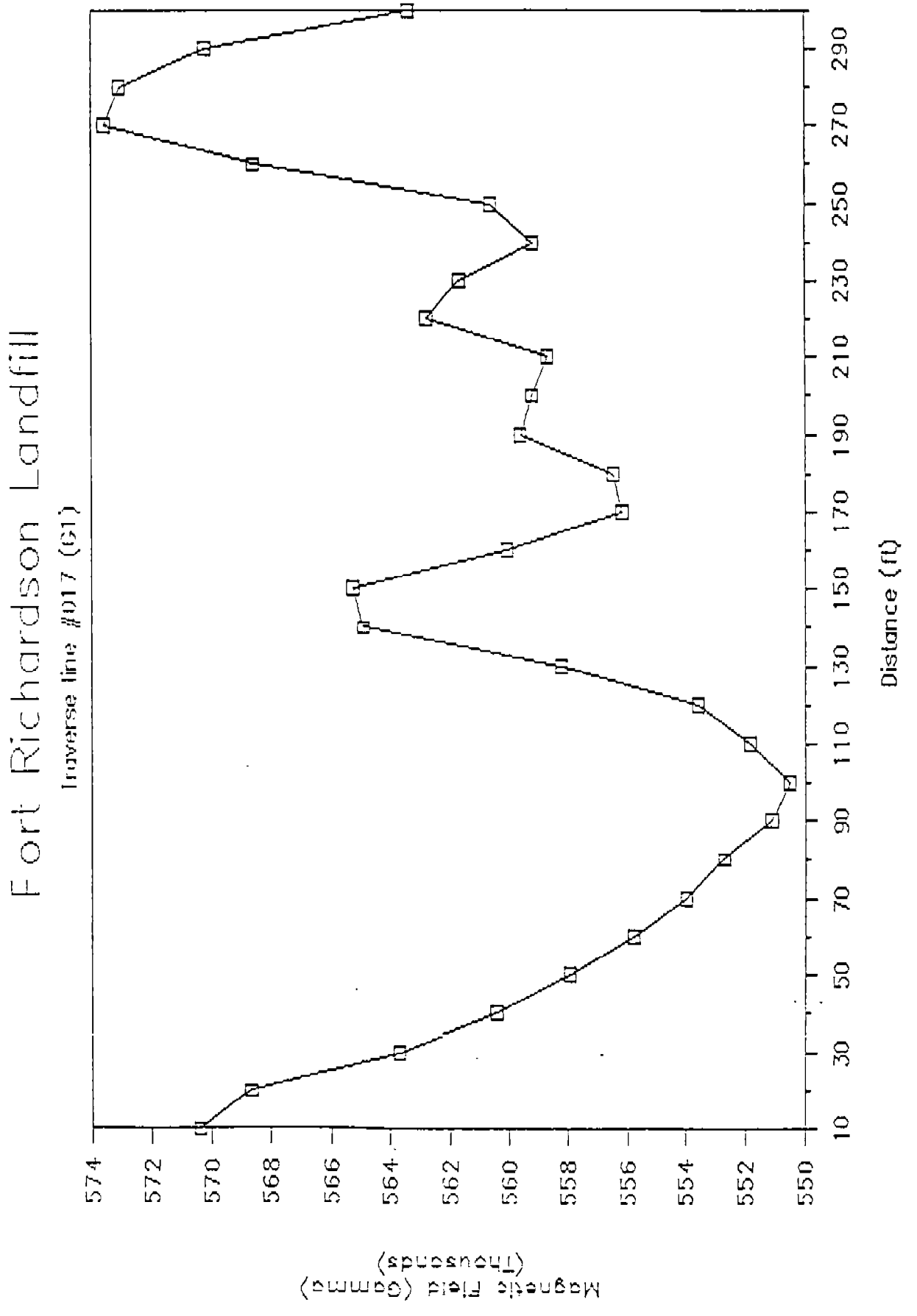
ECOLOGY & ENVIRONMENT, INC.

