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7. Abstract

Bergstrom, K. A., J. P. Kiesler, and T. H. Mitchell, 1994, *Geophysical Investigation of Trench 4, Burial Ground 218-W-4C, 200 West Area*, WHC-SD-EN-TI-285, Rev. 0, Westinghouse Hanford Company, Richland, Washington.

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CONTENTS

FIGURES:

PLATES:

1.0 INTRODUCTION

This report contains the results of a geophysical investigation conducted to characterize Trench 4, located in Burial Ground 218-W-4C, 200 West Area (Figure 1). Trench 4, one of 25 trenches in the 200 Area, is where transuranic (TRU) waste is stored. TRU waste was generated by the national defense programs and was stored in a form that is retrievable pending decisions on its permanent disposal. The work described in this report will be used in the Phase I, Definitive Design, of Project W113, Solid Waste Retrieval Facility.

2.0 OBJECTIVES

The primary objective of the geophysical investigations was to determine the outer edges of the trench/modules and select locations for plate load-bearing tests. The test locations are to be 5 to 8 ft beyond the edges of the trench. Secondary objectives include differentiating between the different types of waste containers within a given trench, determining the amount of soil cover over the waste containers, and to locate the module boundaries. Ground-penetrating radar (GPR) and electromagnetic induction (EMI) were the methods selected for this investigation.

3.0 METHODOLOGY

3.1 GROUND-PENETRATING RADAR METHODOLOGY

The GPR system used for this work utilized a 300-megahertz (MHz) transducer. The transducer transmits electromagnetic energy into the ground. Buried objects such as pipes, barrels, foundations, and buried wires can cause all, or a portion, of the transmitted energy to be reflected back towards a receiving antenna. Geologic features such as crossbedding, caliche horizons, paleosols, and clays can also cause reflections of the transmitted energy. The reflected energy provides the means for mapping the subsurface features of interest, whether man-made or geologic.

The maximum depth of investigation varies from site to site and is a function of the transmit power, receiver sensitivity, frequency of the antenna, and attenuation of the transmitted energy. The attenuation of the energy is primarily a function of the local soil conditions. Depth of investigation is also affected by highly conductive material, such as metal drums and pipes which essentially reflect all the energy. The method cannot "see" directly below areas of highly reflective material since "all" of the energy is reflected. Maximum depth of penetration for these surveys ranged from 8 to 12 ft.

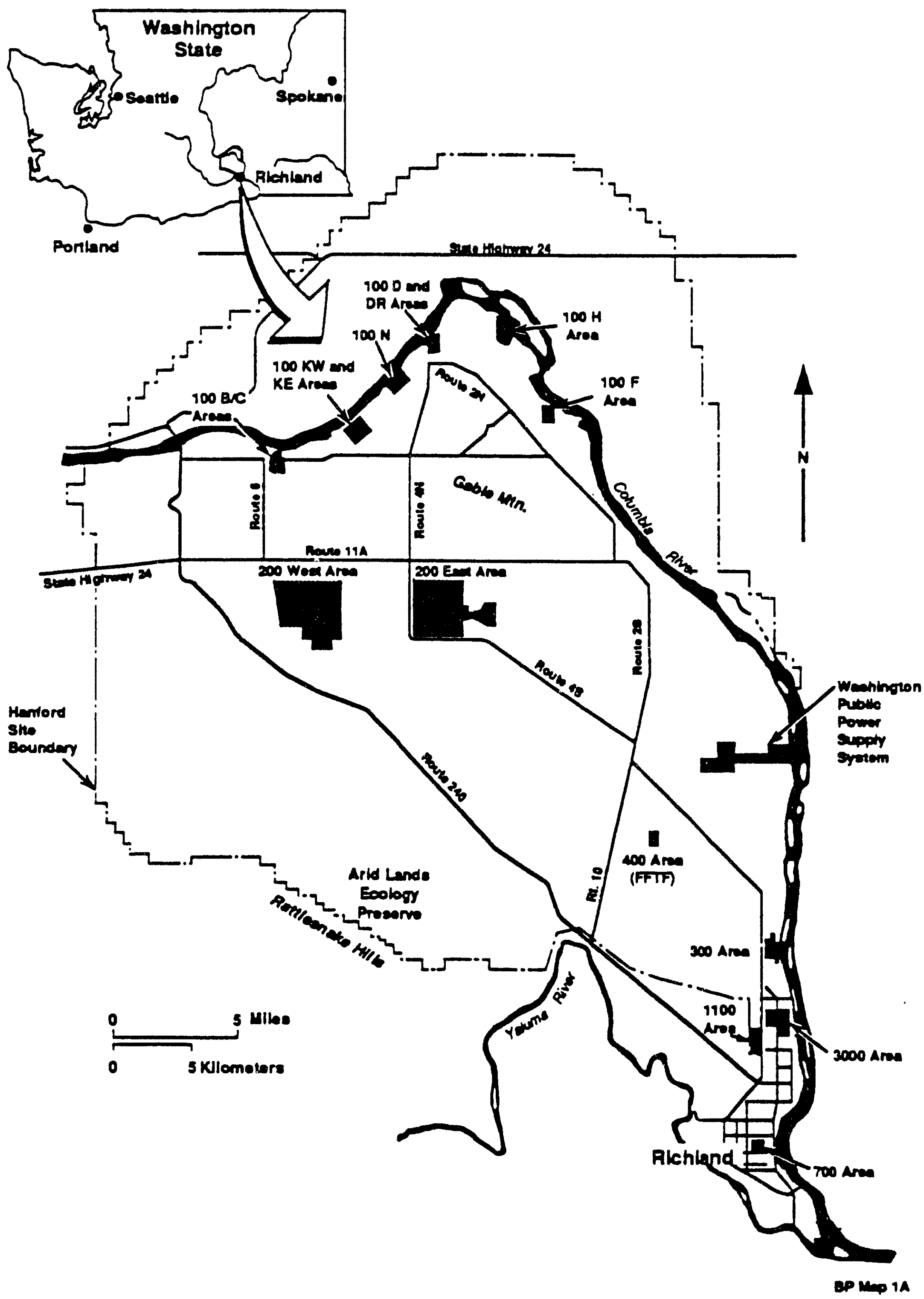


Figure-1. General Site Location Map.

Display and interpretation of GPR data are similar to that of seismic reflection data (i.e., data displayed as horizontal distance vs. time, depicting pseudo cross-sections of the earth). The approach to an interpretation is quite variable and influenced by the objectives of the survey and the experience of the interpreter. There are also numerous data processing techniques available that may or may not aid in the interpretation process. In some areas, interpretations can be straight forward, but often a highly variable subsurface yields complex data that are difficult to interpret. A common end product is a plan-view map showing the locations and depths of the features that were detected within the survey area.

GPR data in these surveys were collected with a Geophysical Survey Systems Inc. (GSSI) Subsurface Interface Radar (SIR)™ (a trademark of Geophysical Survey Systems, Inc., [GSSI]) System 8, model 4800, and digitally stored on a GSSI DT6000A tape drive. A recording window of 100 nanoseconds, two-way travel time, was used.

3.2 ELECTROMAGNETIC INDUCTION

EMI techniques are used to determine the electrical conductivity of the subsurface soil, rock, and groundwater. They are generally used for shallow investigations. The method is based on a transmitting coil radiating an electromagnetic (EM) field which induces eddy currents in the earth. A resulting secondary EM field is measured at a receiving coil as a voltage which is linearly related to the subsurface conductivity.

Terrain or ground conductivity is a function of the natural soil matrix and pore-fluid electrical conductivity. The depth of investigation is dependent upon the electrical conductivity of the subsurface, the distance between the transmitting and receiving coils, sensitivity of the equipment, and the power of the source. The conductivity value resulting from a measurement is a composite, and represents the combined effects of the thickness of the stratigraphic layers, their depths, their specific conductivity, and any man-made conductive objects such as metal objects that may be present. Metallic objects generally overwhelm the natural conductivity of the ground.

A Geonics' EM-31D™ (a trademark of Geonics Limited) ground conductivity meter was used for the survey . It has a maximum depth of penetration of approximately 18 ft.

EMI is a very effective reconnaissance method used to locate buried metallic objects. The interpretation of EMI data does not yield reliable quantitative information such as depths and the shape and size of objects. However, in areas where the effectiveness of GPR is limited by the surrounding terrain, EMI often yields valuable information. The most reliable interpretations are a result of the integration of GPR and EMI.

3.3 ACCURACY/RELIABILITY OF THE RESULTS

EMI and GPR investigations are based on very accurate measurements. However, the results of an investigation are based on the interpretation of these data, which is a very subjective process. The only way to measure the accuracy of an interpretation is by ground-truthing (i.e. excavating the subsurface). A better way to assess interpretations is in terms of reliability. Reliability is defined here as the degree of confidence the interpreter(s) have in their interpretation of the data. There are many factors that affect the reliability of an interpretation. Two of the most important factors are the density of the data points/profiles (which is determined by the objectives of the survey) and the experience of the interpreter(s). Other factors that directly affect the reliability of an interpretation are soil conditions, topography, availability of accurate drawings and photographs, geologic knowledge, and the accessibility to the area which is to be investigated. The more direct control or knowledge the interpreter has over these factors the more reliable the interpretation. To complicate matters, the control or knowledge of these factors may vary significantly within the area being investigated.

The only effective way to communicate the reliability of an interpretation is by constant and direct communication between the user and the interpreters. Reliability and accuracy of an interpretation should be discussed openly during the course of a project. An interpretation map should never be taken at face value without communication with the interpreters.

4.0 SURVEY GRID PARAMETERS

The survey boundary is a rectangle, measuring 50 ft by 480 ft (Figure 2). The long axis of the survey strikes approximately east-west. All distances were measured and posted in feet. Painted stakes are located every 100 ft and mark the corners of the grid. The grid is also tied to the state-plane coordinate system via the orange survey stakes. The southwestern corner of the grid is designated E100/N100 and serves as the "origin" for the survey locations. The letters "E" or "N" refer to a direction that trends generally east or north, respectively. The number refers to a distance in feet. For example, grid point E135/N120 lies 35 ft "east" and 20 ft "north" of grid point E100/N100.

GPR data were collected along two sets of profiles perpendicular to each other. The centers of the profiles were spaced 2.5 ft apart. EMI profile spacing varied from 2.5 to 10 ft. EMI data points along each profile were spaced 2.5 ft apart.

5.0 GEOLOGIC SETTING

In the 200 West Area, the unsaturated zone is about 200 ft thick. The upper geologic unit, the Hanford formation, is approximately 100 ft thick and consists of two stratigraphic sequences. The first is a coarse-grained sequence of inter-stratified gravel, sand, and to some degree silt. The second sequence is much finer-grained, consisting of silt, silty sand, and sand interbedded with coarse sand. The sediments that were a factor for this investigation were primarily the uppers sands and gravels that were "reworked" during the excavation and subsequent refilling of the trench. The only strata that appears not to have been disturbed are near the southern and northern edges of the survey area, just outside of the boundaries of the trench.

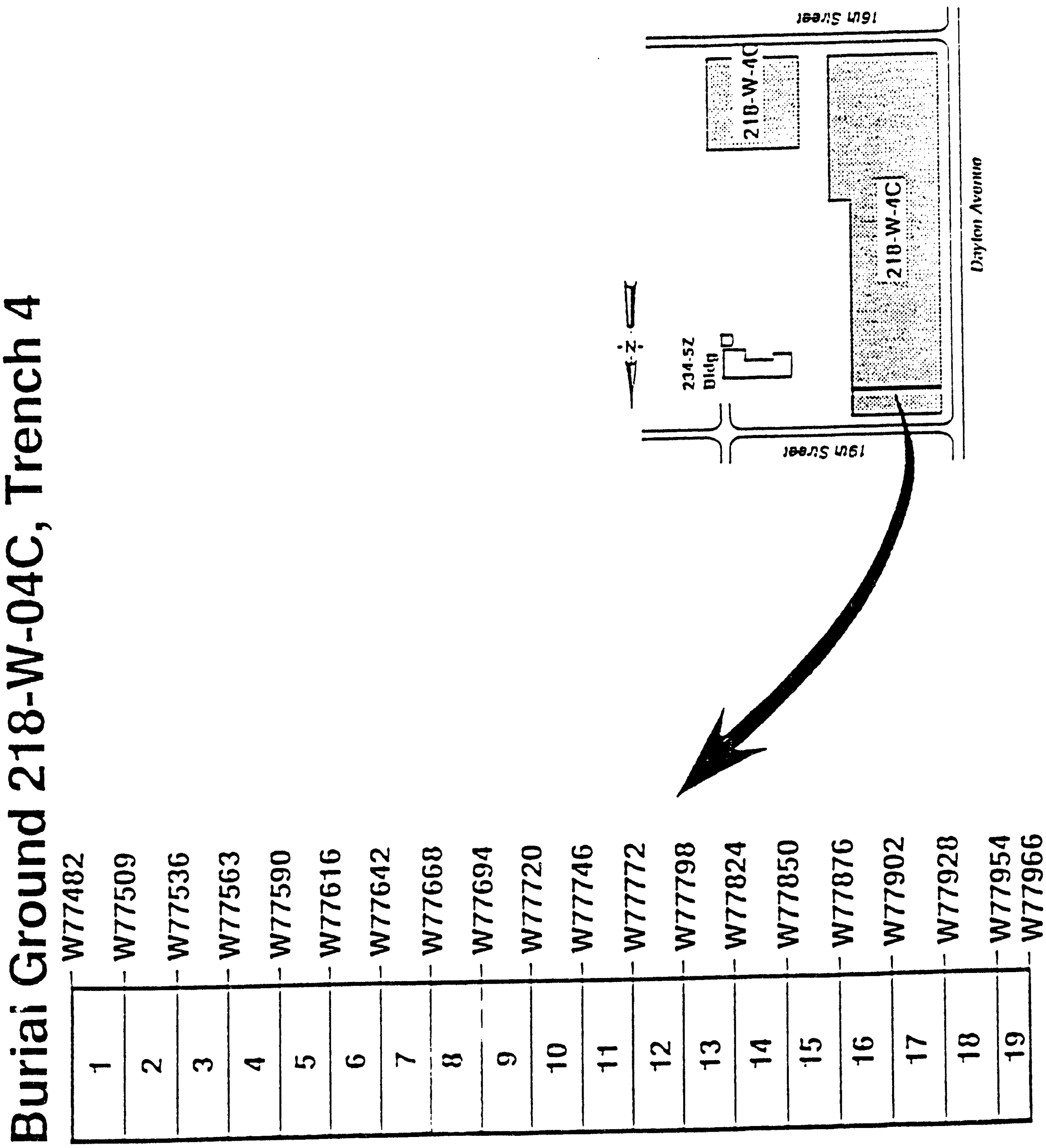


Figure 2. The location of Burial Ground 218-W-4C, Trench 4, 200 West Area.

6.0 RESULTS

Trench 4 has been divided into three sections: Section (Western), E100 to E300; Section II (Central), E300 to E500; and Section III (Eastern), E500 to E580. Plates I and II should be referred to throughout the following discussion of the results. Plate I shows the integrated interpretation of the GPR and EMI data. The documented distribution of the waste in tier 4, taken from drawing H-2-87544, Rev.0, is shown on Plate II, which is a contour map of the EMI data.

In general, GPR was effective at determining the thickness of the fill that overlies the waste containers and identifying the outer edges of the modules. However, the reliability of the interpreted locations of the outer boundaries of the waste within the trench varied throughout the length of the trench.

Interpreted boundaries between some of the modules were identified. EMI appears to be an effective method for identifying the module boundaries. To identify a boundary between two modules at least one or more of the following conditions is required. These include:

1. A change in the type of waste containers (e.g. barrels in module A, Casks in module B)

2. A gap between modules that is large enough to be resolved by GPR and/or EMI

3. A change in the depth of burial between modules (e.g. three-tier stack of barrels to a four-tier stack)

4. A vertical conductivity boundary between modules.

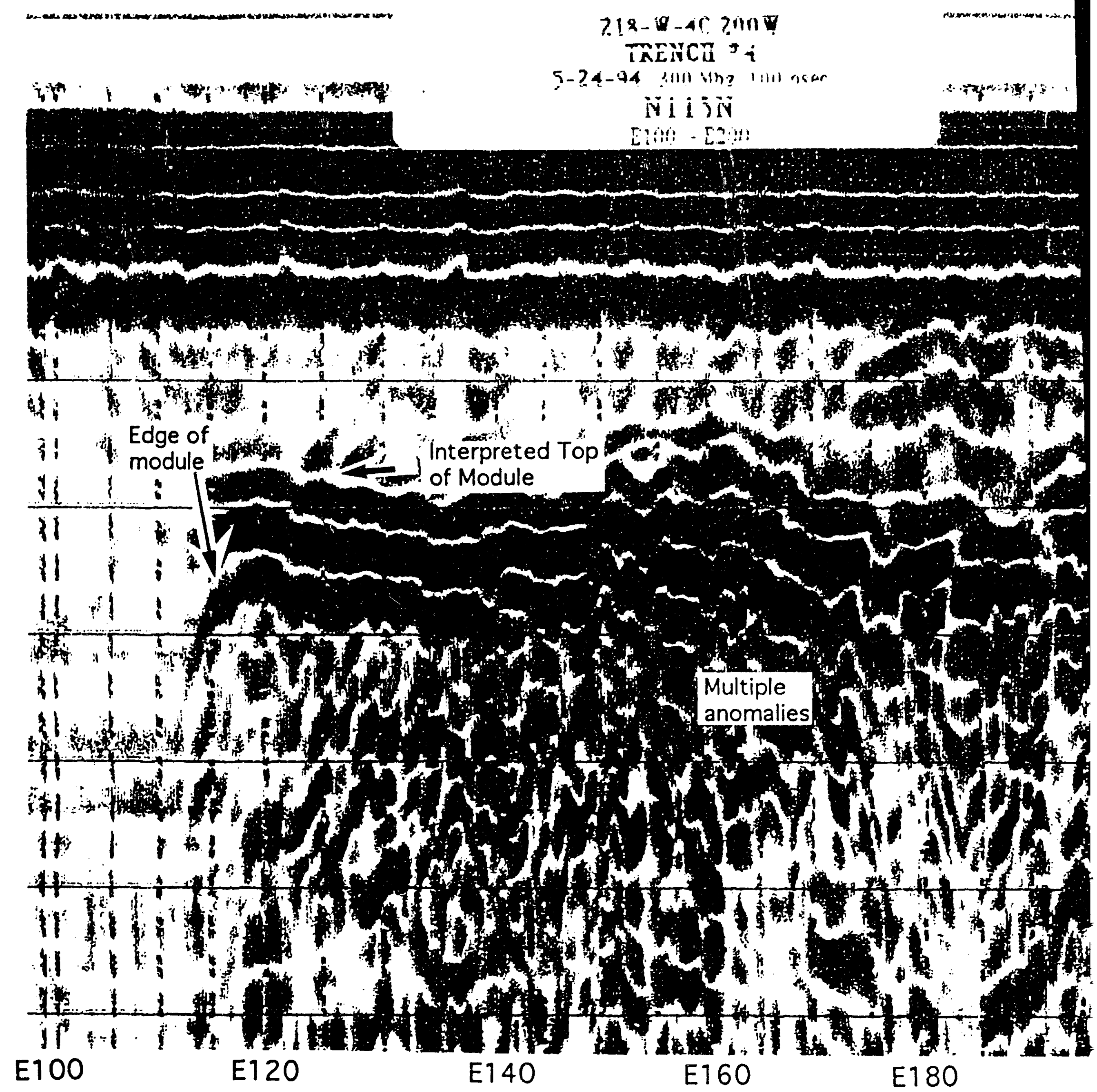
In several areas, the resolving power of the methods was degraded by the rough terrain above the trench. In general, the smoother the topography the more reliable the results. The results primarily represent the waste in the upper one or two tiers. Some information on the deeper/lower tiers may be in the data; however, it may be impossible to extract the information from the data with any confidence.

A persistent reflector is evident in most of the GPR records (Figure 3). The reflector is believed to be primarily from the upper surface of the waste containers and/or affiliated with the cover (i.e. tarp/plywood) that is typically installed directly over the waste containers. Generally 4 to 5 ft of soil fill covers the waste containers.

The interpreted outer boundaries of the modules are believed to be relatively accurate to within 3 to 5 ft. In general, the northern and southern boundaries correlate very well with the documented module boundaries. A more detailed discussion of the results within each of the three sections of the trench are given below.

6.1 SECTION I, E100 TO E300

Section I includes the western end of Trench 4. The topography is relatively flat with minimal vegetation. The highest quality GPR data are from section I. Generally, about 4 to 5 ft of soil fill covers the modules.



218-W-4C 200W
TRENCH #4
5-24-94
N115N
E100 - E200
Edge of module
Interpreted Top of Module
Multiple anomalies
E100
E120
E140
E160
E180

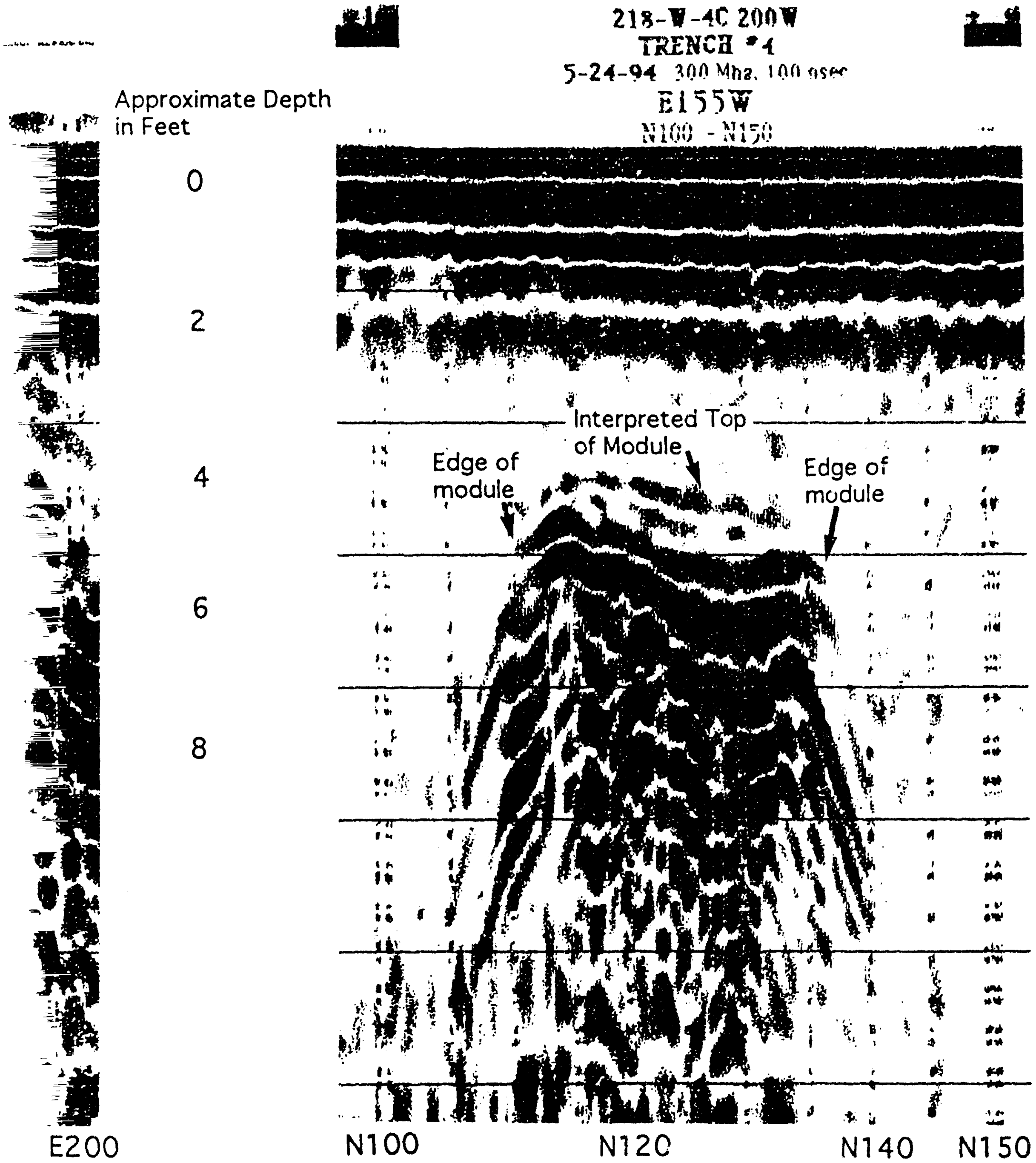


Figure 3. Ground-penetrating radar profiles from Section I, showing the persistent reflector 4-5 feet below the surface, interpreted to be from the "top" of the modules. Note the anomalies below this reflector. Profile E155 is a north-south profile and profile N115 is an east-west profile.

The geophysical data, primarily GPR, indicate a relatively variable western edge of the waste containers in contrast to documentation which indicates a straight row of barrels, twelve across. Several scenarios were considered to explain this discrepancy. First, the documented distribution of the waste may not be entirely correct, or the outer barrels have been knocked over leaving an edge that is no longer a sharp distinct row of barrels. Another possibility is that the tarp cover and associated plywood, typically covering the waste containers, extends irregularly beyond the barrel edge producing the irregular edge in the GPR results. A final scenario is that the containers of waste within the northwest corner are "soft waste" (e.g. cardboard, wood) and were overlooked in the interpretation.

In some areas within the documented module boundaries, the reflector interpreted to be associated with the top of the waste containers is missing. These areas are believed to represent gaps between waste containers, different types of waste containers (i.e., barrels vs. wood casks) with different dielectric properties, or variations in properties of the cover which overlies the modules.

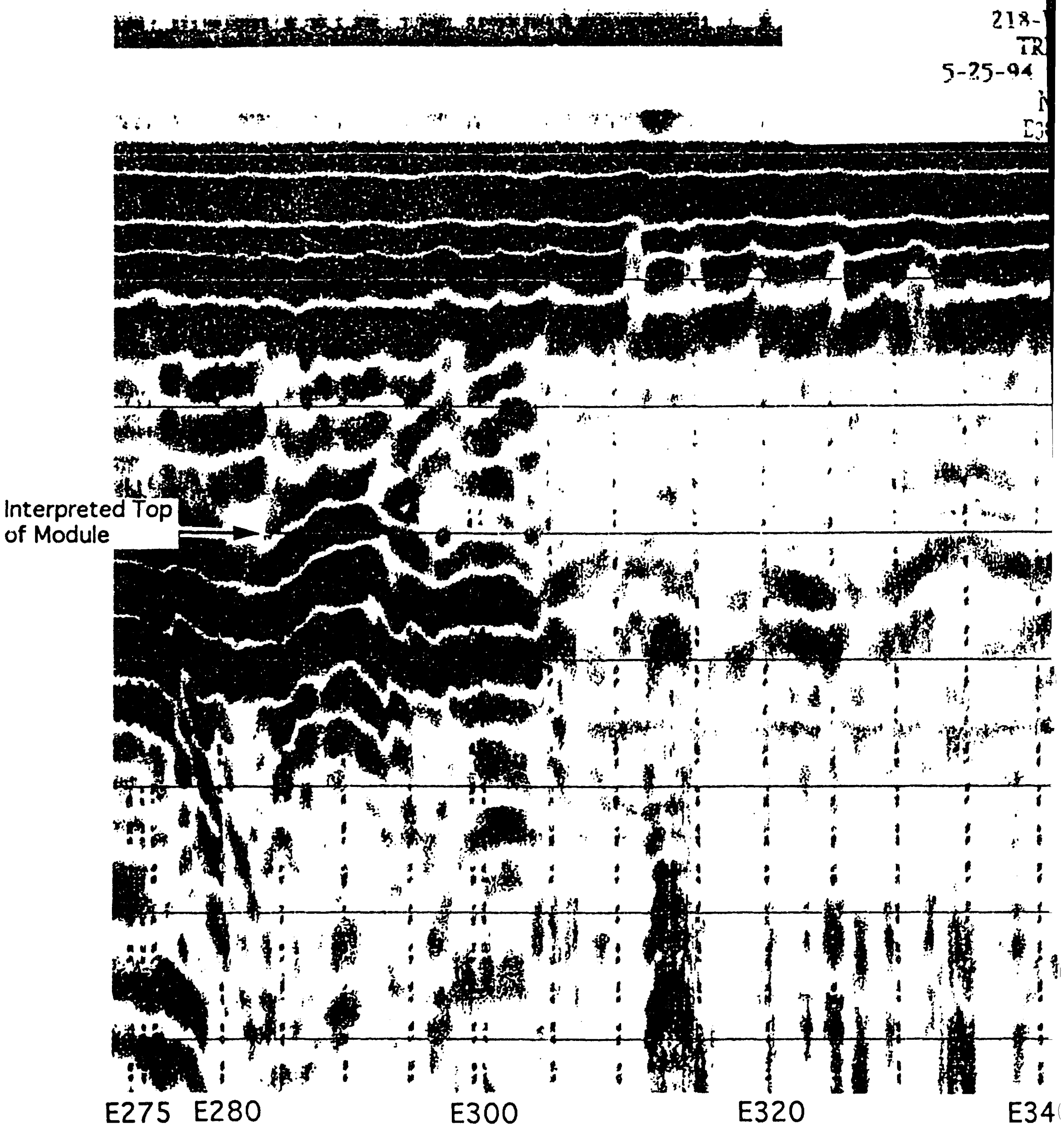
6.2 SECTION II, E300 TO E500

There is a distinct character change in the GPR, and to some degree EMI, data near E300. The strong reflector that was observed in the GPR data in Section I changes to a subtle, more intermittent reflector in most of Section II (Figure 4). Documentation indicates that most of Section II (modules 5-10) is a solid mass of barrels with the only exception a gap between modules 4 and 5. The EMI data in Plate II, Section II show a series of seven evenly spaced highs, all about the same size and character, unlike Section I where the EMI data consist of a more complex pattern of highs and lows. Each EMI high in Section II correlates with the documented center of a module. The EMI data suggest that there is a barrier or small gap between the modules.

It is very difficult to pinpoint the primary cause of the change in the character of the GPR data between Section I and Section II. The directly observable changes between Section I and Section II are the topography and the ground cover. The topography in Section II is much rougher and there is a notable increase in the amount of surface vegetation as compared to Section I. Rougher topography and vegetation will generally degrade the quality of GPR data, but not nearly to the extent observed.

The changes in the GPR data are probably a consequence of the type of buried debris and/or the tarps/wood used to cover the waste (Figure 5). A change in the properties of the soil overlying the waste could be a contributing factor. But at the surface, the soil "looks" the same and appears to be the same soil observed in and around the other trenches.

A couple of scenarios were considered that could, in part, explain the data sets from Section II. The first is that there is some "soft waste" in wood or cardboard type containers above the documented drums. Barrels would be more difficult to detect with GPR through this debris. These types of waste usually do not notably effect the EMI data. Therefore the EMI data would still be responding primarily to the barrels stacked below the "random debris."


218-
TR
5-25-94
Interpreted Top of Module
E275
E280
E300
E320
E34

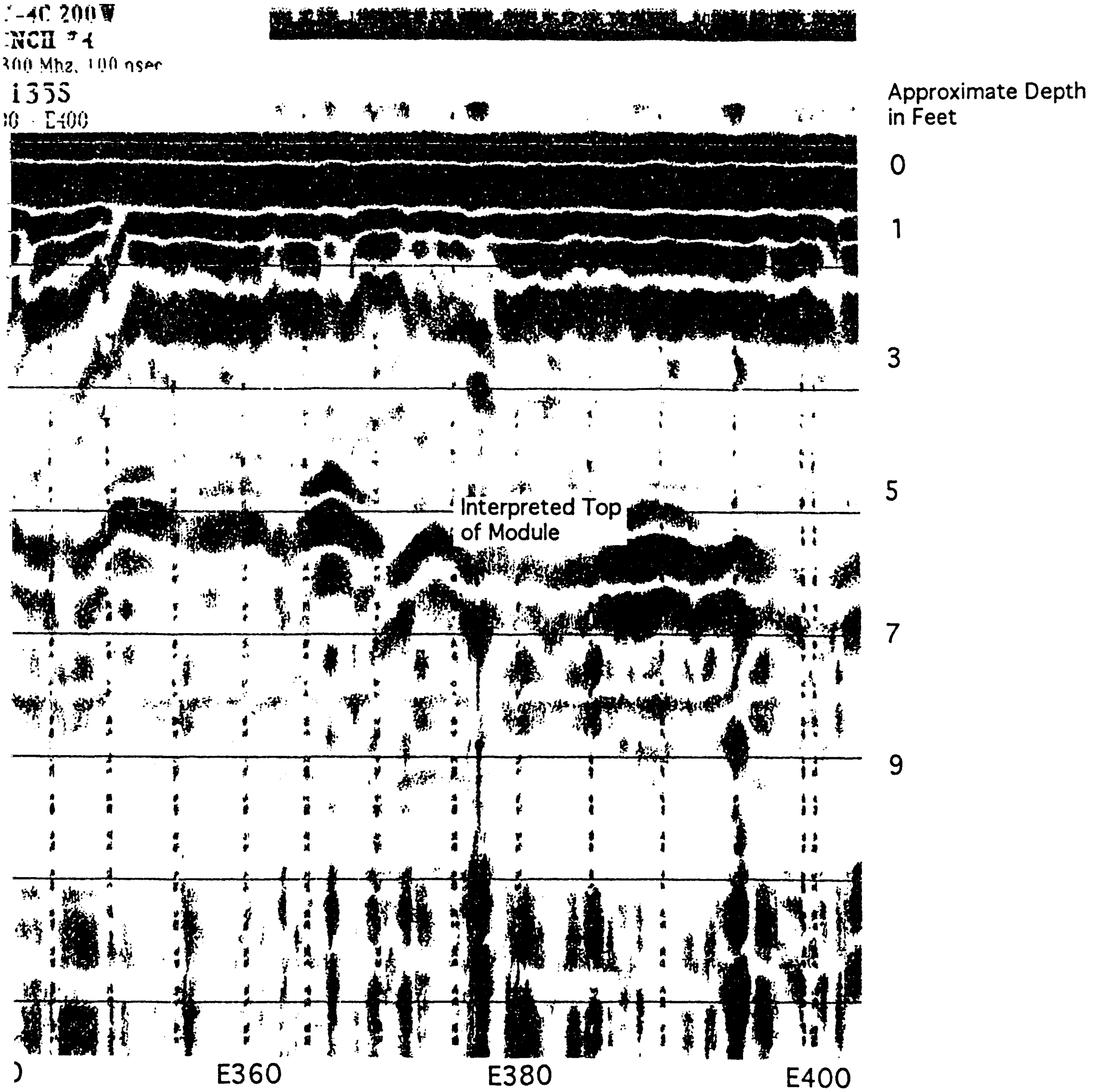


Figure 4. Ground-penetrating radar profile along N135, extending from Section I to Section II, from E275 to E400. Note the significant character change of the reflector, 4-5 feet below the surface, at E305. This reflector is interpreted to be from the top of the modules.

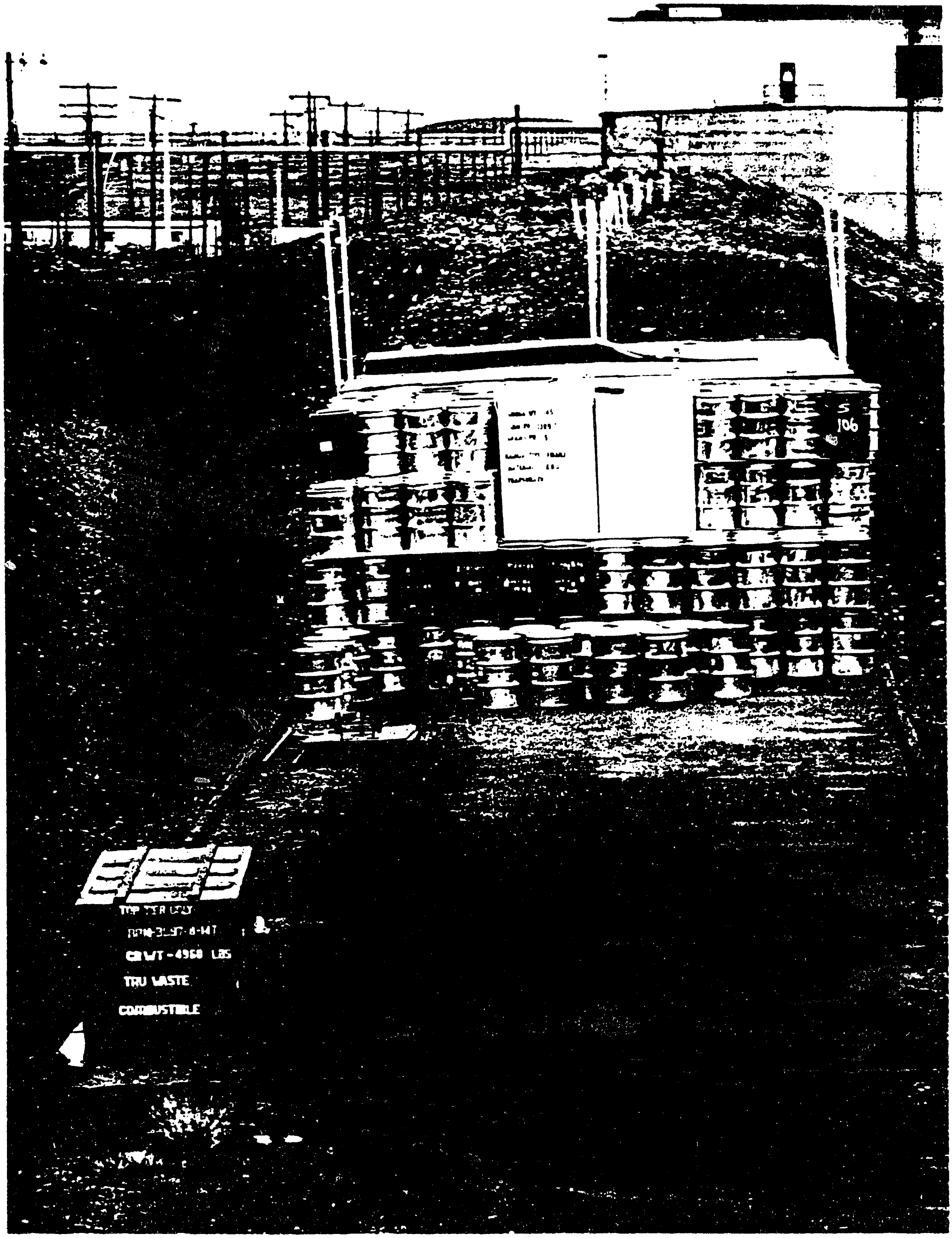


Figure 5. Photograph of partially exposed Trench 4 waste containers.

A second scenario is that the waste barrels are covered by a different type of tarp/liner/wood than was used to the west. The cover could be attenuating the electromagnetic energy transmitted by the GPR system. In this case, the GPR would be misleading and the EMI, for the most part, would support the documented module layout.

There were enough good GPR data in this section to determine the thickness of the fill to be 4 to 5 ft, overlying the reflector interpreted to represent the top of the waste containers. The northern and southern boundaries of the modules are at approximately N140 and N110, respectively. The EMI was used to estimate the module to module boundaries, assuming the observed character changes were a result of a gap or barrier between modules. The GPR data should be used with discretion in this section until the enigmas in the data are better understood. Ground-truthing is the only known way to verify the data and determine to what extent the GPR data can be used.

6.3 SECTION III E500 TO E580

The terrain in Section III is the roughest of all three sections. This section essentially is on a 10- to 15-ft-high mound with steeply dipping slopes to the south, north, and east. As a result, the grid is only 30 ft wide in this section. Documentation shows a four tier high, tightly packed stack of barrels throughout the section with small gaps between modules 1, 2, 3, 4, and 5. Additionally, there is a fifth tier of barrels in modules 1 and 2.

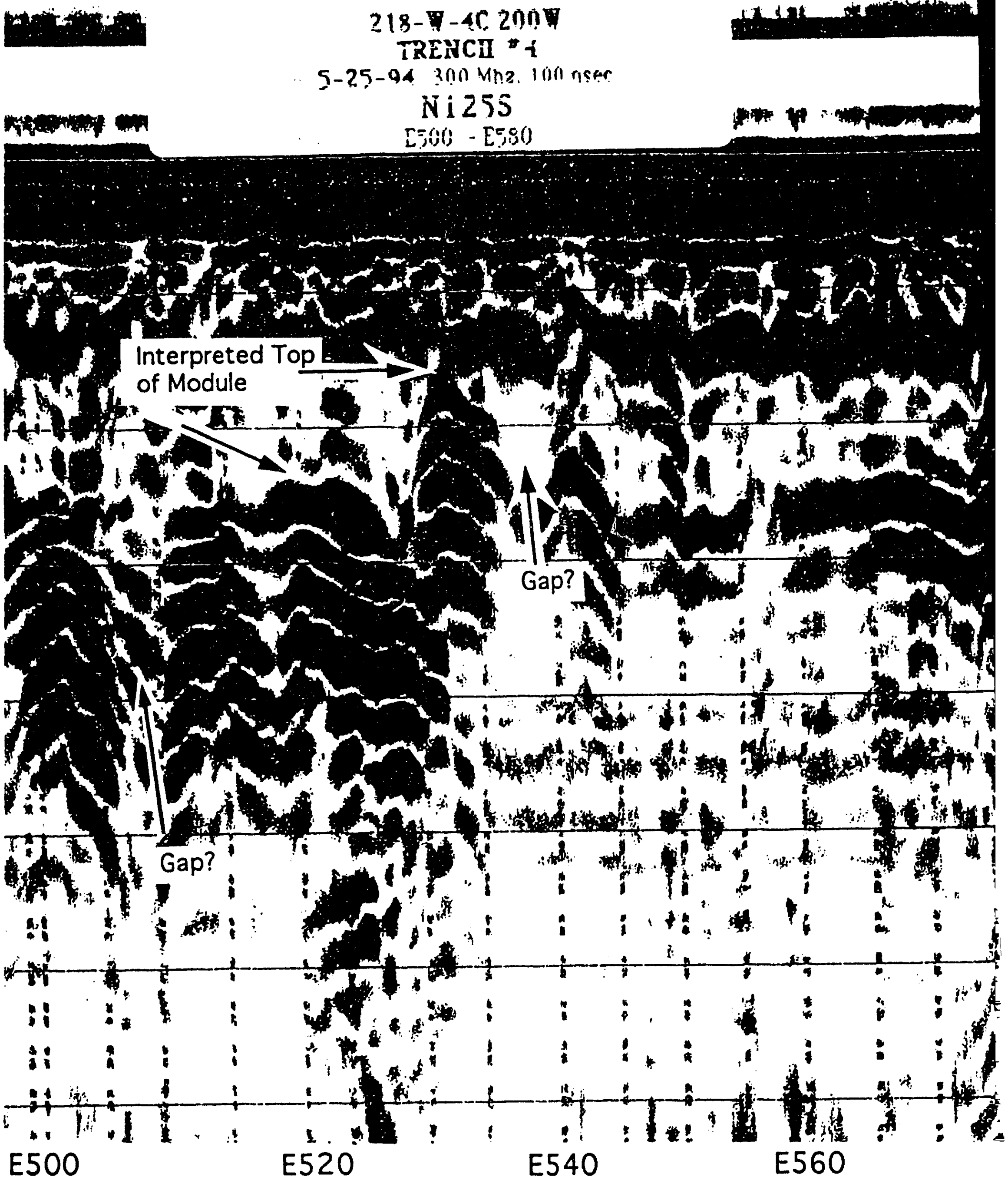
The GPR data show a strong, but discontinuous, reflector 2 to 4 ft below the surface. However, numerous gaps in the reflector (see Figure 6) are not consistent with a tightly packed stack of barrels shown in the documentation. The EMI was affected by surface cable and wires that severely hampered the data in the vicinity of E535. Despite the surface interference, the EMI data show three relatively similar highs that correspond with the documented centers of the modules as shown in the documentation. The highs are very similar in character to the EMI highs discussed for Section II.