FORT RICHARDSON LANDFILL
MAGNETIC SURVEY DATA

TRAVERSE LINE # 003/ 17

LINE #	SITE #	FEET	TIME	GAMMAS
003/ 17	497	0	14:18:25	57037.8
003/ 17	498	10	14:18:50	56864.2
003/ 17	499	20	14:19:14	56369.2
003/ 17	500	30	14:19:26	56043.9
003/ 17	501	40	14:19:40	55794.1
003/ 17	502	50	14:20:15	55579.8
003/ 17	503	60	14:20:27	55397.6
003/ 17	504	70	14:20:46	55259.9
003/ 17	505	80	14:20:57	55112.2
003/ 17	506	90	14:21:10	55051.1
003/ 17	507	100	14:21:25	55183.4
003/ 17	508	110	14:21:57	55356.8
003/ 17	509	120	14:22:16	55521.5
003/ 17	510	130	14:22:31	56491.1
003/ 17	511	140	14:22:44	56536.4
003/ 17	512	150	14:23:04	56006.3
003/ 17	513	160	14:23:23	55619.9
003/ 17	514	170	14:23:40	55649.2
003/ 17	515	180	14:24:24	55553.7
003/ 17	516	190	14:24:45	55919.2
003/ 17	517	200	14:25:01	55867.6
003/ 17	518	210	14:25:21	56275.8
003/ 17	520	220	14:26:22	56164.2
003/ 17	521	230	14:26:40	55915.0
003/ 17	522	240	14:26:59	56061.0
003/ 17	523	250	14:27:19	56856.6
003/ 17	524	260	14:27:37	57356.4
003/ 17	525	270	14:27:58	57306.1
003/ 17	526	280	14:28:32	57021.7
003/ 17	527	290	14:28:47	56339.5

FTR 001866


Fort Richardson Landfill
Traverse line #017 (G1)
Magnetic Field (Gamma)
(Thousands)
574
572
570
568
566
564
562
560
558
556
554
552
550
10
30
50
70
90
110
130
150
170
190
210
230
250
270
290
Distance (ft)

ECOLOGY & ENVIRONMENT, INC.