Similar to Section II, the GPR, EMI, and documentation in Section III give somewhat conflicting information. The explanations for the differences in the data sets in the discussions of Section II are also applicable for Section III.

Once again, the GPR data should be used with discretion in this section until the enigmas in the data are better understood.

7.0 SUMMARY

A combination of GPR and EMI were effective at determining the thickness of the fill that overlies the waste containers, identifying the outer edges of the modules, and to some extent the boundaries between modules and variability of waste containers. The outer edges of the modules were delineated to within 3 to 5 ft and the overlying soil covering the modules was typically 4 to 5 ft thick. The interpretation presented in this report only summarizes the data. There is additional


218-W-4C 200W
TRENCH #4
5-25-94 300 Mhz. 100 nsec
N125S
E500 - E580
Interpreted Top of Module
Gap?
Gap?
E500
E520
E540
E560

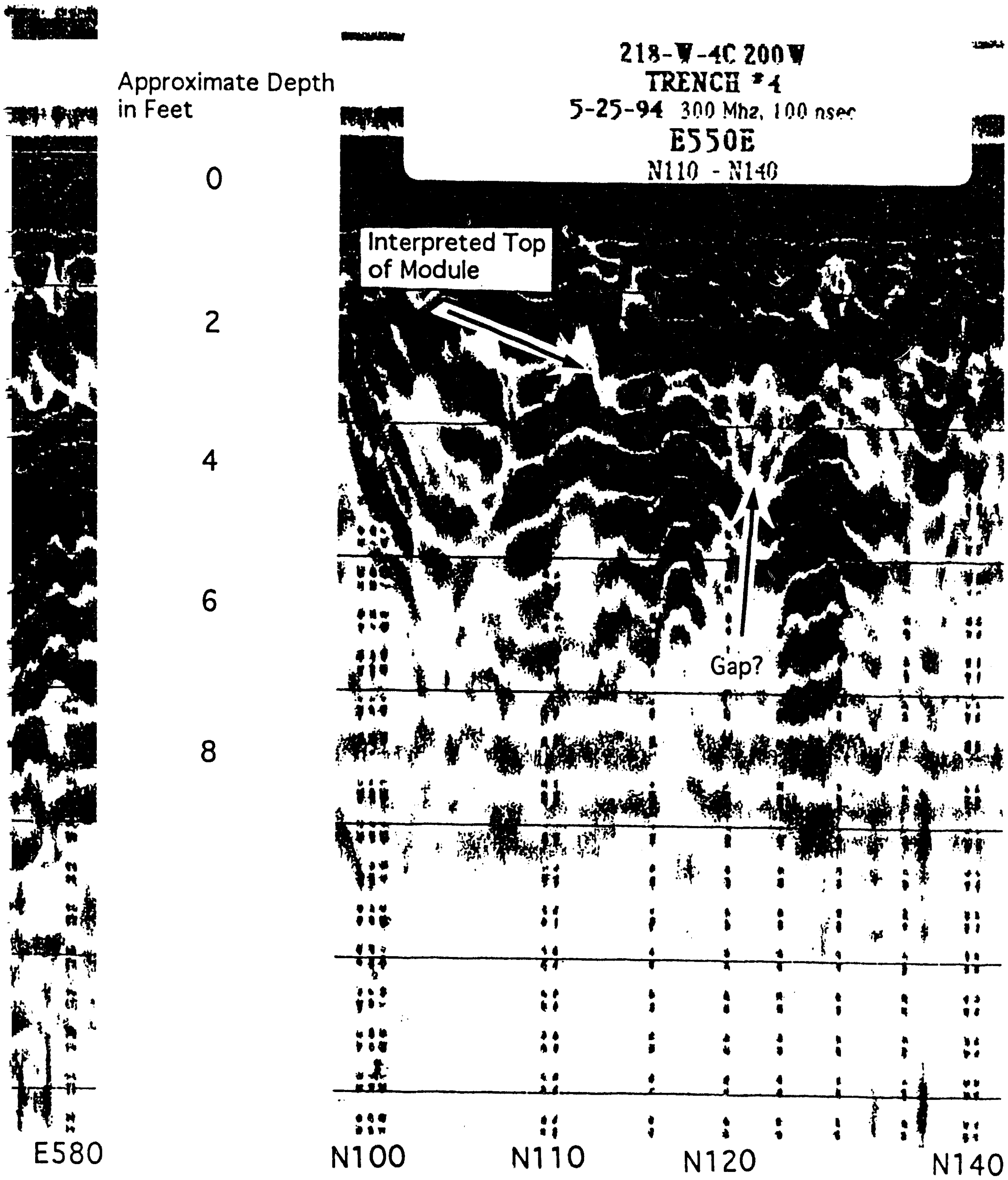
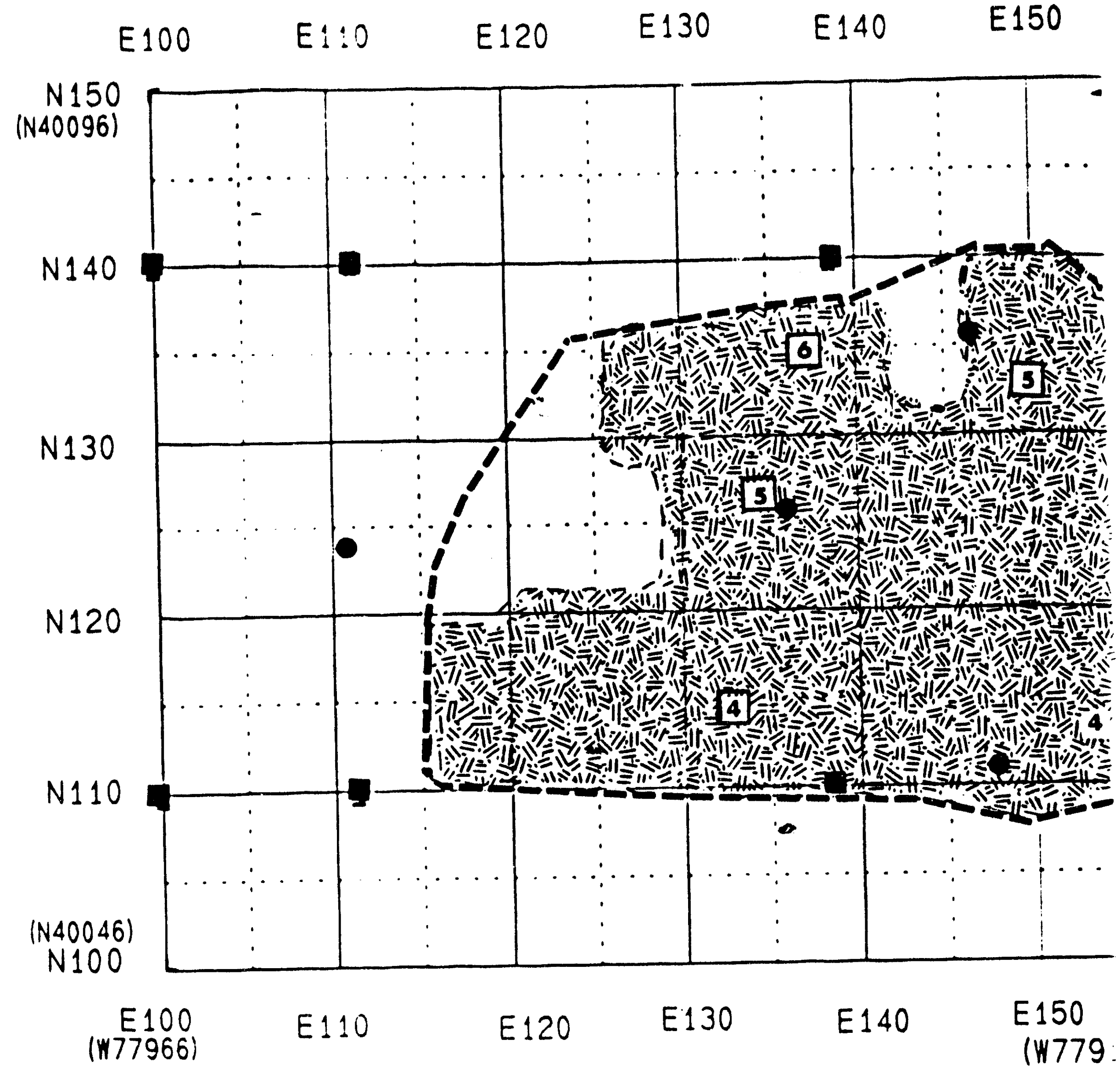


Figure 6. Ground-penetrating radar profiles from Section III, showing the strong but laterally discontinuous reflector, 2-4 feet below the surface. Profile E550 trends north-south and profile N125 trends east-west. Note the module height change at E530 in profile N125, interpreted to be the transition from 4-tier to 5-tier drum stacks.

site-specific information that was not included on Plate I. It is recommended that the authors be contacted prior to any site-specific excavations, tests, drillings, etc., for the more detailed, site-specific information that may be available.

Eight sites for plate load-bearing tests (see Plate I) were determined to be greater than 5 ft from the module edges and not over any other geophysical anomalies.


E100
E110
E120
E130
E140
E150
N150
(N40096)
N140
N130
N120
N110
(N40046)
N100
6
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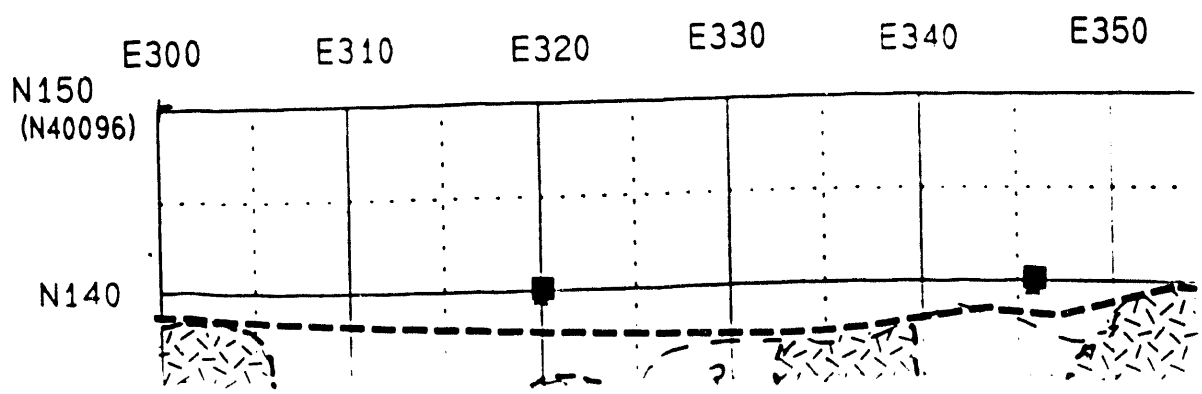
E100
(W77966)
E110
E120
E130
E140
E150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E310
E320
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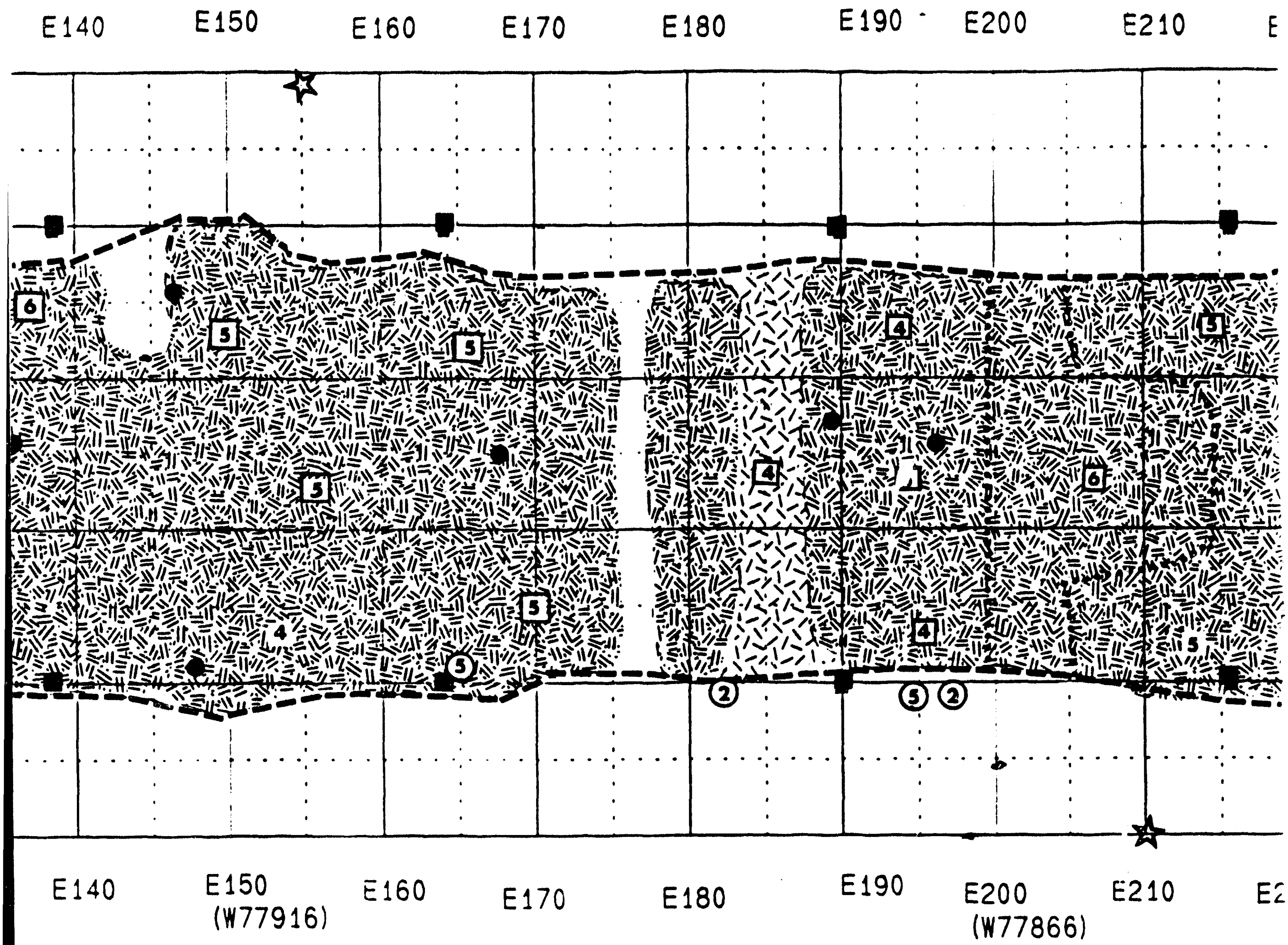
E340
E350
N150
(N40096)
N140



E140
E150
E160
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E180
E190
E200
E210
6
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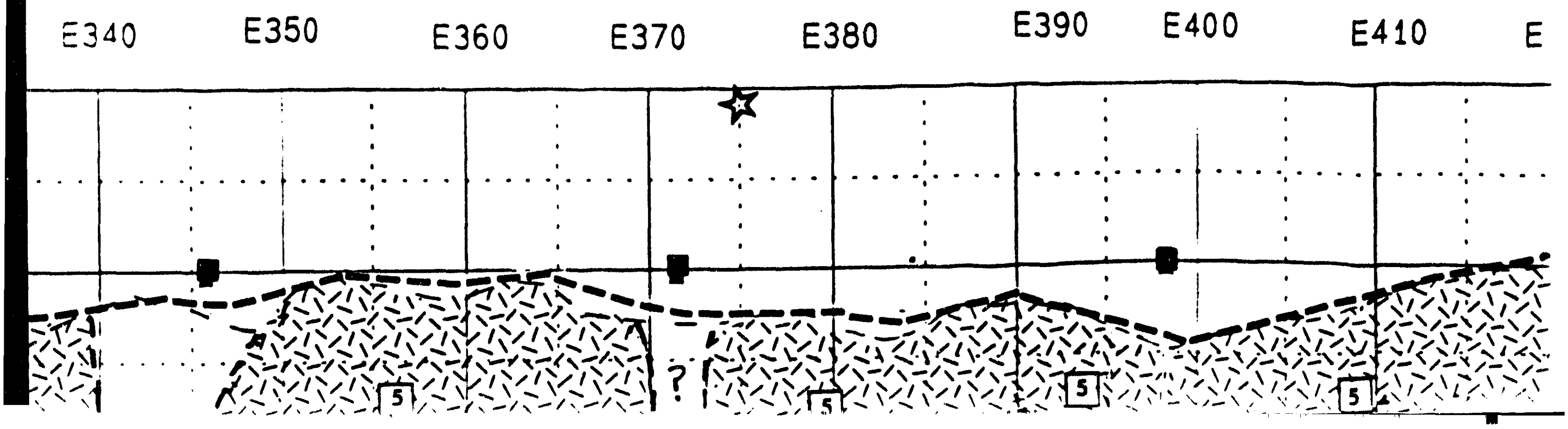
E210



E350
E360
E370
E380
E390
E400
E410
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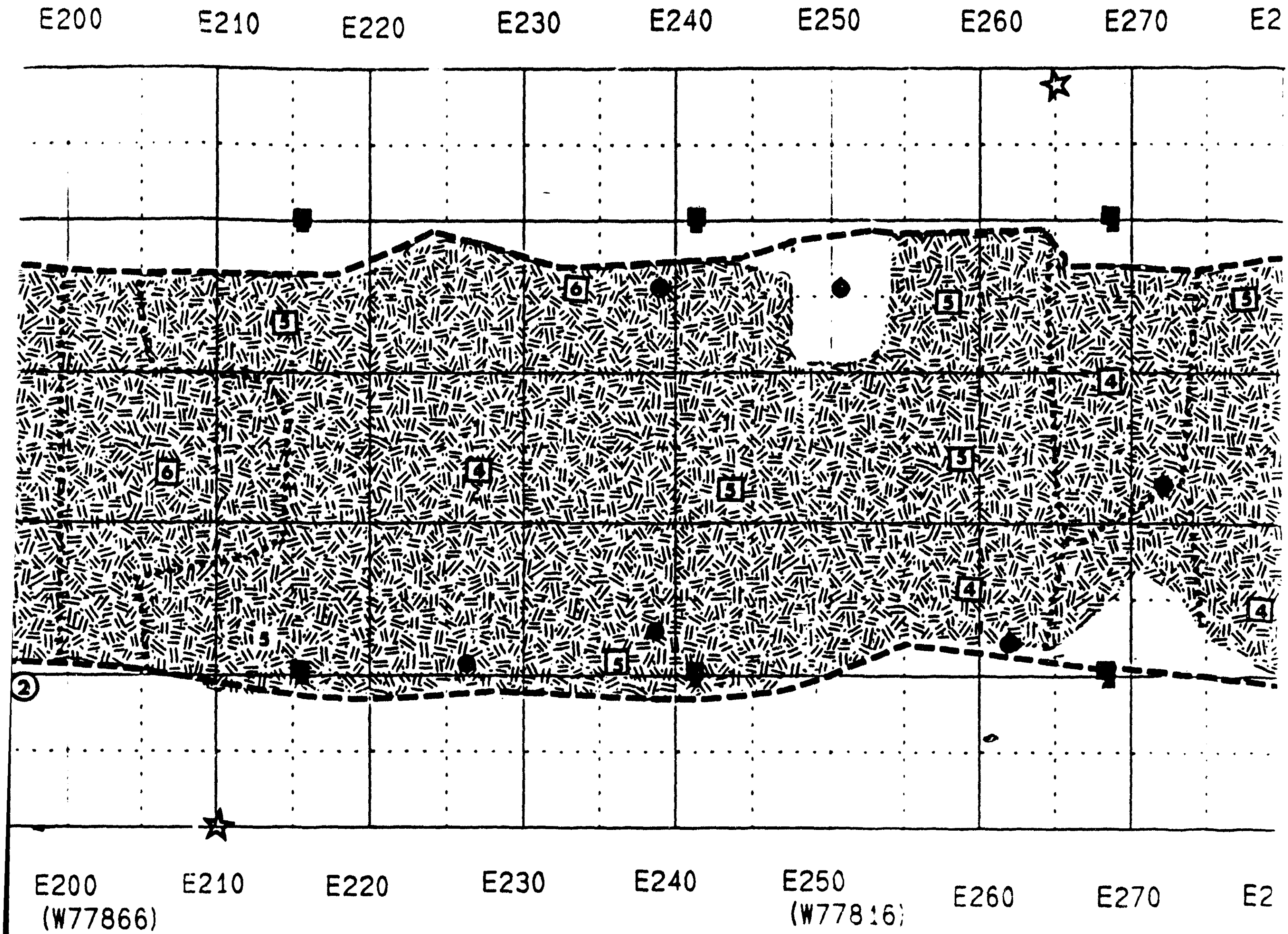

E200
E210
E220
E230
E240
E250
E260
E270
E2
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5
5
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6
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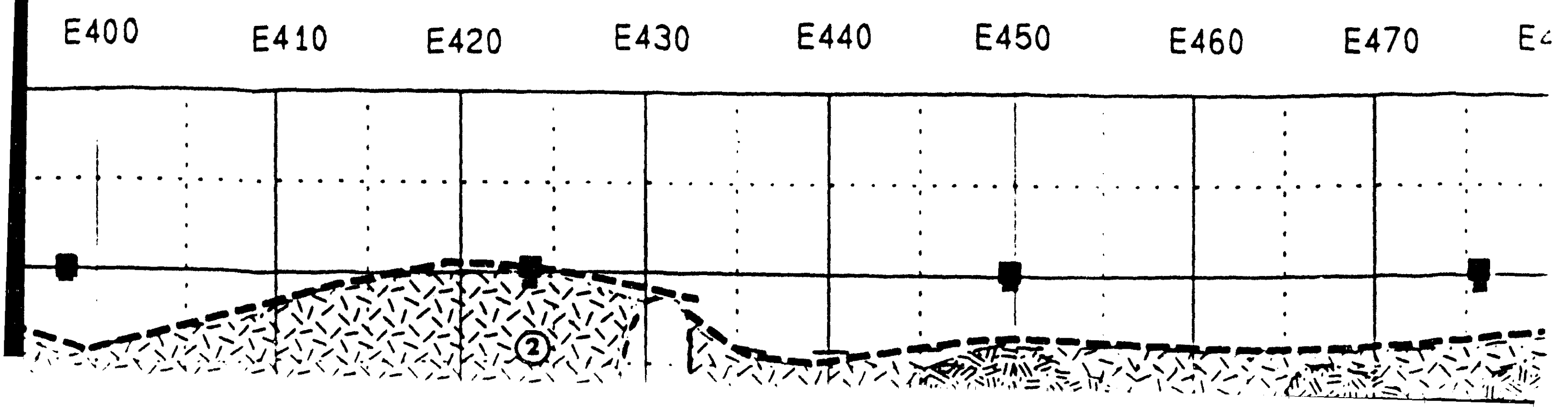
E270
E2



E400
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E450
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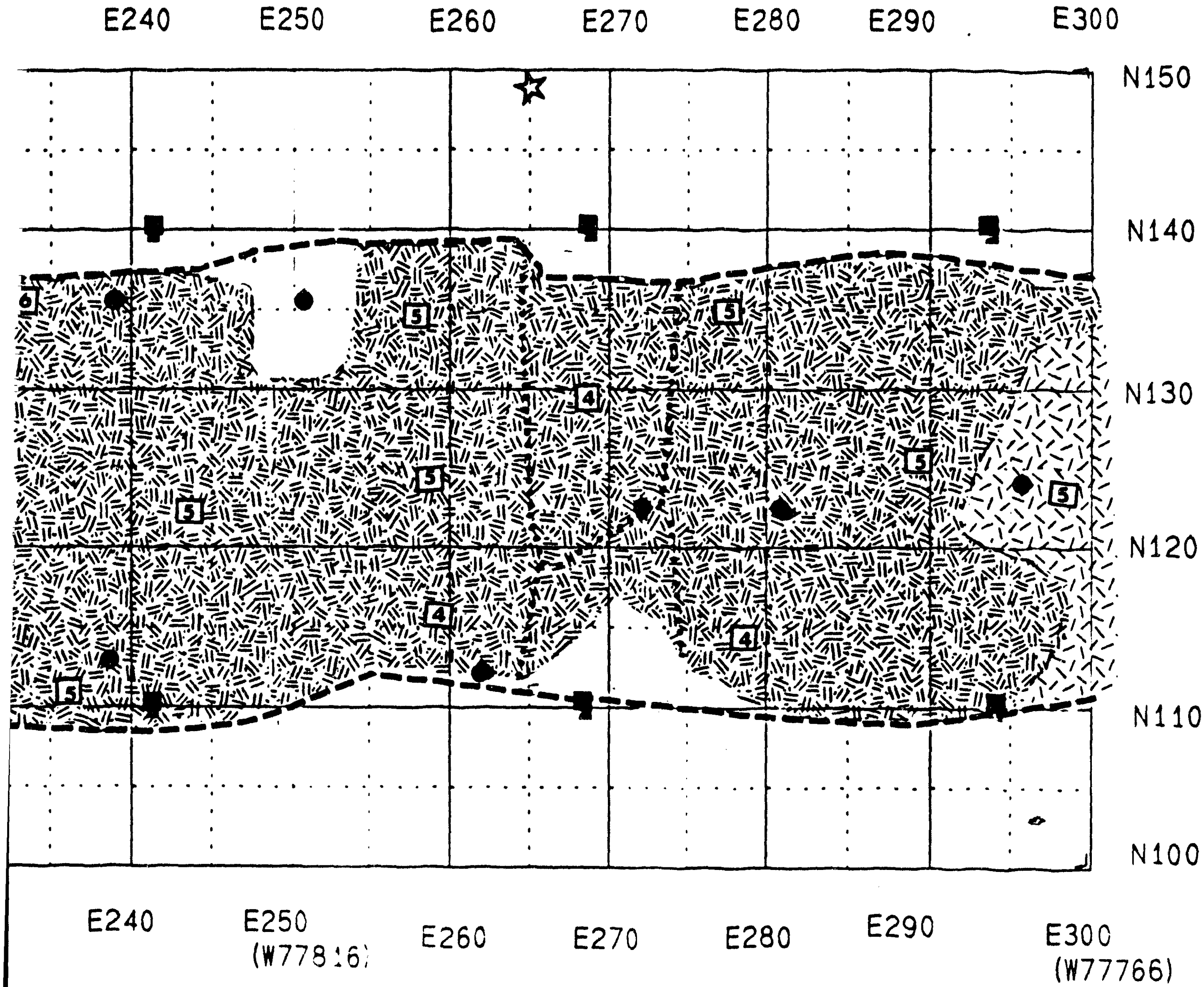
E470
2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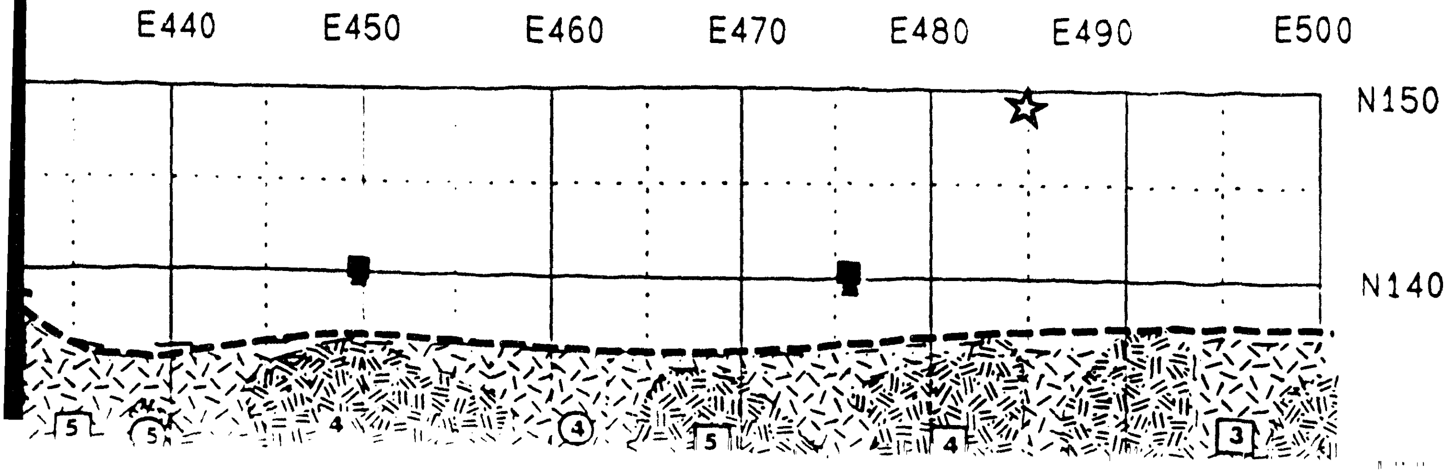
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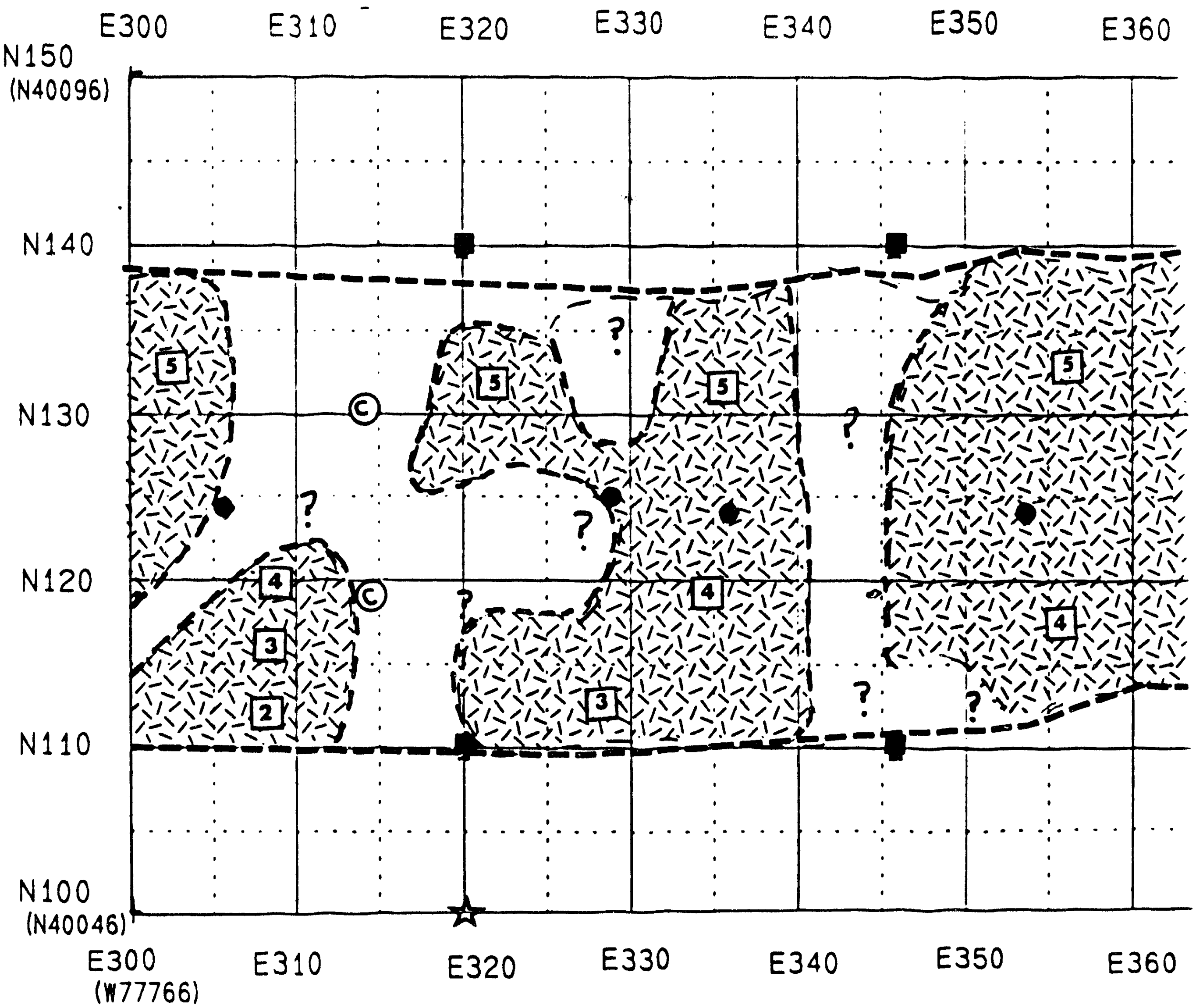
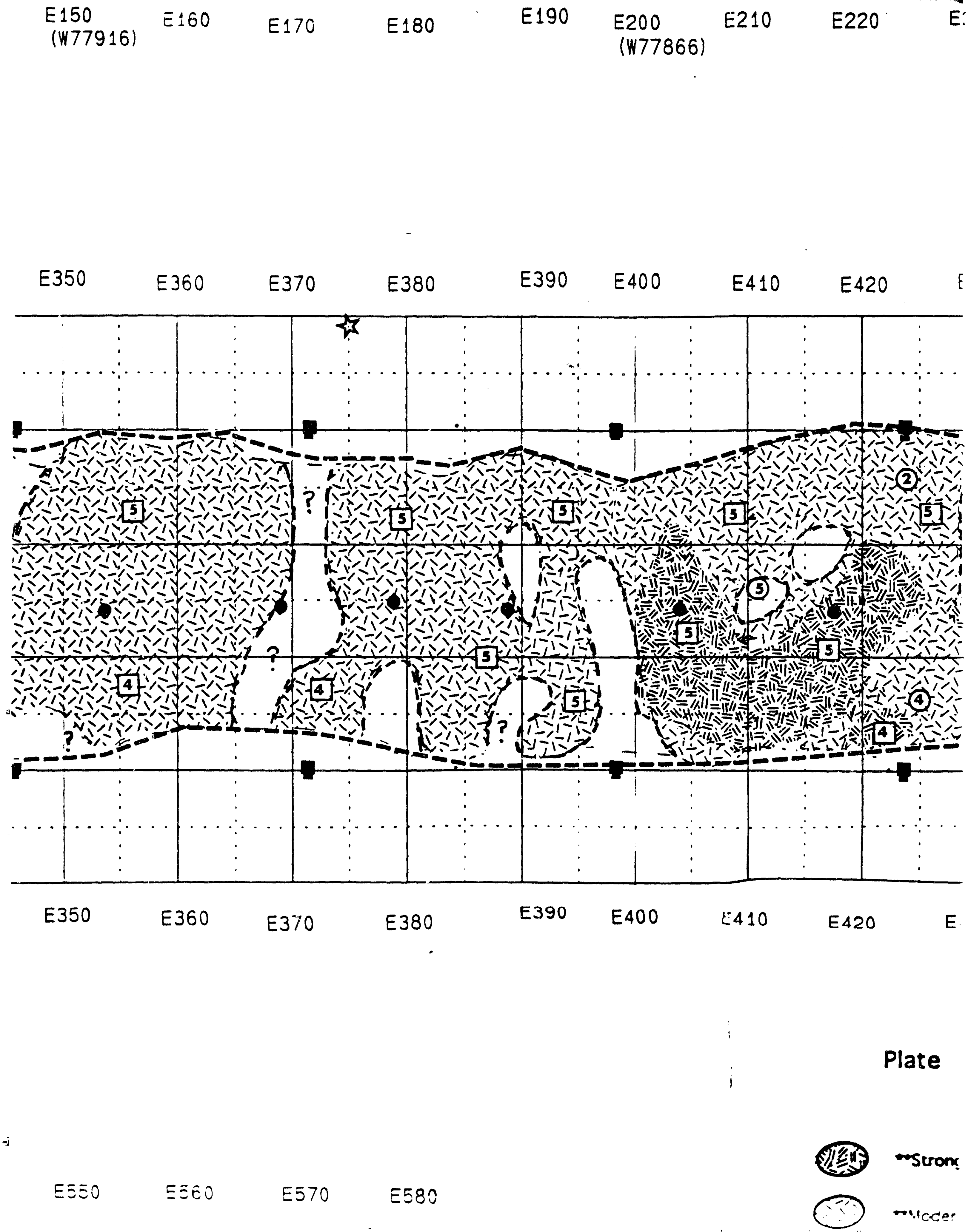
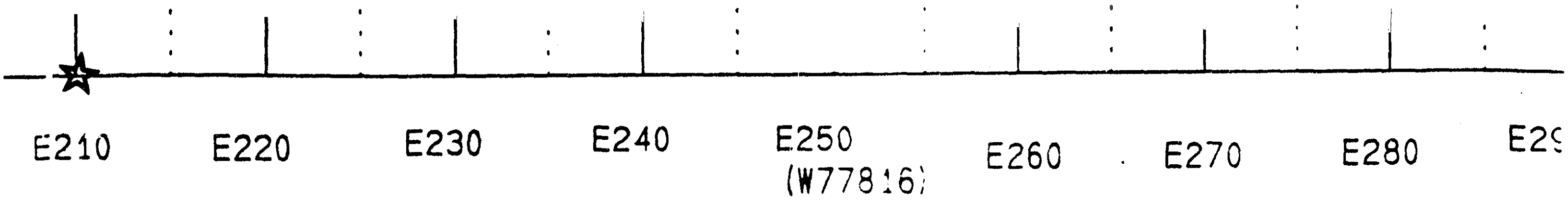
(W77966) E110 E120 E130 E140 E150 E160
(W77916)

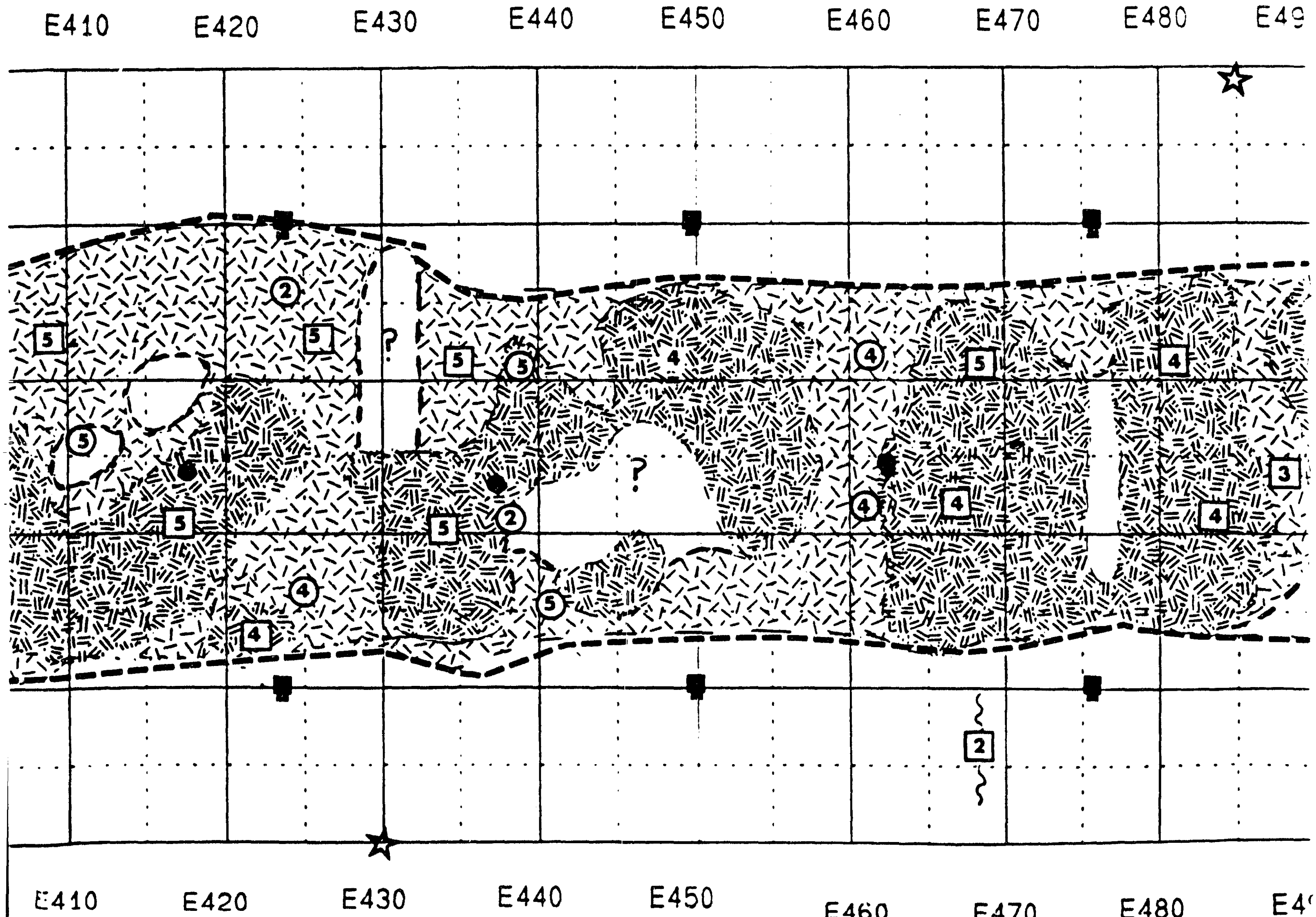


E500 E510 E520 E530 E540 E550 E560


E150
(W77916)
E160
E170
E180
E190
E200
(W77866)
E210
E220
E350
E360
E370
E380
E390
E400
E410
E420
E350
E360
E370
E380
E390
E400
E410
E420
E550
E560
E570
E580
Strong
Moder