FORT RICHARDSON LANDFILL
MAGNETIC SURVEY DATA

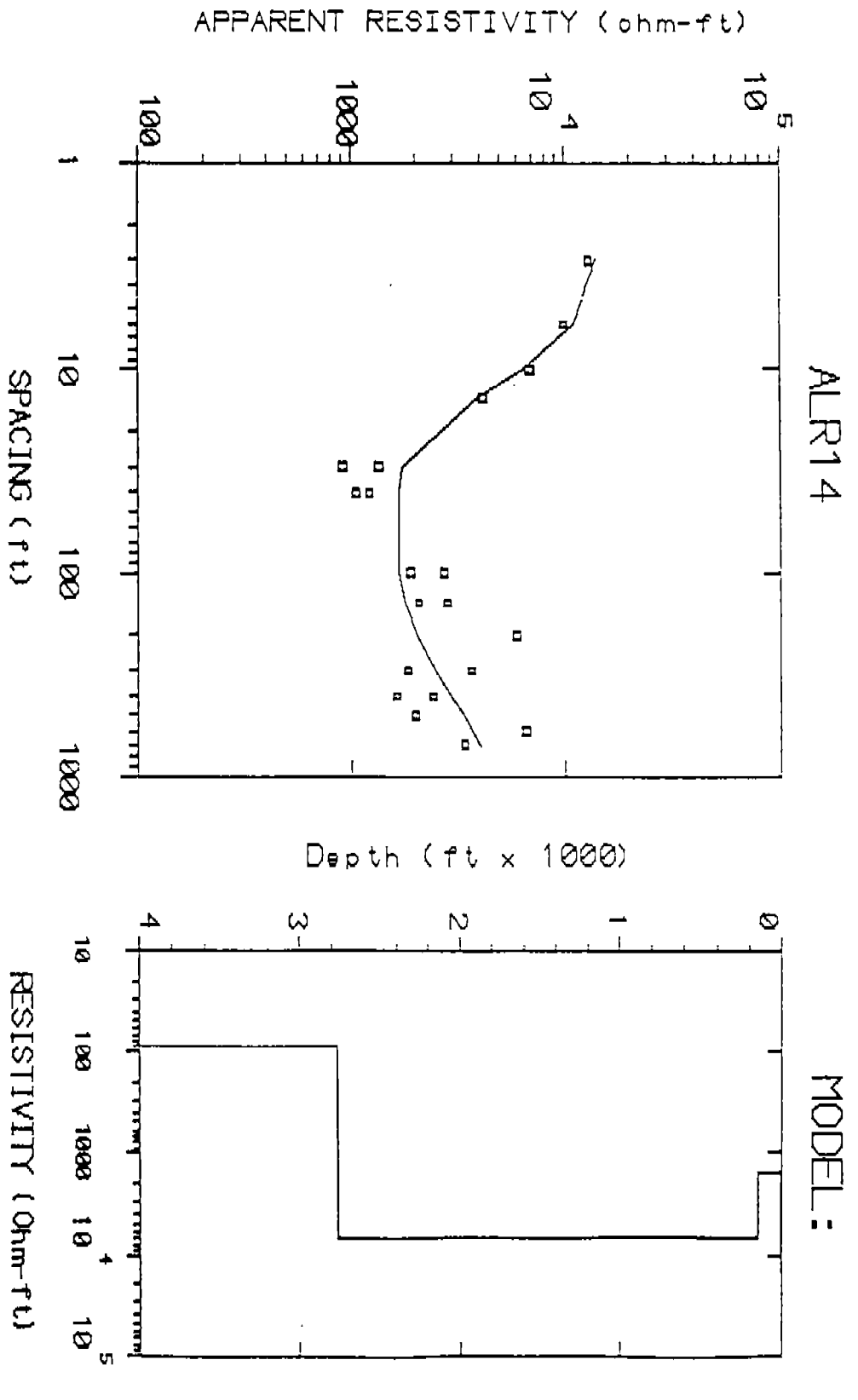
TRAVERSE LINE # 003/ 18

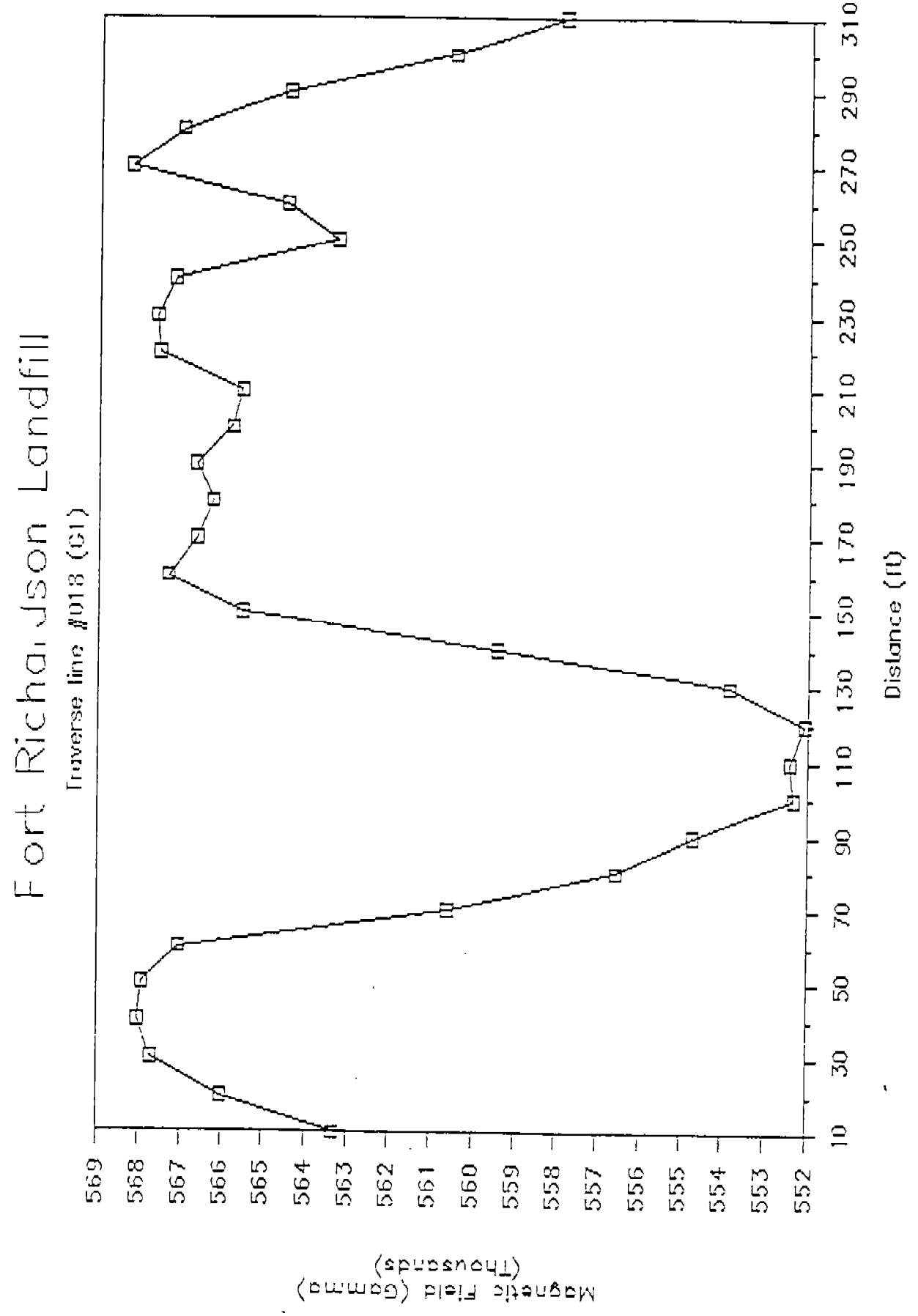
LINE #	SITE #	FEET	TIME	GAMMAS
003/ 18	528	0	14:40:43	56333.4
003/ 18	529	10	14:41:19	56602.7
003/ 18	530	20	14:41:31	56771.3
003/ 18	531	30	14:41:43	56802.9
003/ 18	532	40	14:42:06	56793.4
003/ 18	533	50	14:42:19	56705.7
003/ 18	534	60	14:42:33	56060.1
003/ 18	535	70	14:43:15	55657.5
003/ 18	536	80	14:43:27	55470.7
003/ 18	537	90	14:43:39	55233.0
003/ 18	538	100	14:43:52	55241.6
003/ 18	539	110	14:44:14	55306.4
003/ 18	540	120	14:44:36	55384.9
003/ 18	541	130	14:44:53	55943.6
003/ 18	542	140	14:45:07	56558.7
003/ 18	543	150	14:46:54	56721.4
003/ 18	544	160	14:47:12	56656.1
003/ 18	545	170	14:47:37	56620.9
003/ 18	546	180	14:47:41	56615.9
003/ 18	547	190	14:48:06	56581.2
003/ 18	548	200	14:48:31	56557.5
003/ 18	549	210	14:48:58	56758.3
003/ 18	550	220	14:49:31	56763.6
003/ 18	551	230	14:49:47	56720.9
003/ 18	552	240	14:50:04	56332.7
003/ 18	553	250	14:50:20	56458.5
003/ 18	554	260	14:50:35	56824.2
003/ 18	555	270	14:50:49	56703.2
003/ 18	556	280	14:51:02	56449.6
003/ 18	557	290	14:51:15	56051.0
003/ 18	558	300	14:51:36	55783.2