Plate





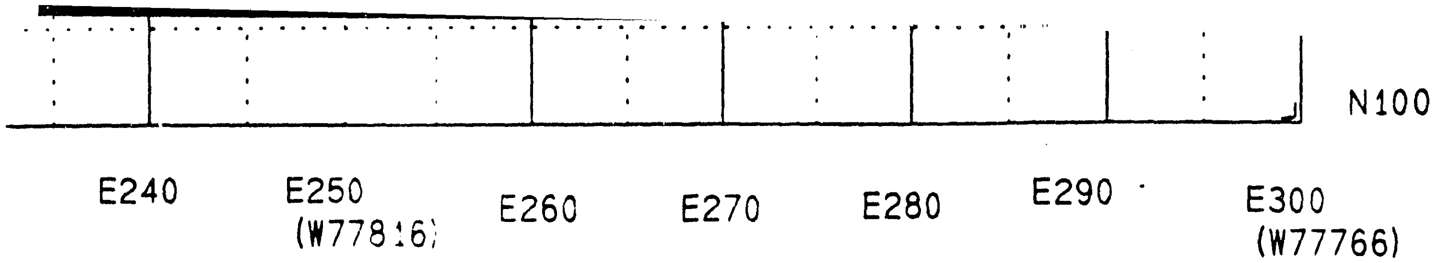
WHC-SD-EN-TI-285, Rev.0

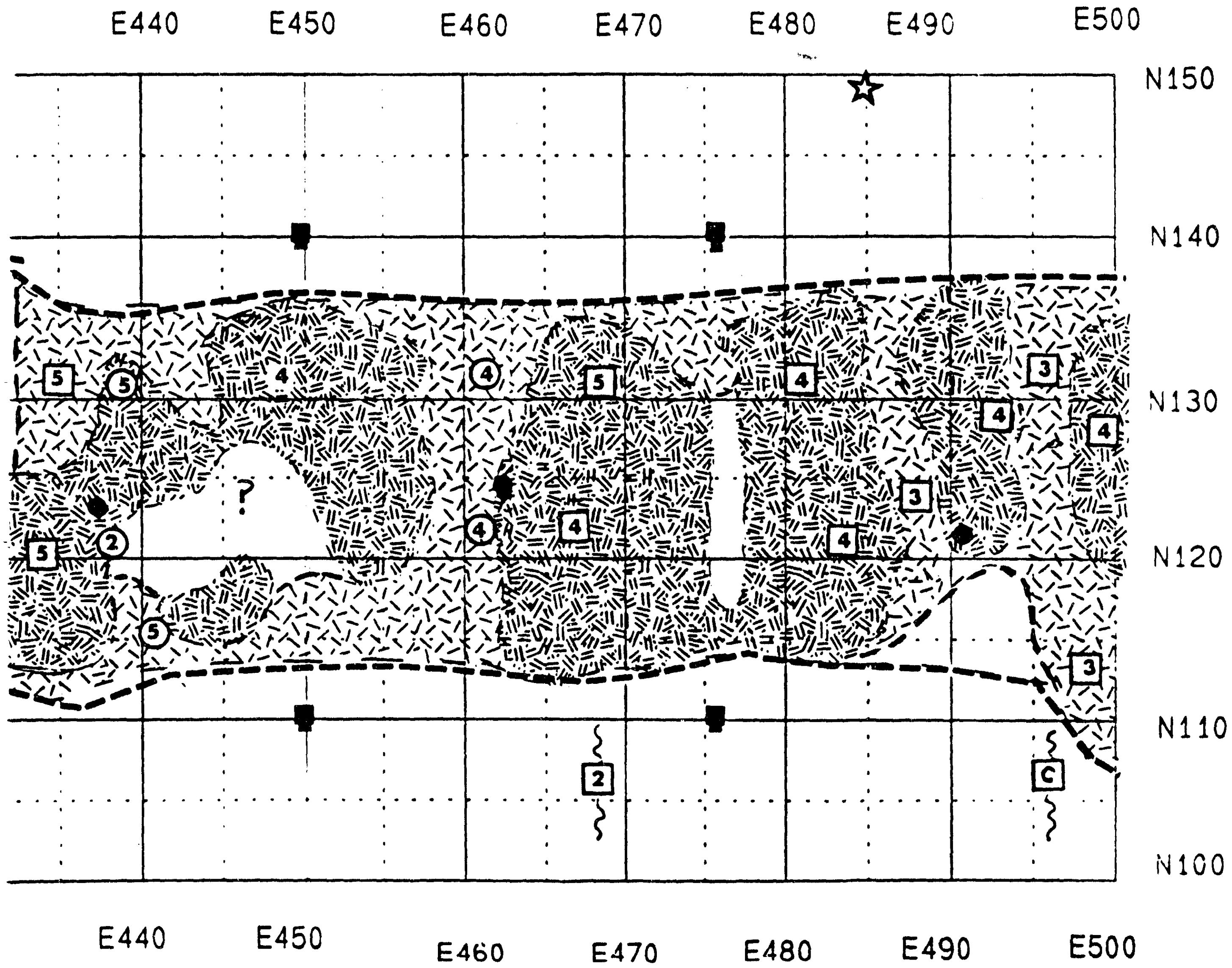
Plate I. Geophysical Interpretation Summary Map of Trench #4, Burial Ground 218-W-4C.

Legend

Strongest Reflector

Scale (Feet)



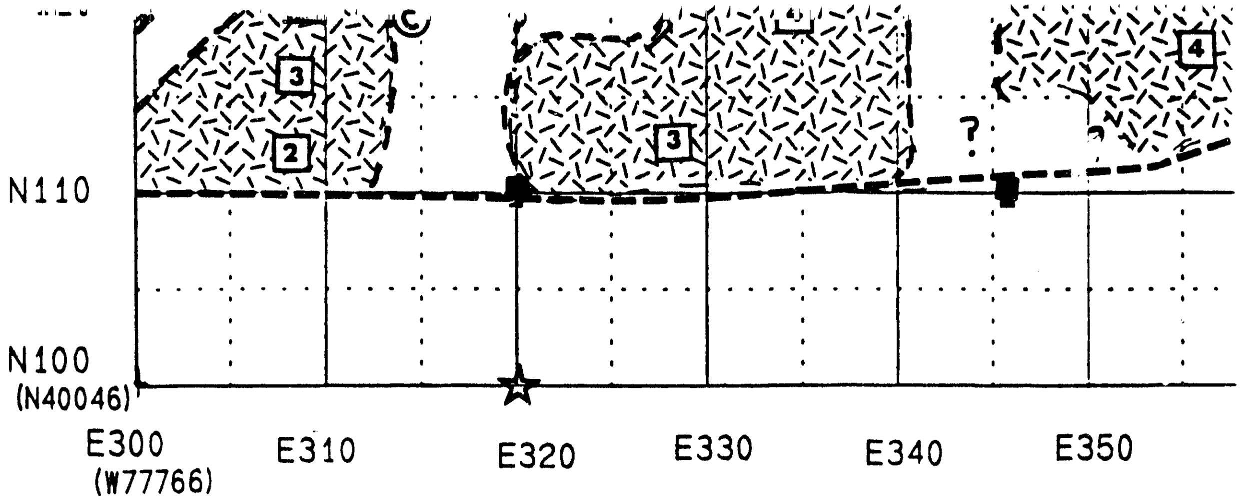


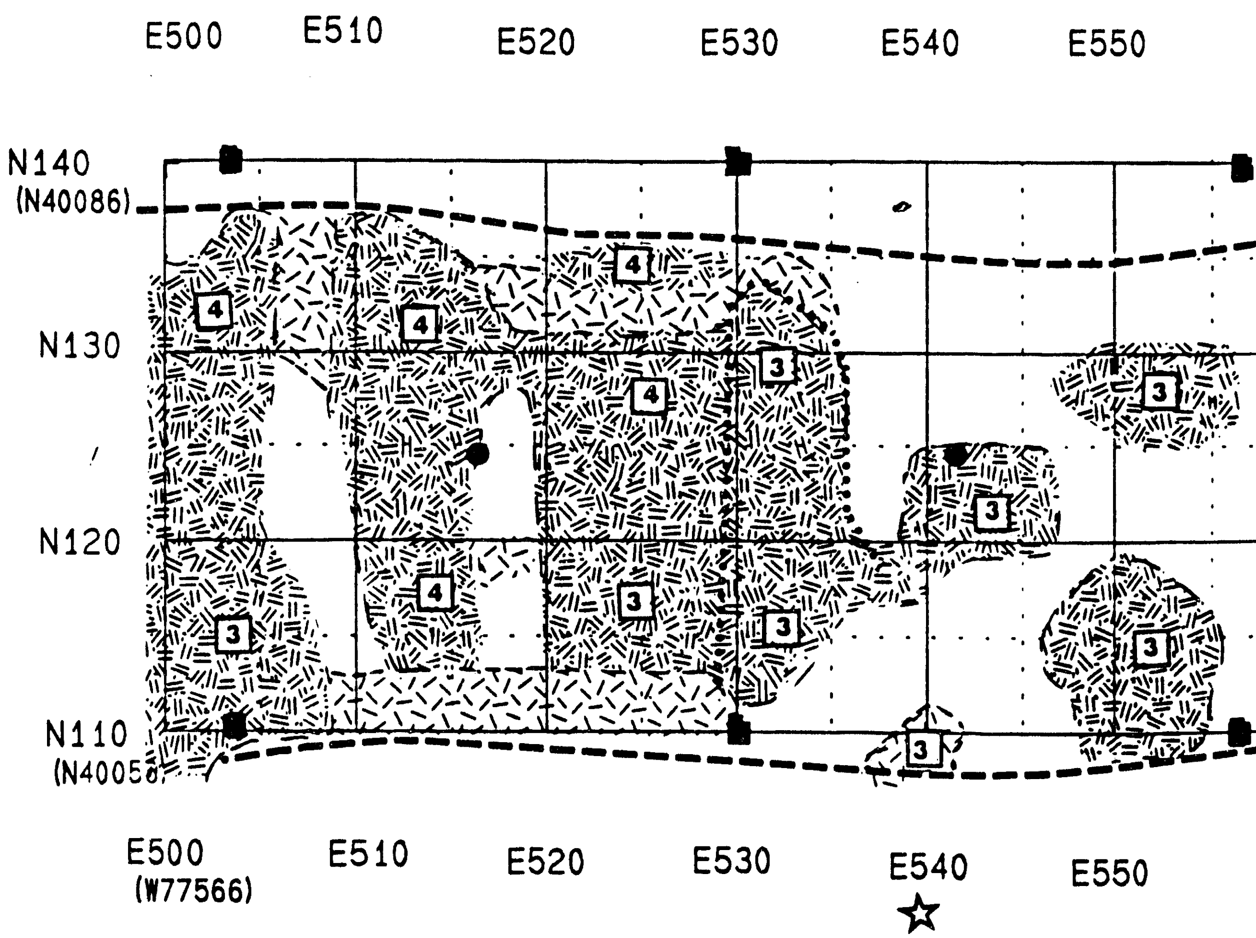
WHC-SD-EN-TI-285, Rev.0

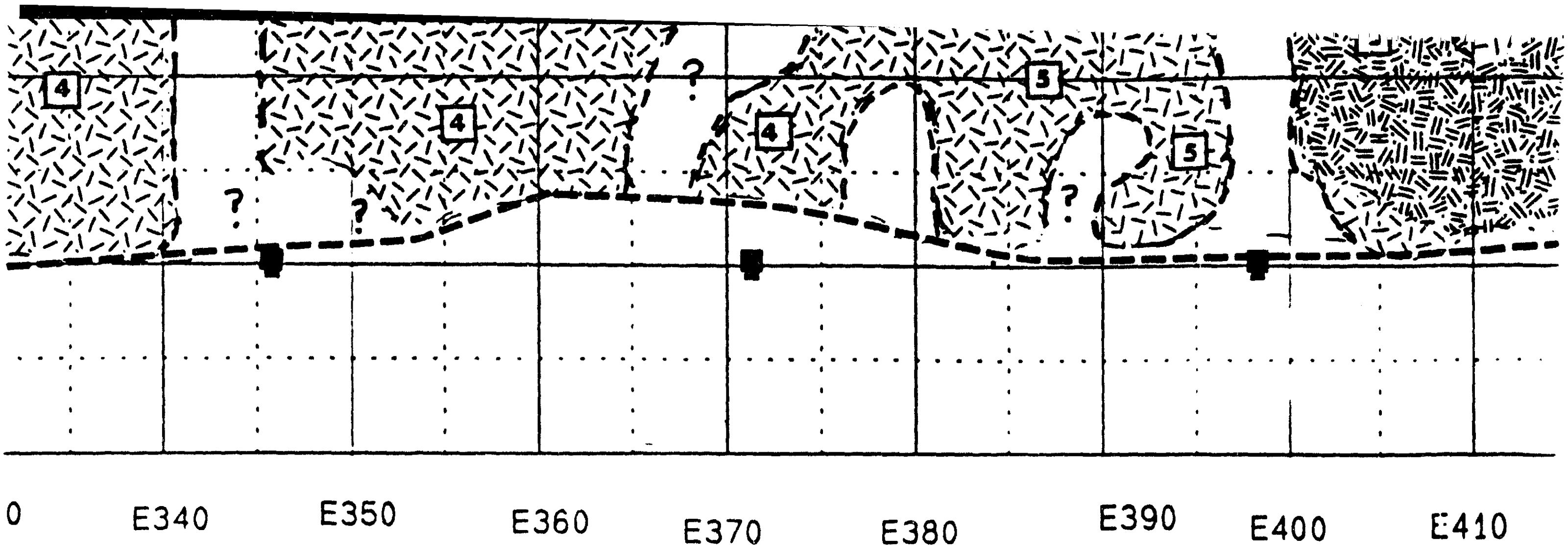
Geophysical Interpretation Summary Map of Trench #4, Burial Ground 218-W-4C.

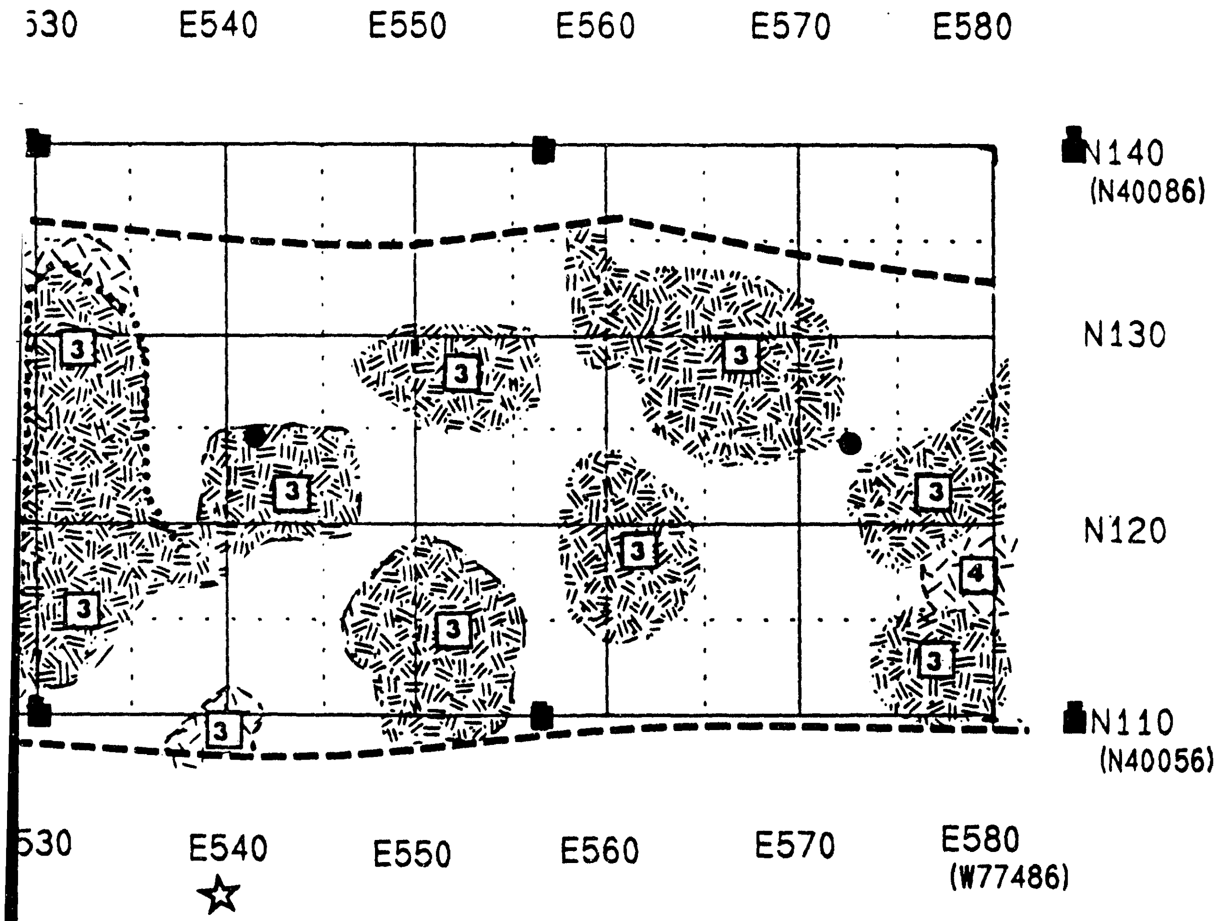
Legend

Scale (Feet)


N110
N100
(N40046)
E300
(W77766)
E310
E320
E330
E340
E350
3
2
3
4
?


E500
E510
E520
E530
E540
E550
N140
(N40086)
N130
N120
N110
4
4
4
4
3
4
3
3
3
3
3
3
3
E500
(W77566)
E510
E520
E530
E540
E550


4
4
4
5
5
?
?
?
?
0
E340
E350
E360
E370
E380
E390
E400
E410


530
E540
E550
E560
E570
E580
N140
(N40086)
N130
N120
N110
(N40056)
3
3
3
3
3
3
3
3
3
3
4
530
E540
E550
E560
E570
E580
(W77486)

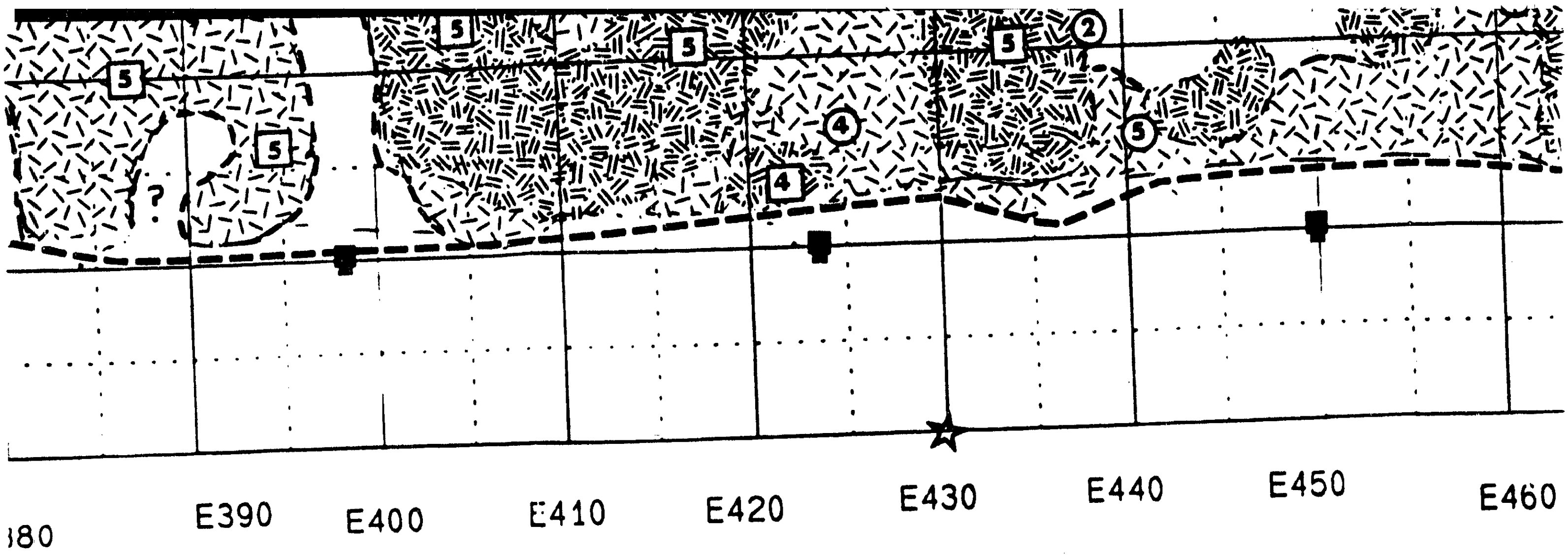


Plate I. Geophysical Interpretation of Trench #4, Burial Groun(

Legend

**Strongest Reflector

**Moderate or Intermittent Reflector

**No Notable Reflector Present

** It is assumed that the reflector is primarily a r
to the cover overlying the buried waste contain

Kaiser Survey Monument

PVC Stand Pipe

Interpreted Outer Edge of Modules

Zone with unique character relative to surrounding area.

Isolated buried debris

3 Average thickness of fill over upper reflector

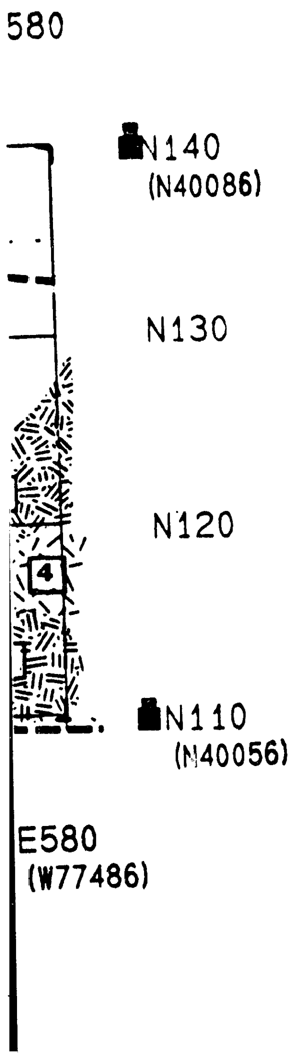
Load Bearing Plate Test Location

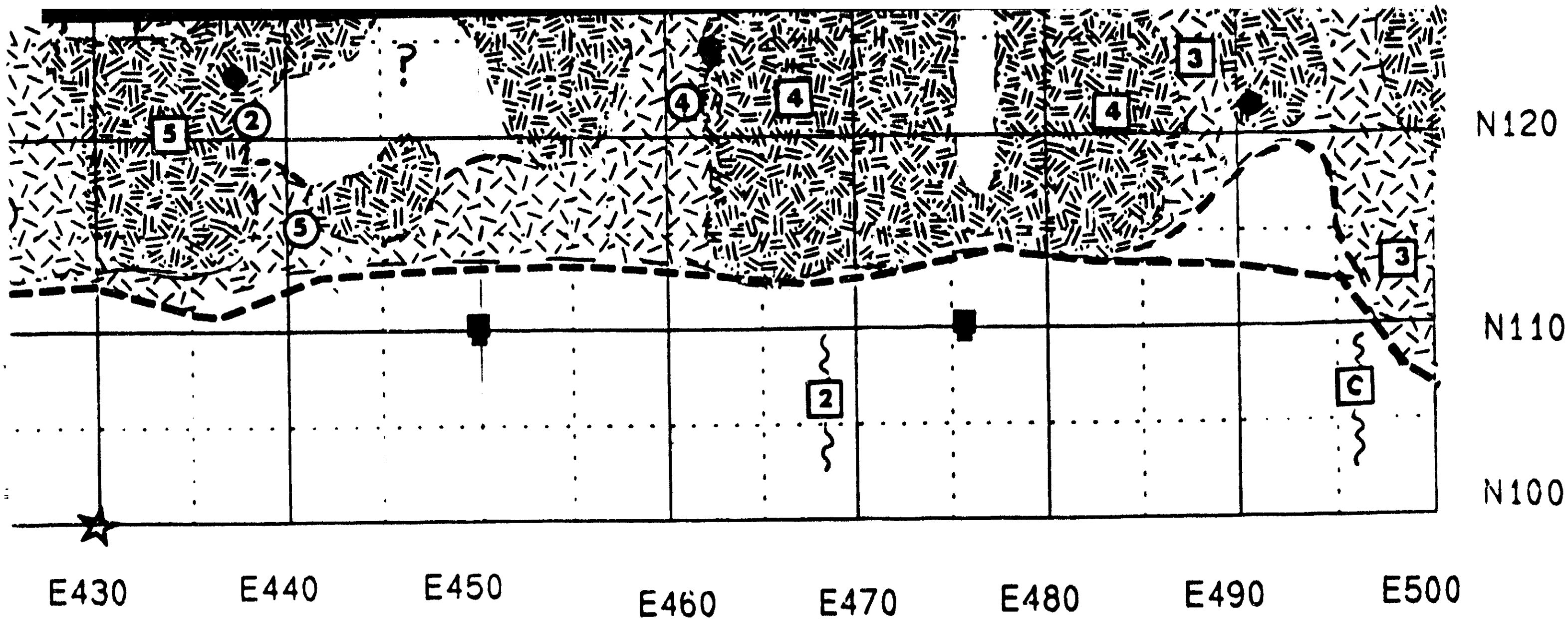
2 Prominent Anomaly

Anomaly <2 feet below surface

(W77456) Location tied to surface stake

W77457 Documented location off drawing H-2-8754





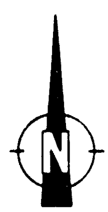
WHC-SD-EN-TI-285, Rev.0

e I. Geophysical Interpretation Summary Map of Trench #4, Burial Ground 218-W-4C.