No.	SPACING (ft)	P-I-A (cm-ft) DATA	SYNTHETIC	DIFFERENCE (percent)
33	700.0	3387.0	4004.3	-18.26

PARAMETER RESOLUTION MATRIX:
'F' INDICATES FIXED PARAMETER

	P 1	P 2	P 3	P 4	T 1	T 2	T 3
P 1	0.72						
P 2	-0.01	0.92					
P 3	0.00	0.02	0.20				
P 4	0.00	0.00	0.00	0.00			
T 1	0.13	0.03	-0.01	0.00	0.87		
T 2	-0.02	-0.09	-0.27	0.00	0.03	0.62	
T 3	0.00	0.00	0.00	0.00	0.00	0.00	0.00


APPARENT RESISTIVITY (ohm-ft)
100
1000
10 4
10 5
1
10
100
1000
SPACING (ft)
ALR14
Depth (ft x 1000)
4
3
2
1
0
10
100
1000
10 4
10 5
RESISTIVITY (Ohm-ft)
MODEL:


Fort Richardson Landfill
Traverse line #018 (G1)
Magnetic Field (Gamma)
(Thousands)
569
568
567
566
565
564
563
562
561
560
559
558
557
556
555
554
553
552
10
30
50
70
90
110
130
150
170
190
210
230
250
270
290
310
Distance (ft)

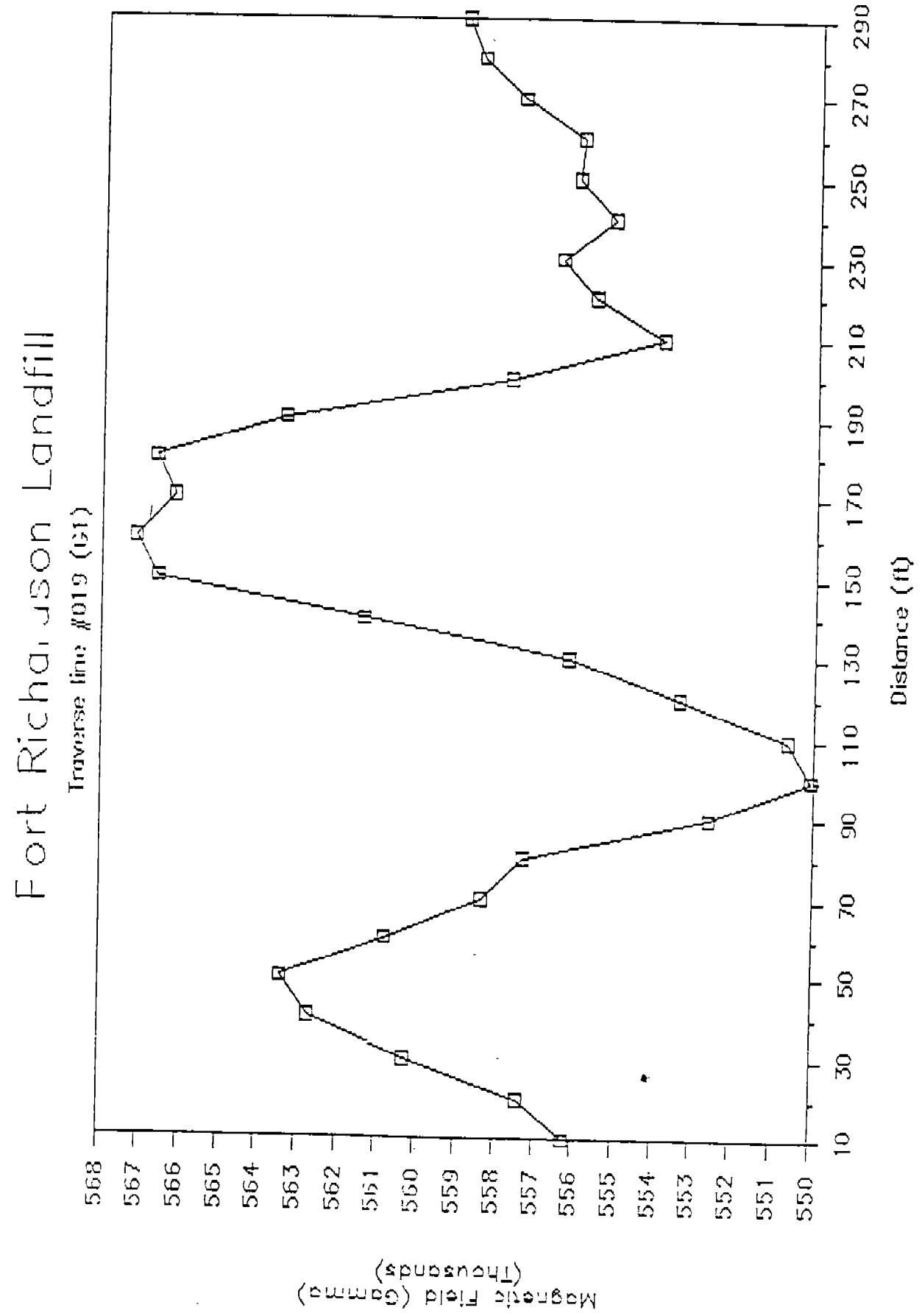
ECOLOGY & ENVIRONMENT, INC.

FORT RICHARDSON LANDFILL
MAGNETIC SURVEY DATA

TRAVERSE LINE # 003/ 19

LINE #	SITE #	FEET	TIME	GAMMAS
003/ 19	559	0	15:04:37	55621.6
003/ 19	560	10	15:05:13	55741.2
003/ 19	561	20	15:05:28	56027.6
003/ 19	562	30	15:05:41	56271.5
003/ 19	564	40	15:06:13	56340.8
003/ 19	565	50	15:06:25	56080.2
003/ 19	566	60	15:06:40	55837.8
003/ 19	567	70	15:07:00	55732.0
003/ 19	568	80	15:07:16	55858.8
003/ 19	569	90	15:07:33	55905.0
003/ 19	570	100	15:08:02	55864.9
003/ 19	571	110	15:08:17	55387.4
003/ 19	572	120	15:08:31	55619.4
003/ 19	573	130	15:08:52	56139.9
003/ 19	574	140	15:09:57	56857.2
003/ 19	575	150	15:10:11	56713.4
003/ 19	576	160	15:10:25	56617.2
003/ 19	577	170	15:10:43	56664.3
003/ 19	578	180	15:11:03	56340.4
003/ 19	579	190	15:11:16	55773.5
003/ 19	580	200	15:12:25	55286.8
003/ 19	581	210	15:12:37	55560.6
003/ 19	582	220	15:13:02	55845.6
003/ 19	583	230	15:13:24	55814.8
003/ 19	585	240	15:13:39	55695.8
003/ 19	586	250	15:13:55	55595.9
003/ 19	587	260	15:14:08	55748.0
003/ 19	588	270	15:14:21	55850.2
003/ 19	589	280	15:14:45	55893.9

FTR 001870


Fort Richardson Landfill
Traverse line #019 (G1)
Magnetic Field (Gamma)
(Thousands)
Distance (ft)
568
567
566
565
564
563
562
561
560
559
558
557
556
555
554
553
552
551
550
10
30
50
70
90
110
130
150
170
190
210
230
250
270
290

APPENDIX C

RESISTIVITY DATA

FTR 0018672

DATA SET: ALR1

CLIENT: COE
LOCATION: FT.RICHARDSON
COUNTY: ALASKA
PROJECT: KN1080
ELEVATION: 0.00

DATE: JULY 1990
SOUNDING: R1
AZIMUTH: Unknown
EQUIPMENT: ABEM300C

Schlumberger Configuration

FITTING ERROR: 31.717 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	CONDUCTANCE (Siemens)	RESISTANCE (Ohms)
			0.0		
1	25487.7	10.01	-10.01	3.930E-04	255329.3
2	2093.8	16.72	-26.74	0.00799	35030.1
3	1176.1	472.9	-499.6	0.402	556226.8
4	85.19				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	4.00	10390.0	25150.7	-142.0
2	6.00	30089.0	24515.1	18.52
3	10.00	30731.0	22083.9	28.13
4	14.00	23737.0	18370.0	22.61
5	10.00	24846.0	22083.9	11.11
6	14.00	19742.0	18370.0	6.94
7	30.00	5709.0	6344.4	-11.13
8	40.00	2970.0	3460.9	-16.53
9	30.00	6790.0	6344.4	6.56
10	40.00	3430.0	3460.9	-0.902
11	80.00	1214.0	1432.2	-17.97
12	100.0	1327.0	1345.3	-1.38
13	140.0	1386.0	1262.4	8.91
14	200.0	1462.0	1196.2	18.17
15	300.0	1116.0	1147.7	-2.84
16	400.0	1207.0	1100.1	8.85
17	300.0	1599.0	1147.7	28.21
18	400.0	1236.0	1100.1	10.99
19	500.0	642.0	1031.3	-60.63
20	600.0	853.0	944.6	-10.74
21	700.0	581.0	848.9	-46.12