Legend

Scale (Feet)

0 5 10



rongest Reflector

›derate or Intermittent Reflector

· Notable Reflector Present

** It is assumed that the reflector is primarily a response to the cover overlying the buried waste containers.

er Survey Monument

Stand Pipe

preted Outer Edge of Modules

with unique character relative to surrounding

ted buried debris

age thickness of fill over upper reflector

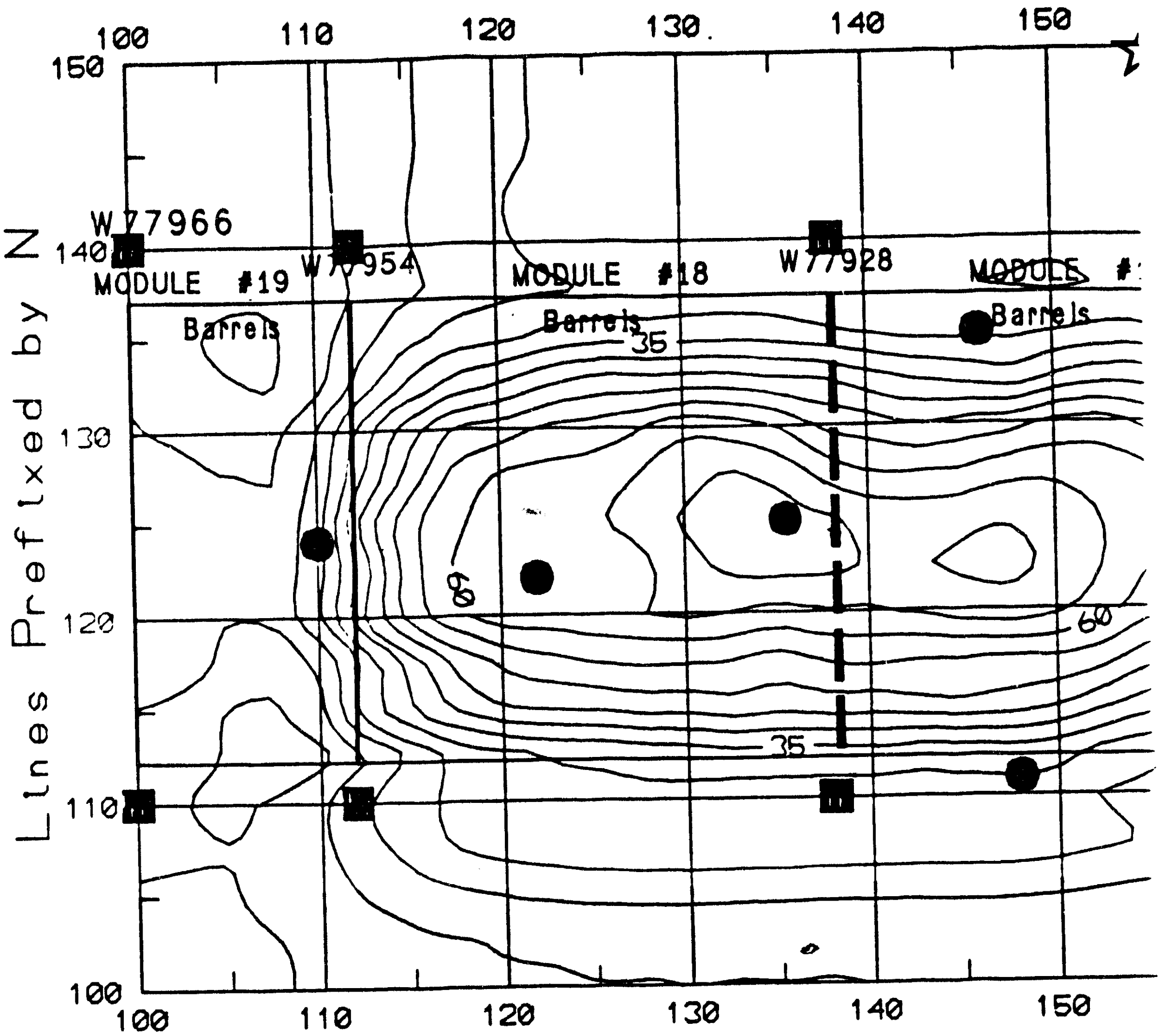
Bearing Plate Test Location

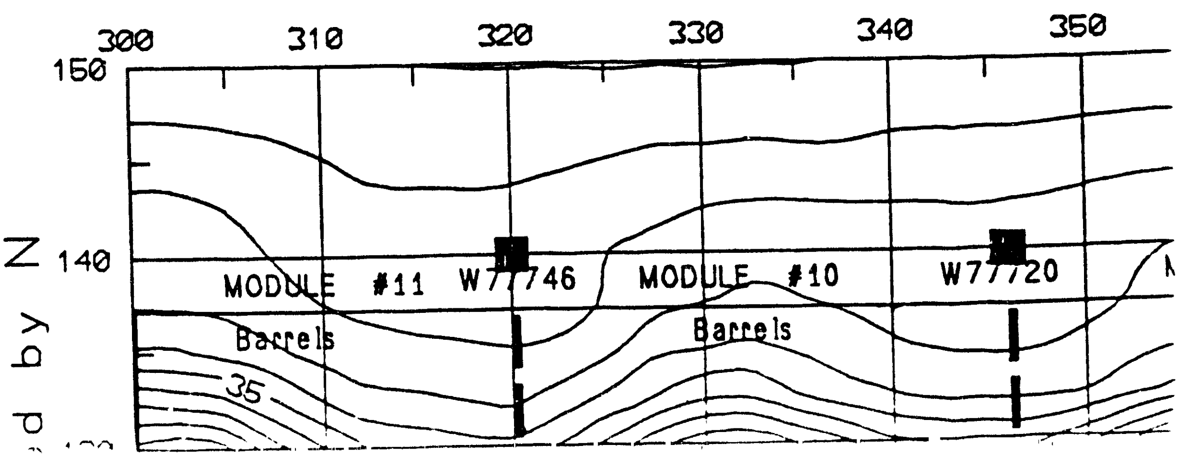
-inent Anomaly

ıaly <2 feet below surface

456) Location tied to surface stake

:57 Documented location off drawing H-2-87544, Rev.0


Lines Prefixed by N
100
110
120
130.
140
150
W77966
W77954
MODULE #19
MODULE #18
W77928
MODULE
Barrels
Barrels
Barrels
35
60
60
35


d by N
300
310
320
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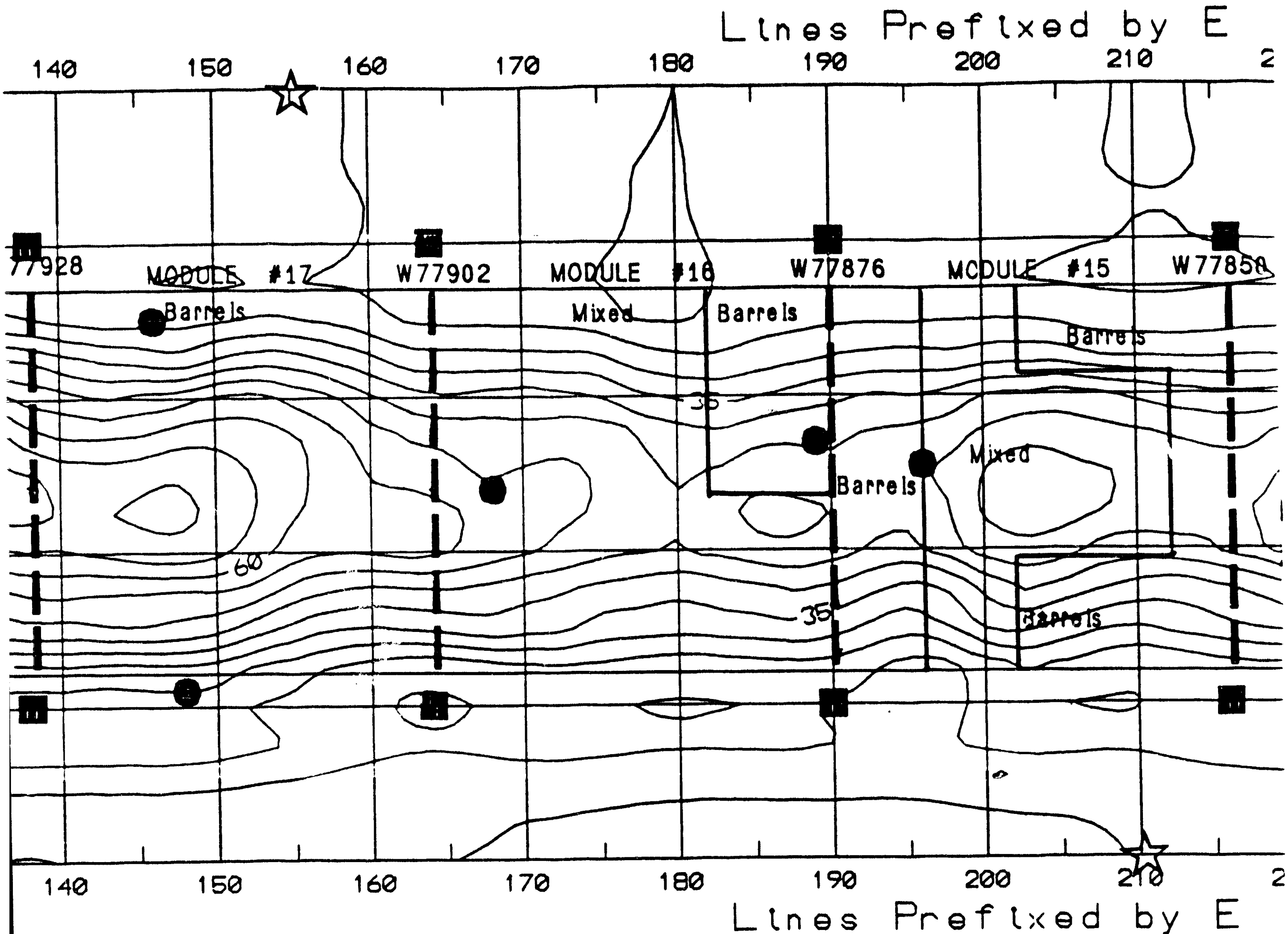
340
350
150
140
MODULE #11
W77746
MODULE #10
W77720
Barrels
Barrels
35


Lines Prefixed by E
140
150
160
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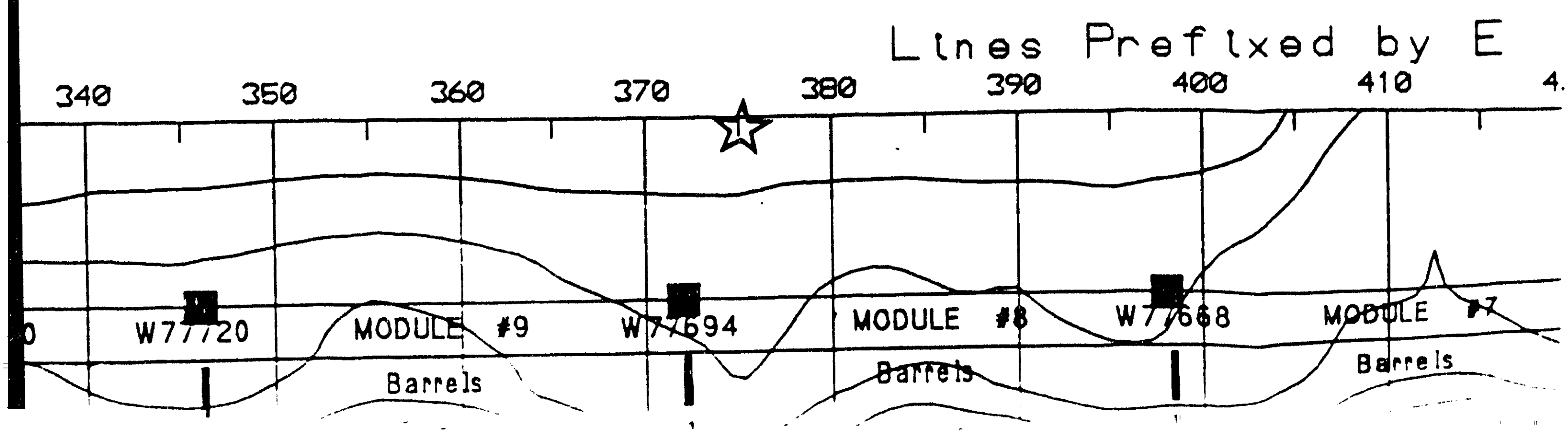
180
190
200
210
MODULE #17
W77902
MODULE #16
W77876
MODULE #15
W77850
Barrels
Mixed
Barrels
Barrels
35
Mixed
Barrels
60
35
Barrels
140
150
160
170
180
190
200
210
Lines Prefixed by E


Lines Prefixed by E
340
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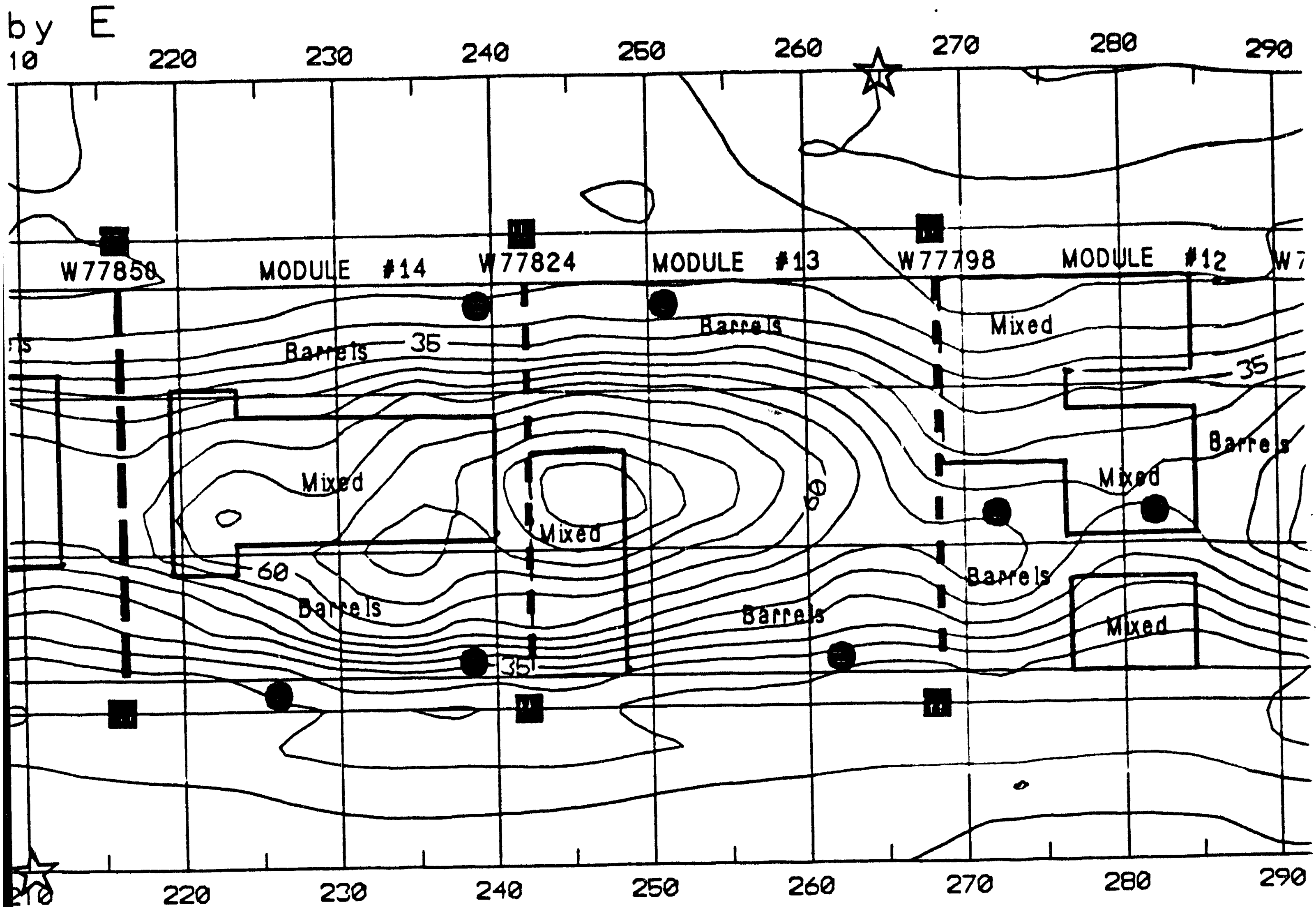
400
410
W77720
MODULE #9
W77694
MODULE #8
W77668
MODULE #7
Barrels
Barrels
Barrels



by E
10
220
230
240
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260
270
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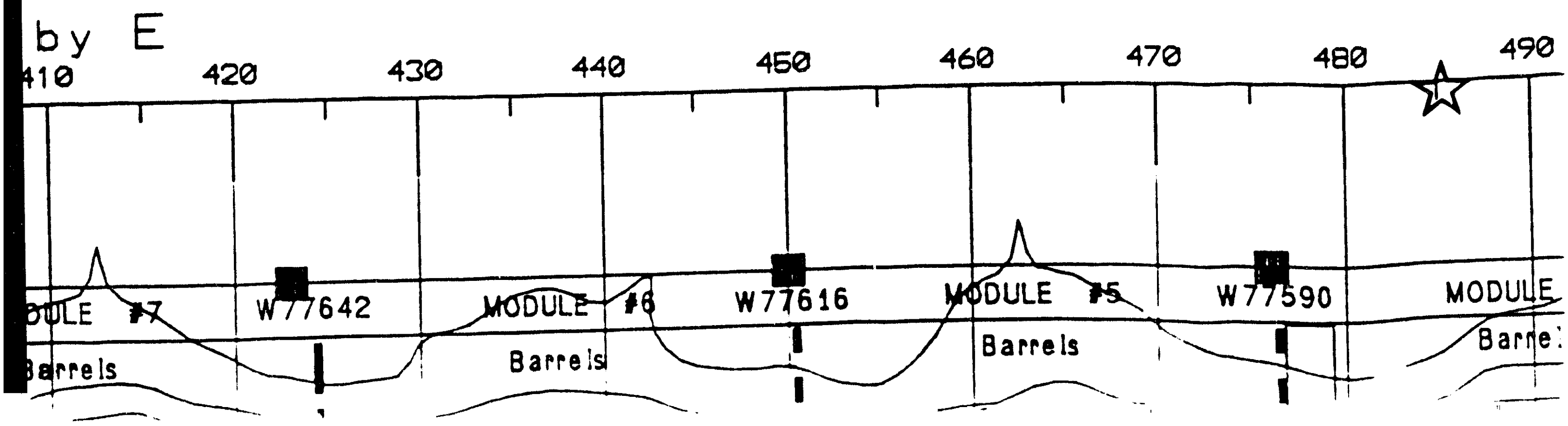
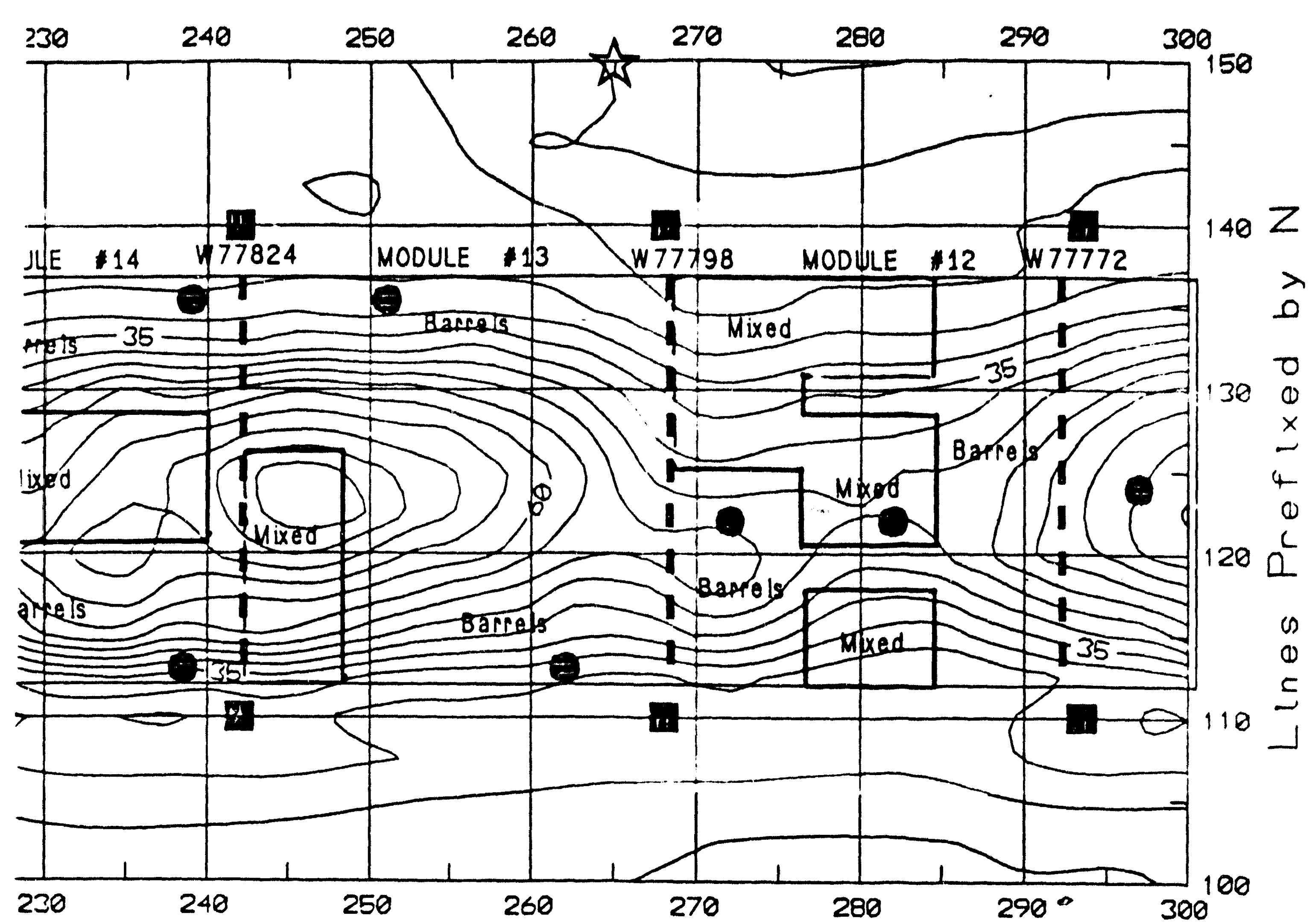
290
W77850
MODULE #14
W77824
MODULE #13
W77798
MODULE #12
Barrels
35
Mixed
60
210



by E
410
420
430
440
450
460
470
480
490
W77642
MODULE #6
W77616
MODULE #5
W77590
MODULE
Barrels



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300
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100
Lines Prefixed by N
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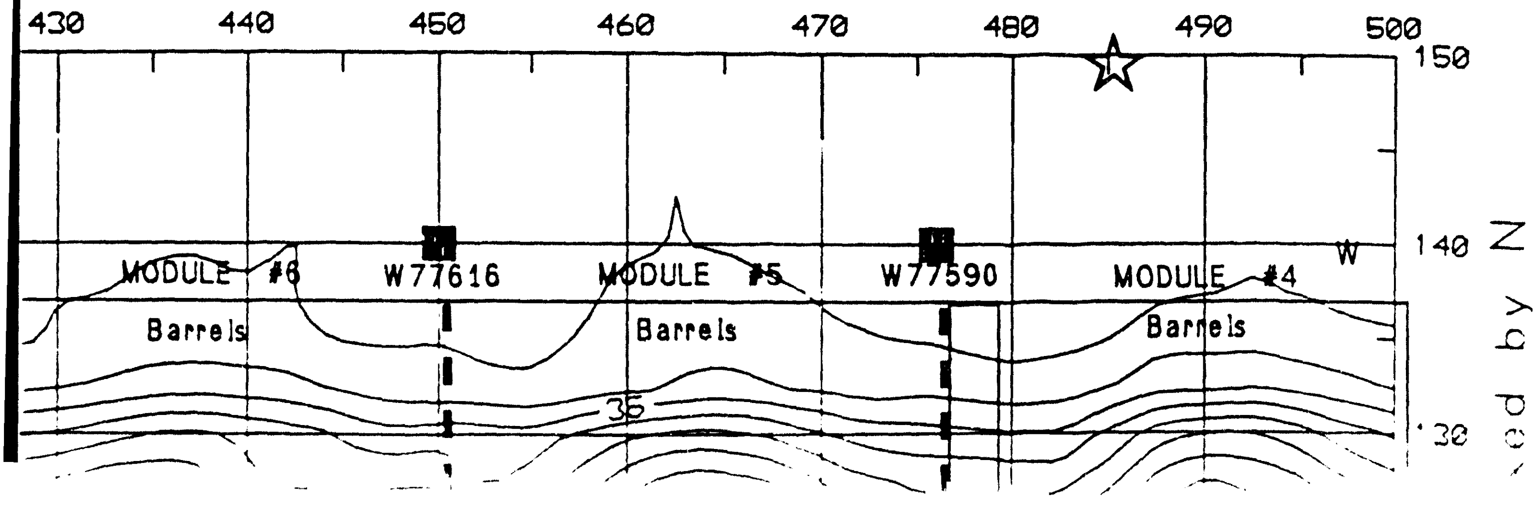
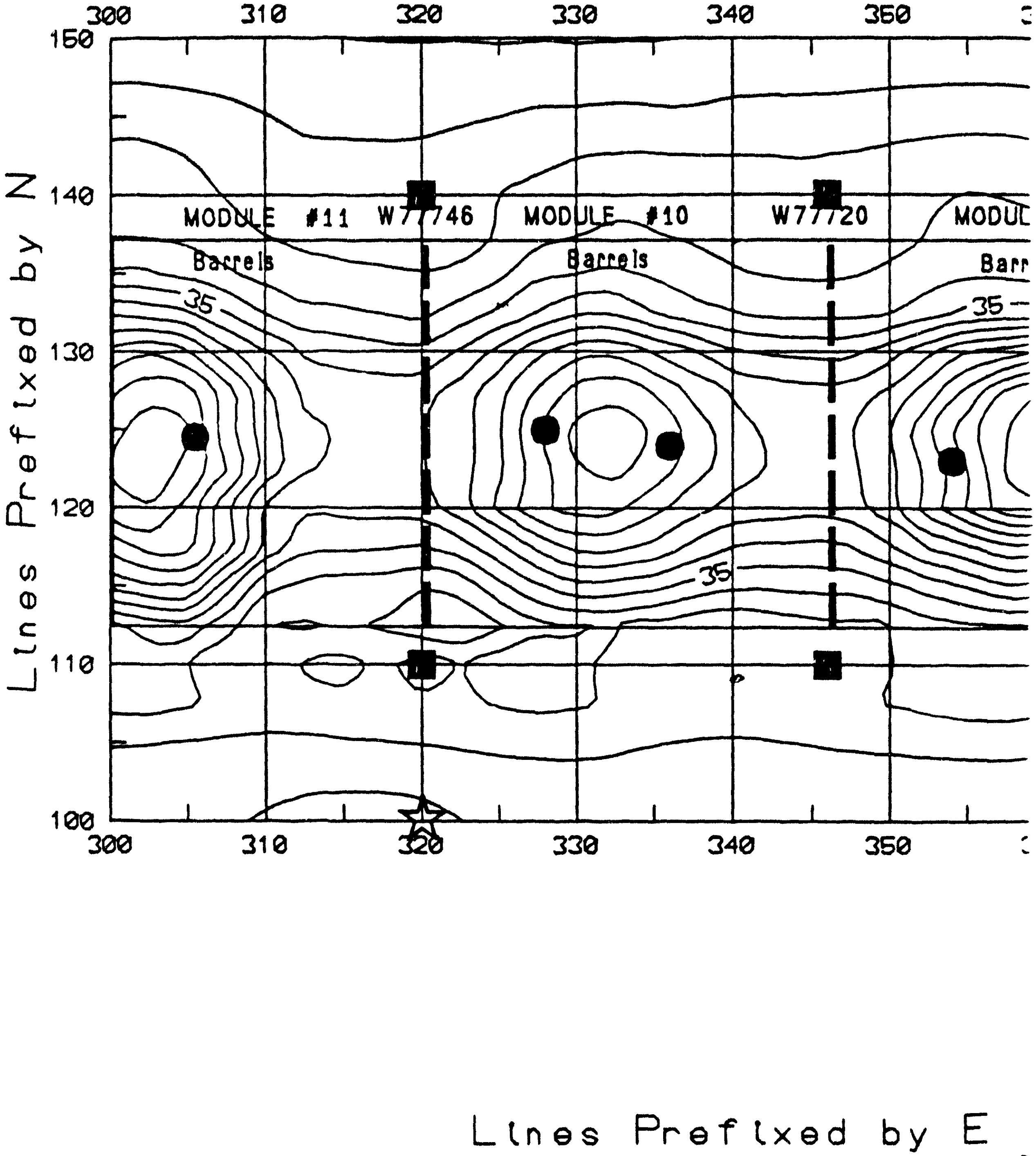
MODULE #12
W77824
W77798
W77772
Barrels
Mixed
35



430
440
450
460
470
480
490
500
150
140
MODULE #6
W77616
MODULE #5
W77590
MODULE #4
Barrels
35


Lines Prefixed by N
Lines Prefixed by E
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110
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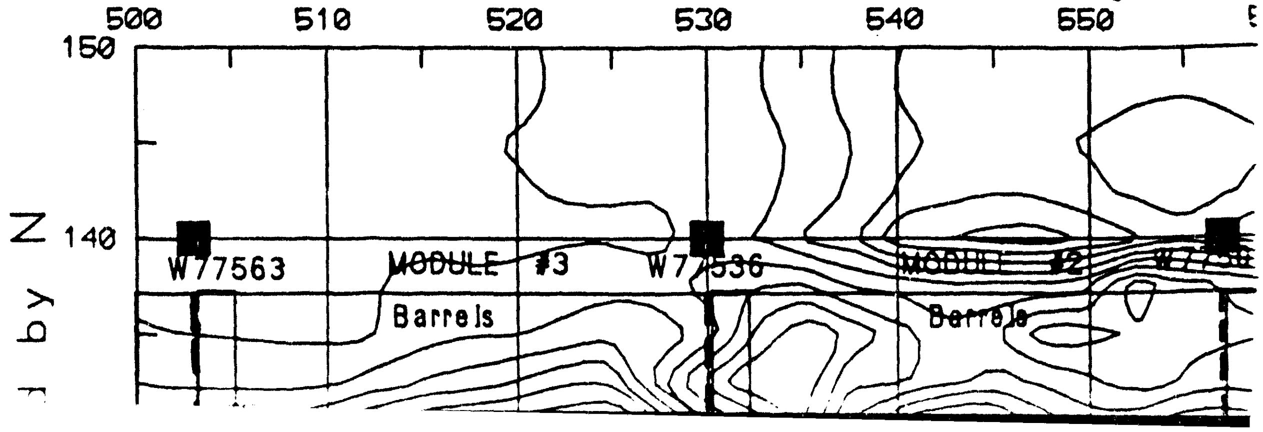
MODULE #11
W77746
MODULE #10
W77720
Barrels
35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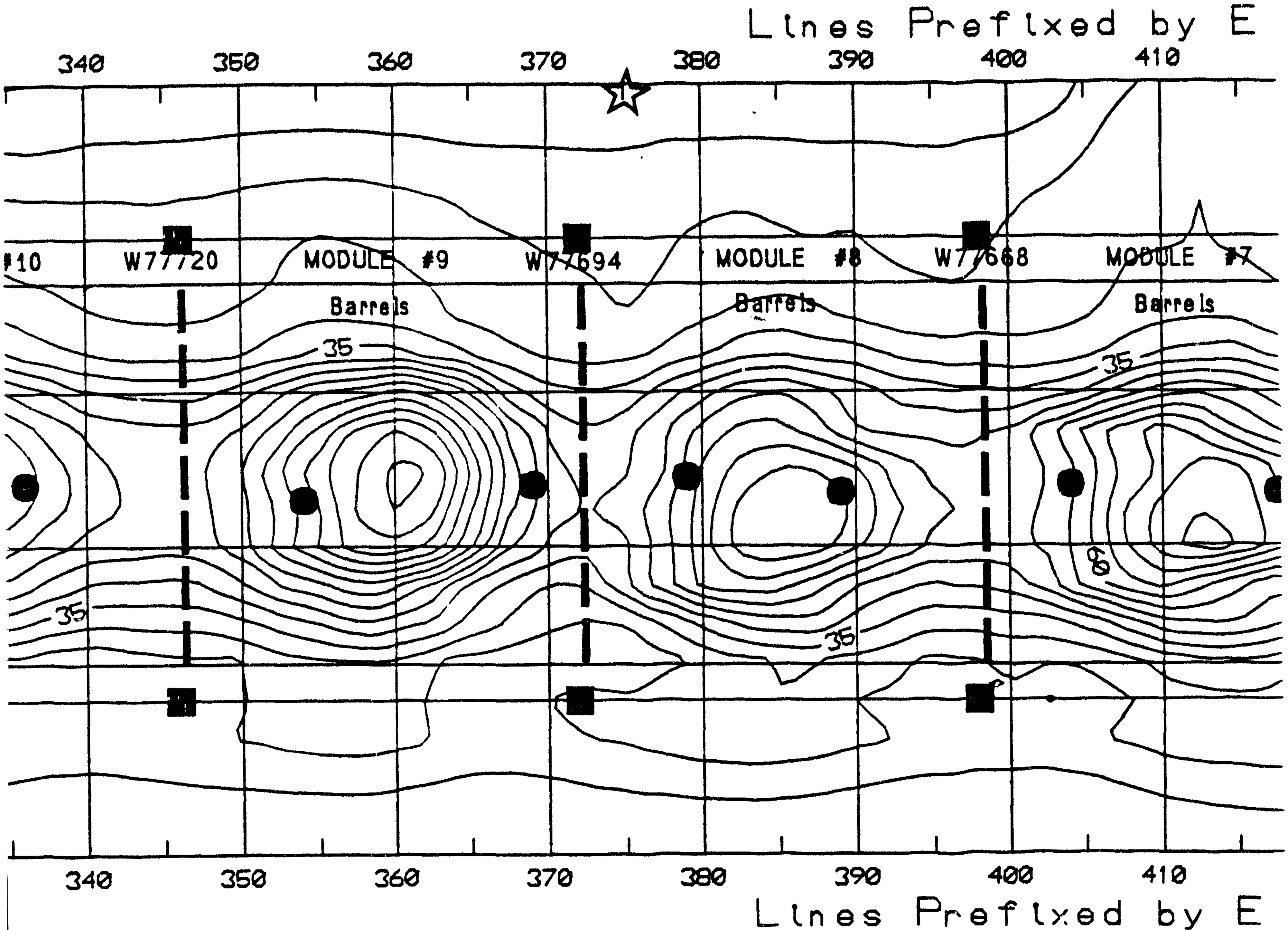
510
520
530
540
550
150
140
W77563
MODULE #3
W77536
MODULE #2
Barrels


Lines Prefixed by E
340
350
360
370
380
390
400
410
#10
W77720
MODULE #9
W77694
MODULE #8
W77668
MODULE #7
Barrels
Barrels
Barrels
35
35
35
35
340
350
360
370
380
390
400
410
Lines Prefixed by E

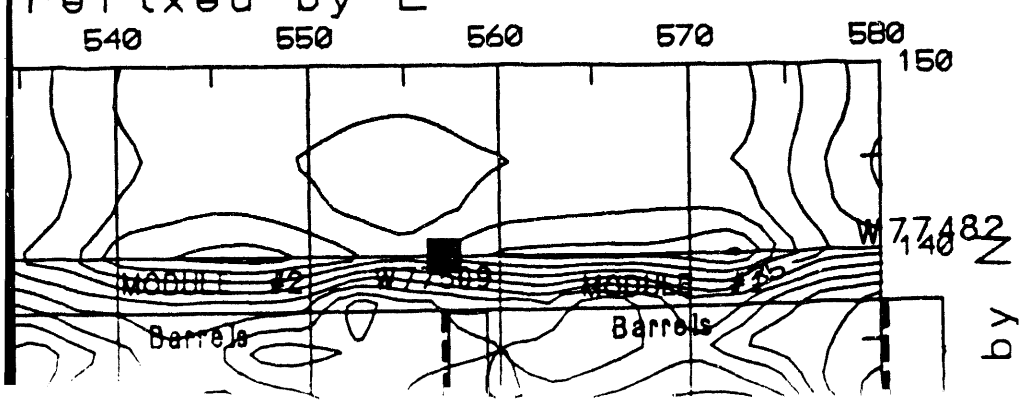
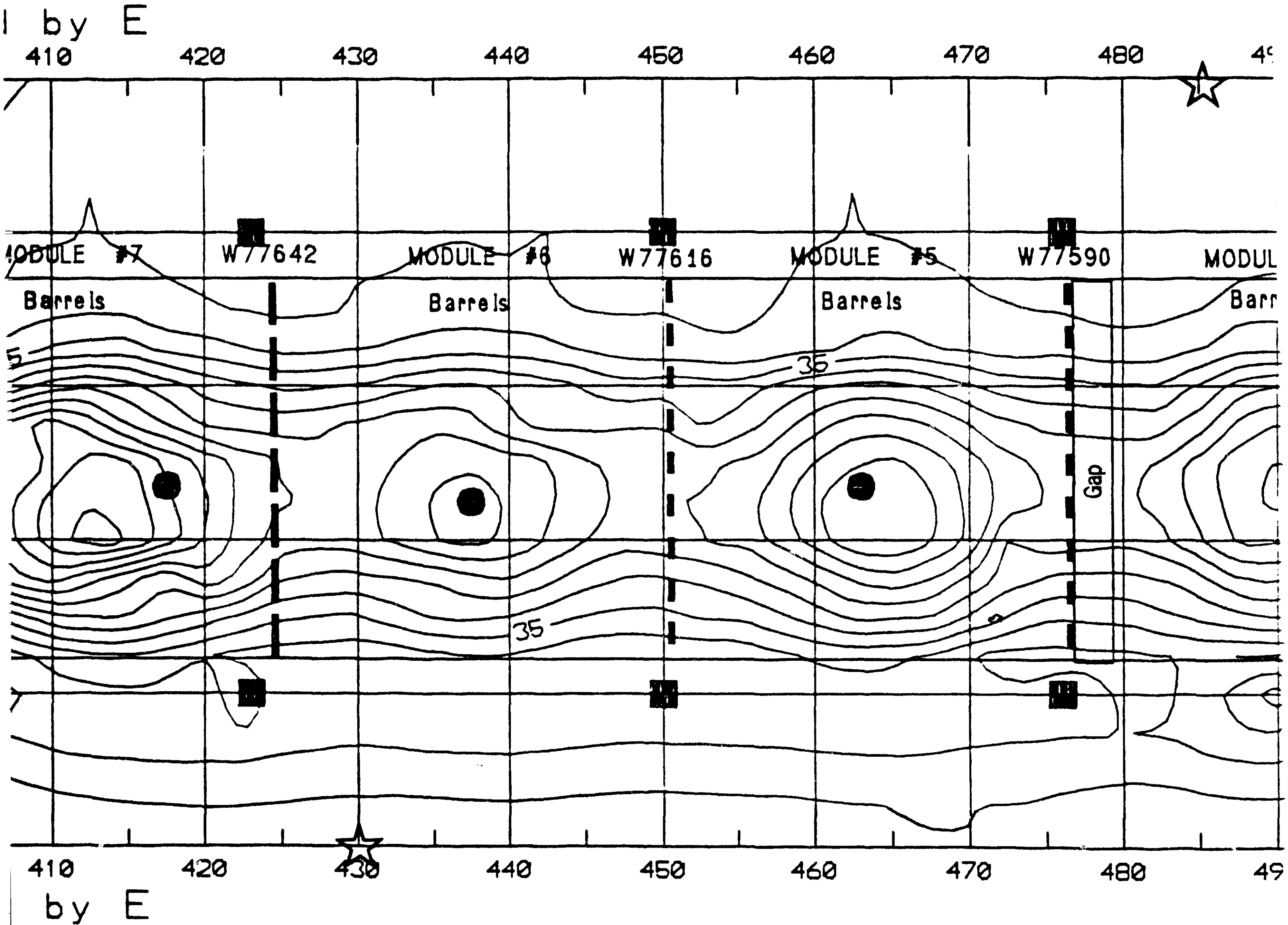
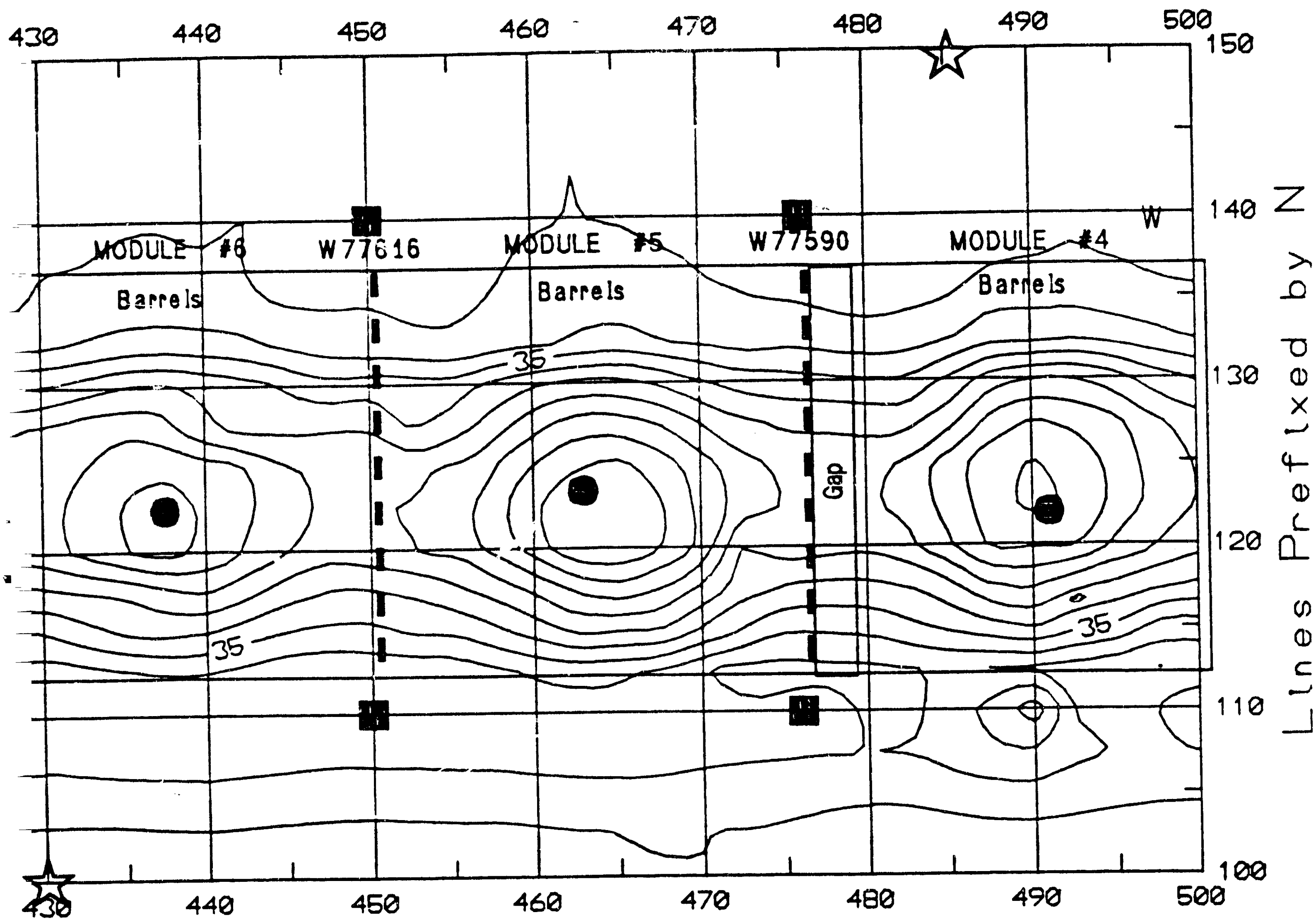

Prefixed by E
540
550
560
570
580
150
140
W77482
MODULE #2
MODULE
Barrels
Barrels
by

Plate II.