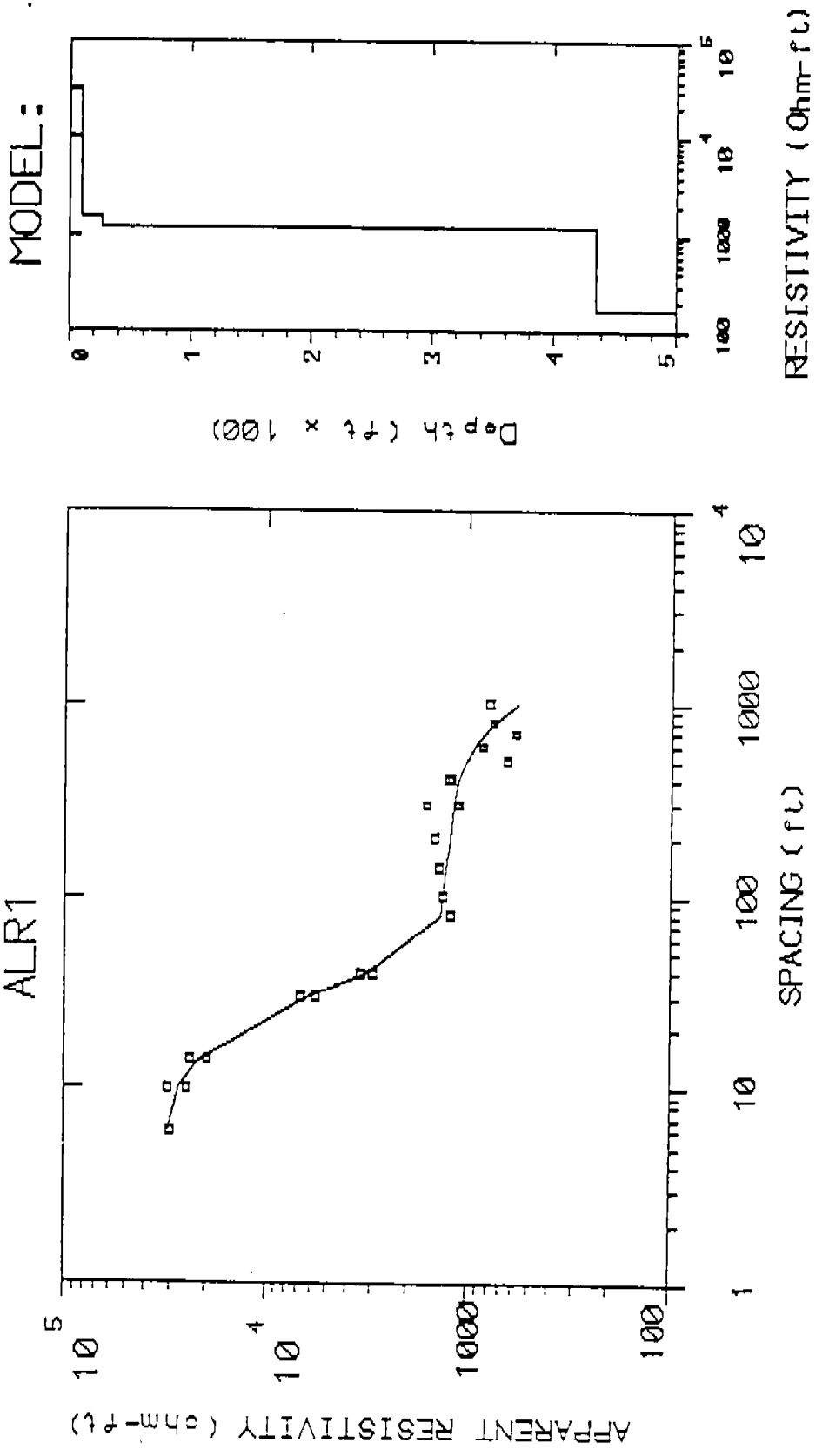
FTR 0018673

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	SYNTHETIC	DIFFERENCE (percent)
22	800.0	758.0	752.1	0.770
23	1000.0	790.0	575.3	27.17