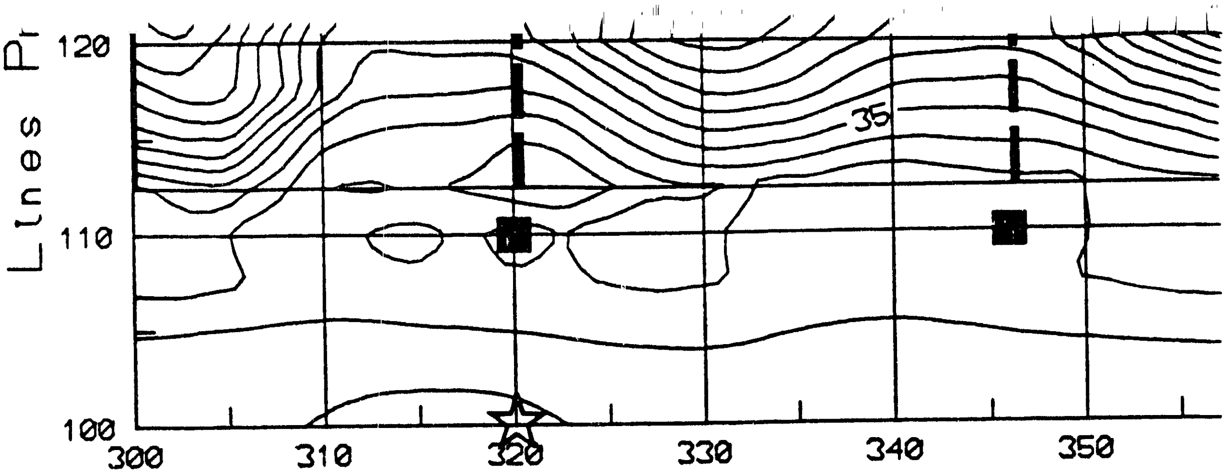
OF



e II. ELECTROMAGNETIC INDUCTION CONTOUR MAP OF 218-W-4 BURIAL GROUND: Trench 4



OMAGNETIC INDUCTION CONTOUR MAP
-4 BURIAL GROUND: Trench 4



Lines Pr
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110
100
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300
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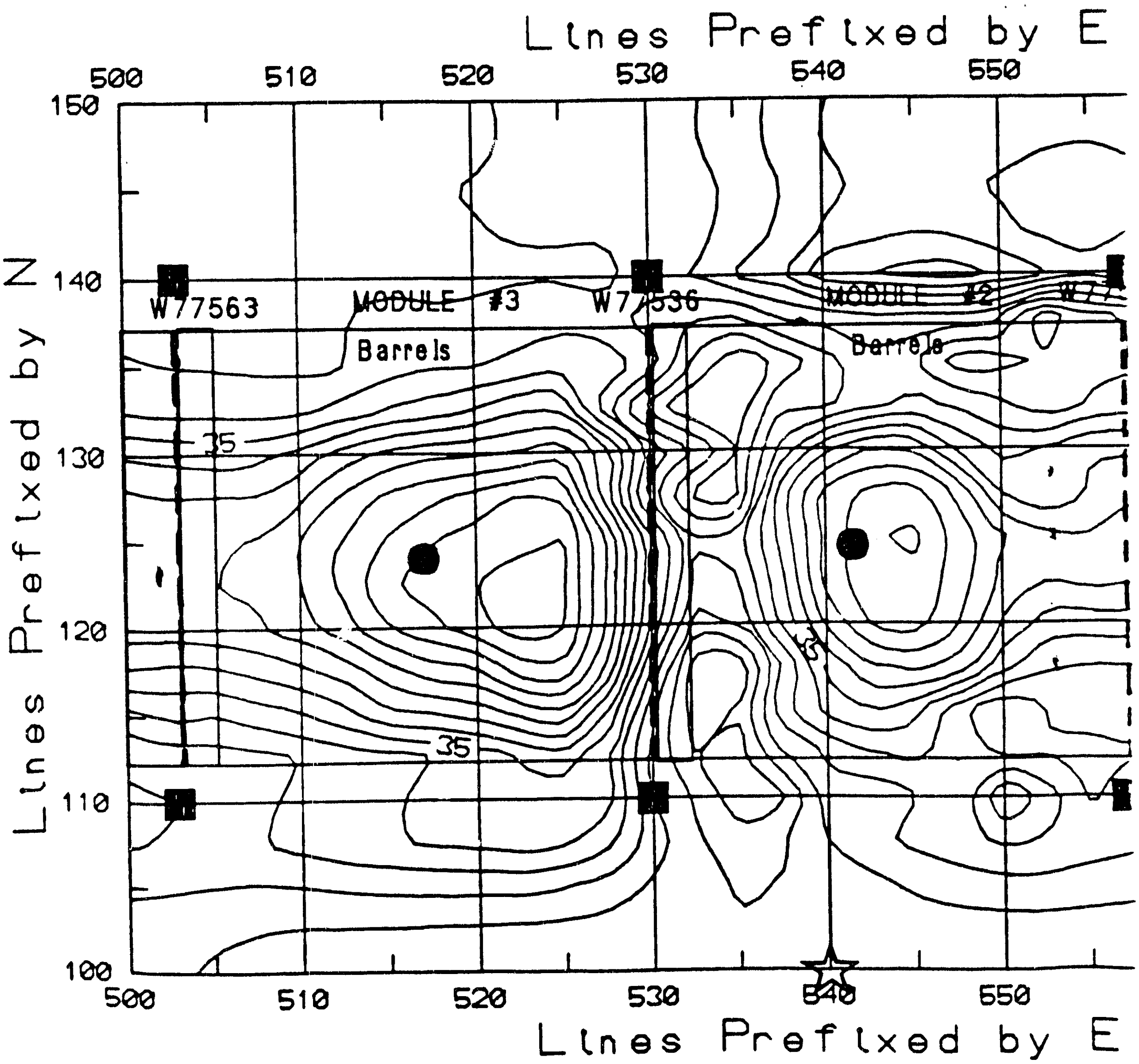
340
350



Lines Prefixed by E
500
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520
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540
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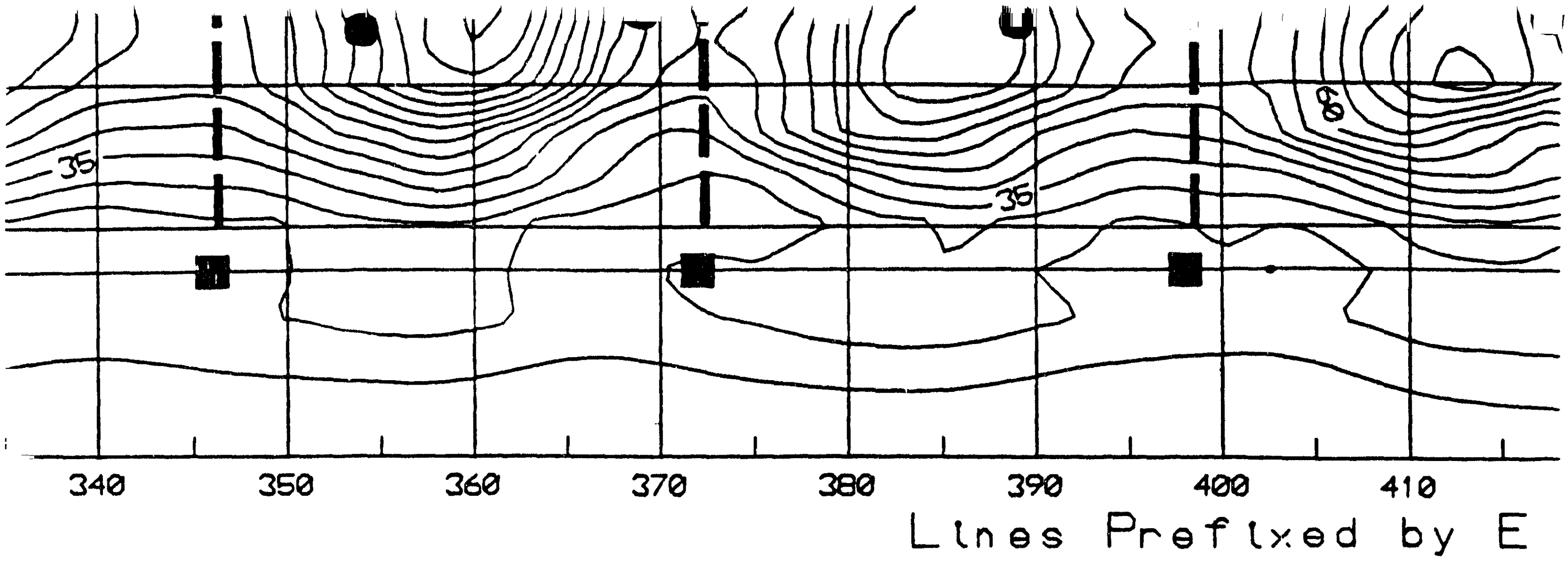
100
Lines Prefixed by N
W77563
MODULE #3
W77536
MODULE #2
Barrels
Barrels
35
35
Lines Prefixed by E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35
340
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360
370
380
390
400
410
Lines Prefixed by E

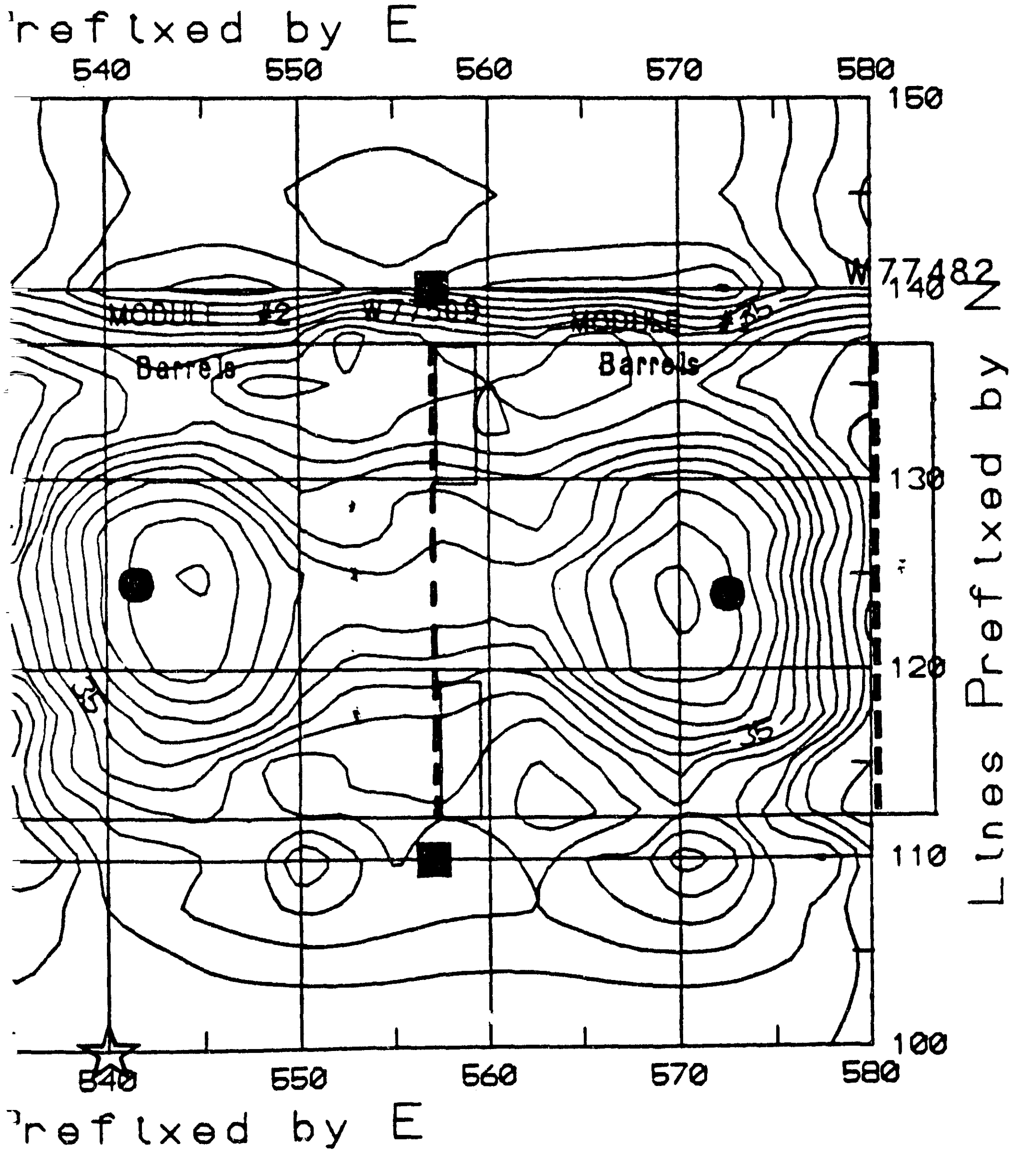
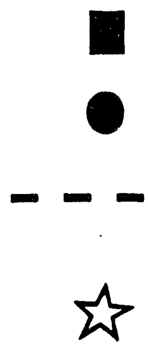
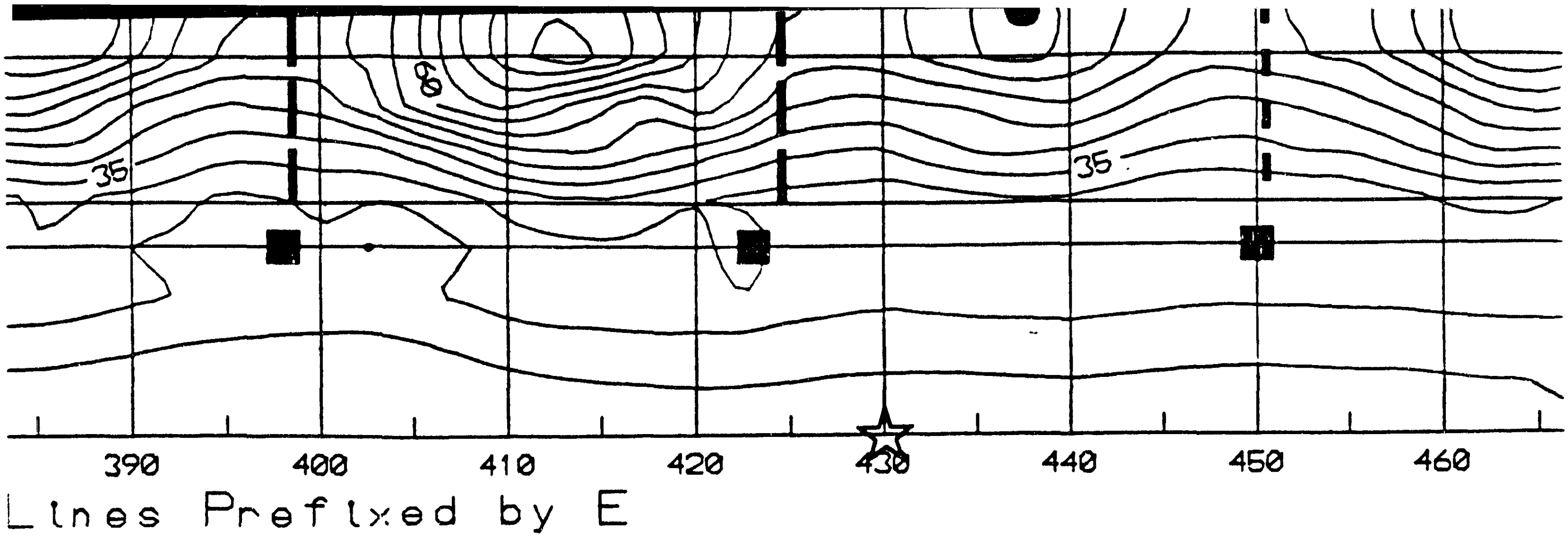

refixed by E
540
550
560
570
580
150
140
130
120
110
100
W77482
MODULE #2
MODULE #3
Barrels
Barrels
35
Lines Prefixed by N
refixed by E

Plate II.

OF





Lines Prefixed by N

482

Plate II. ELECTROMAGNETIC INDUCTION CONT
OF 218-W-4 BURIAL GROUND: Trench

WHC-SD-EN-TI-285, Rev.0

Legend

CONTOUR INTERVAL = 5 mS/m

■ Kaiser Survey Monument

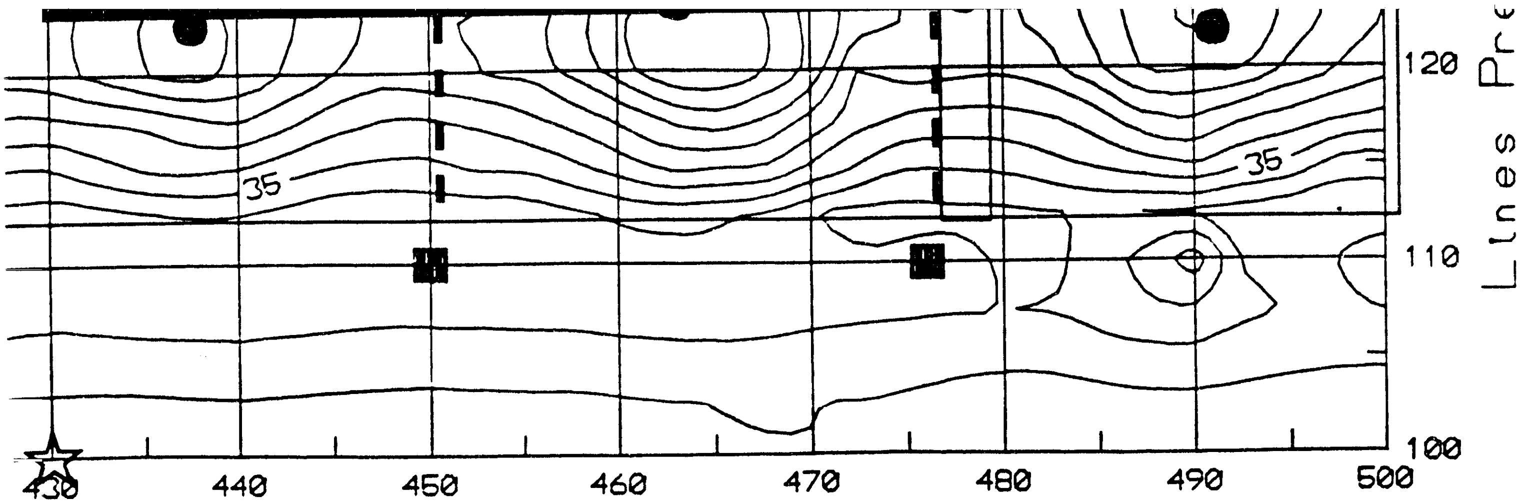
● PVC Stand Pipe

— — — Module Boundary as per Drawing H-2-87544 , Rev.0

☆ Load Bearing Plate Test Location

Scale (Feet)

0 5 10



OMAGNETIC INDUCTION CONTOUR MAP
-4 BURIAL GROUND: Trench 4

SD-EN-TI-285, Rev.0

Legend

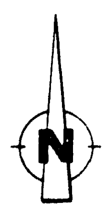
NTOUR INTERVAL = 5 mS/m

Monument

e

ary as per
37544 , Rev.0

late Test Location



Scale (Feet)

0 5 10

DATE
FILMED
10/13/94

END