PARAMETER RESOLUTION MATRIX:
'F' INDICATES FIXED PARAMETER

P 1	0.85						
P 2	-0.03	0.11					
P 3	0.00	0.03	0.89				
P 4	0.00	0.00	0.00	0.01			
T 1	0.06	0.18	0.00	0.00	0.89		
T 2	-0.02	0.09	0.07	0.00	0.04	0.11	
T 3	0.00	-0.04	0.10	0.07	0.00	-0.04	0.71
	P 1	P 2	P 3	P 4	T 1	T 2	T 3

FTR 0018674


ALR1
APPARENT RESISTIVITY (ohm-ft)
SPACING (ft)
MODEL:
Depth (ft x 100)
RESISTIVITY (Ohm-ft)

---------- ALR2 ---------- PAGE 1

DATA SET: ALR2

CLIENT: COE
LOCATION: FT.RICHARDSON
COUNTY: ALASKA
PROJECT: KN1080
ELEVATION: 0.00

DATE: JULY 1990
SOUNDING: R2
AZIMUTH: Unknown
EQUIPMENT: ABEM300C

Schlumberger Configuration

FITTING ERROR: 62.892 PERCENT

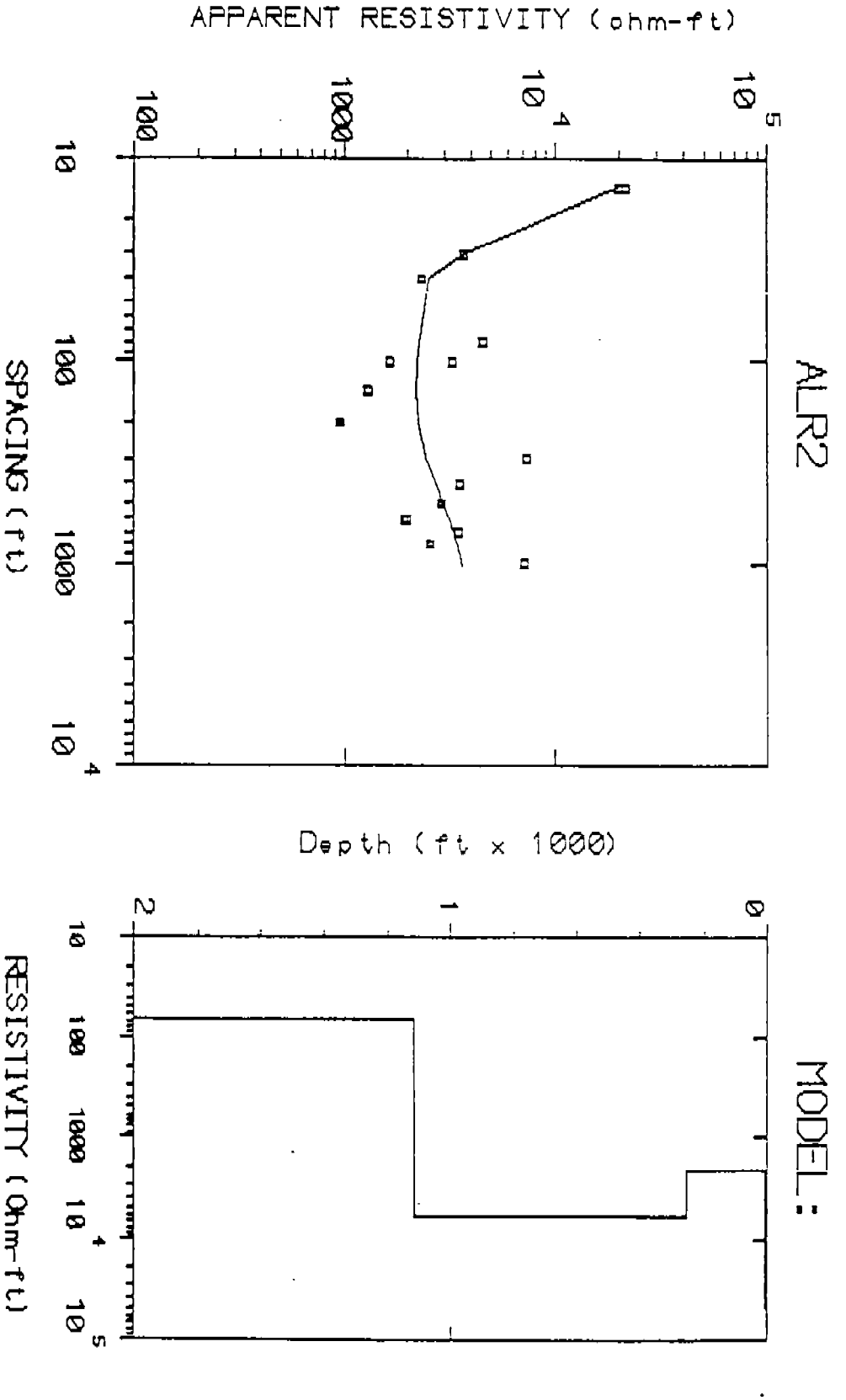
L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	CONDUCTANCE (Siemens)	RESISTANCE (Ohms)
			0.0		
1	46550.1	6.60	-6.60	1.41E-04	307580.5
2	2128.5	249.0	-255.6	0.117	530134.4
3	5936.2	862.5	-1118.5	0.145	5.122E+06
4	64.03				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	PHI-A (ohm-ft) DATA	PHI-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	14.00	19974.1	19867.4	0.533
2	14.00	21677.5	19830.4	8.52
3	30.00	3673.5	3779.1	-2.88
4	40.00	2818.3	3487.2	-7.55
5	80.00	4575.7	3550.3	80.74
6	100.0	3253.1	3013.2	31.94
7	100.0	1659.9	3813.2	-35.71
8	140.0	1385.1	2179.1	-68.55
9	200.0	945.4	2242.9	-137.0
10	300.0	7252.3	2454.4	66.15
11	400.0	3520.1	2696.9	23.39
12	500.0	2863.8	2931.0	-2.34
13	600.0	1905.5	3139.1	-64.74
14	700.0	3483.8	3314.2	4.86
15	600.0	1955.3	3139.1	-60.54
16	800.0	2528.0	3454.2	-36.63
17	1000.0	7110.0	3630.7	48.93

PARAMETER RESOLUTION MATRIX:
'F' INDICATES FIXED PARAMETER

P 1	0.58						
P 2	-0.03	0.91					
P 3	0.01	0.03	0.45				
P 4	0.00	0.00	0.00	0.00			
I 1	0.16	0.03	-0.01	0.00	0.89		
I 2	-0.04	-0.08	-0.30	0.00	0.04	0.38	
I 3	0.00	0.00	0.15	0.00	0.00	-0.05	0.07
	P 1	P 2	P 3	P 4	I 1	I 2	I 3


APPARENT RESISTIVITY (ohm-ft)
100
1000
10 4
10 5
10
100
1000
10 4
SPACING (ft)
ALR2
Depth (ft x 1000)
2
1
0
10
100
1000
10 4
10 5
RESISTIVITY (Ohm-ft)
MODEL:

DATA SET: ALR3

CLIENT: COE
LOCATION: FT.RICHARDSON
COUNTY: ALASKA
PROJECT: KN1080
ELEVATION: 0.00

DATE: JULY 1990
SOUNDING: R3
AZIMUTH: Unknown
EQUIPMENT: ABEM300C

Schlumberger Configuration

FITTING ERROR: 50.479 PERCENT

L #	RESISTIVITY (ohm-ft)	THICKNESS (feet)	ELEVATION (feet)	CONDUCTANCE (Siemens)	RESISTANCE (Ohms)
			0.0		
1	318.3	5.26	-5.26	0.0165	1674.8
2	315.6	92.29	-97.55	0.292	29128.4
3	11828.4	1513.4	-1610.9	0.127	1.790E+07
4	54.19				

ALL PARAMETERS ARE FREE

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	RHO-A (ohm-ft) SYNTHETIC	DIFFERENCE (percent)
1	6.00	382.0	318.5	16.60
2	10.00	307.0	319.3	-4.02
3	14.00	257.0	320.0	-24.52
4	10.00	325.0	319.3	1.73
5	14.00	266.0	320.0	-20.31
6	30.00	296.0	324.3	-9.59
7	40.00	353.0	329.3	6.89
8	30.00	380.0	324.3	14.63
9	40.00	356.0	329.3	7.48
10	80.00	359.0	367.5	-2.37
11	100.0	315.0	398.8	-26.60
12	140.0	607.0	481.0	20.75
13	100.0	482.0	398.8	17.25
14	140.0	527.0	481.0	8.72
15	200.0	664.0	629.3	5.21
16	300.0	995.0	892.2	10.33
17	400.0	569.0	1154.8	-102.9
18	300.0	924.0	892.2	3.44
19	400.0	515.0	1154.8	-124.2
20	500.0	775.0	1411.9	-82.18
21	600.0	2823.0	1660.1	41.19

No.	SPACING (ft)	RHO-A (ohm-ft) DATA	SYNTHETIC	DIFFERENCE (percent)
22	700.0	6581.0	1897.0	71.17

PARAMETER RESOLUTION MATRIX:
'F' INDICATES FIXED PARAMETER

P 1	0.79						
P 2	0.05	0.89					
P 3	0.00	0.01	0.03				
P 4	0.00	0.00	0.00	0.00			
T 1	0.04	0.01	-0.01	0.00	0.01		
T 2	0.04	-0.11	-0.10	0.00	0.06	0.80	
T 3	0.00	0.00	0.00	0.00	0.00	-0.01	0.00
	P 1	P 2	P 3	P 4	T 1	T 2	T 3