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A RADAR SURVEY

AT THE POOR FARM CEMETERY

18 May 1986

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A Radar Survey at the Poor Farm Cemetery

A total of 460 underground echoes were mapped from the radar profiles of this site. An unknown number of these could well be caused by unmarked graves. The most likely grave locations were clustered in the north central part of the survey area; see Figure 1. It appears likely that the natural soils here have a moderately complex stratification; this could have the effect of masking some graves and falsely suggesting others.

The radar echoes shown in Figure 2 were classified in six different categories. At two places, very strong and clear echoes were found to have a depth and character reasonable for a grave; these are the most likely locations for graves. At 40 other places, distinctive echoes were also found and these could also indicate graves. At the next lower level of reliability, an additional 232 rather indistinct echoes were mapped; an uncertain fraction of these could possibly be caused by graves. A further 147 echoes which were mapped appear most likely to be caused by natural contrasts in the earth; however, some of these echoes could mark grave locations. In nine places, echoes were found which could possibly be caused by profiling lengthwise over a grave. The final 30 echoes were caused by near-surface metal; most of these objects are probably trash, but it is not impossible that some metal grave markers were detected.

The Site

This cemetery is located in Rockville, Montgomery County, Maryland. It is just east of highway I-270 and north of Montrose Road. Between about 1789 and 1983, this was an active cemetery for the associated county poor farm. It is possible that there are 200-400 burials in the cemetery. There are no grave markers in place. During this survey, about a half dozen metal grave markers were encountered at the surface or loose in the soil; these typically had a glass-faced plaque and a metal stake. Prior to this survey, Paul Inashima had located possible grave depressions and had marked roughly 75 of them with red flagging.

The area had become overgrown with brush and trees. In order to allow the radar survey to be done, brush and small trees were uprooted and removed by a crew from Montgomery County. This thorough work allowed easy access for the radar traverses. Many dozen larger trees were left and the site was cleared to bare soil. The mechanical equipment and soil scraping has removed most traces of possible grave depressions and has caused some new depressions where trees were uprooted. Rainy weather at the end of this clearing operation left parts of the site heavily rutted by wheels and bulldozer tracks. Possibly about ¼ of the area has a surface roughness of about a foot and about ¼ has a roughness of about three inches; the rest is in between. In the rough areas, the radar traverse speed could be irregular, causing some distortions in the profiles. The antenna could tilt by 30° or so from flatness, but because of the rather high soil resistivity, signal transmission into the earth generally remained good, even though the antenna was partially lofted into the air.

The site clearing crew also removed much of the trash scattered over the site; it was particularly dense on the western half. The debris which remains includes medical supplies such as hypodermic needles and medicine bottles, miscellaneous iron trash, aluminum siding, and broken bottles. During this survey, profiles were halted 60 times to clear the antenna cable from being snagged on trash or brush stumps. Bed springs, scattered over an acre here, were particularly likely to catch the cable.

The surrounding area is undergoing suburban growth and there are no heavy industries, electrified train lines, or high voltage power lines in the vicinity. A very slight amount of radio interference was experienced.

The soils here are rather puzzling. The top soil clearly has a low permeability, for rainfall of April 25 still remained as water fill in depressions over a week later. The surface is also hard and cemented. However, electrical resistivity tests and the 10 ft radar profiling depth show that at a depth of roughly 2 ft, the soil becomes either quite sandy or rocky. Not many rocks are visible at the surface and bedrock is not exposed; it is possible that bedrock is quartzite, gneiss, or schist.

A coordinate system was set up with a utility pole near I-270 as a reference point; the grid was aligned with magnetic north. Hexagons in Figure 1 show where labelled flags were left to aid the relocation of the survey grid. A few trees and other features are also mapped in Figure 1. The relief in the area is about 20 ft, with low areas to the south and northeast.

The Survey

A SIR System-7 ground-penetrating radar was combined with a model 3105 (180 MHz) antenna for this survey; both are manufactured by Geophysical Survey Systems. Antenna traverses were made at a speed of 0.31 mile per hour toward the south and parallel lines were spaced by 5 ft. On the main survey, 118 lines were profiled for a total length of 33,320 ft (6.31 miles) and a total area of 3.8 acres. Caret symbols in Figure 2 mark the end points of traverses. For each recorded profile, it was typically necessary to walk each line five times: once to record, once to retrace the antenna, twice to thread the guide rope through the trees and clear brush, and a last time to carefully place the antenna cable to minimize snags. On lines E145 and E295, a greater concentration of trees caused greater than usual irregularities in the line of traverse. On these and other lines, the exact profile path can deviate as the guide rope or antenna moves east or west around brush or trees. Positional errors of 2 ft or so are to be expected.

The depth scale of the radar profiles has been estimated by a geometrical analysis of 25 echo arcs. From Figure 3, the best estimate gives a pulse velocity of 0.24 ft/ns.

One particularly clear radar echo (echo 1) was retested with a high resolution resurvey, using a 2 ft spacing between lines and also making a separate set of east-west profiles. A high frequency radar antenna, model 3102 (315 MHz), was also tested at this resurvey area; the profiling depth of this antenna was found to be too shallow. A total of 980 ft of additional profiling was done for this test.

On this same small area, three other instruments were also tested. A total of 77 resistivity measurements, 176 proton magnetometer readings, and 176 pairs of EM conductivity measurements were made.

This geophysical survey was done over the span April 27 through May 4, 1986. Most days were sunny and the temperature was moderate; no rain fell during this period.

The Survey Results

Figure 4 and 5 show how clear some the the echo arcs could be. It is likely that both of these echoes are caused by graves. The clues are: a reasonable depth, high echo amplitude (dark bands with thin white lines), a reasonable source width (less than 3 ft), and a symmetrical arc indicating an abrupt lateral change. These and other echoes are plotted in Figure 2, with different symbols to mark the different types of echoes; the number next to each echo symbol gives the estimated depth of the object.

There is a tendency for echoes to be found in clusters and some of these are shown in Figure 1. The major cluster is at "A" in the north central part of the survey area. Cluster A has the greatest concentration of distinct echoes; while not necessarily a good guide, several grave markers were also found in this area. Figures 6 and 7 show some of the echoes from this area. Some very clear echoes are seen at a depth of 7 ft or more; if the depth scale is correct, these are almost surely too deep to be graves. A square symbol marks those echoes which appear to have a geological origin.

It is difficult at this site to be sure of whether some echoes are caused by graves or by natural soil changes. Figure 8 shows some rather clear echoes; the one on the right is very similar to that in Figure 5. The area shown in Figure 8 is echo cluster F; in this area, echoes which appear almost surely caused by natural sources (because of their depth, lateral extent, size, and density) grade towards echoes which, in isolation, appear to be possibly caused by graves.

Figure 9 shows another example. While these echoes could mark graves, this cluster and weaker unmarked echoes are aligned along the upper edge of a slope down to the south. Outcropping strata are possible here. Natural, dipping stratification was clear in some areas and Figure 10 is an illustration. Around echo cluster G, in the northwest corner of the survey area, there is no clear stratification; because of the greater echo depth and complex patterns there, these appear to have a natural origin.

A 5 ft spacing between parallel lines was needed here in order to economically survey this moderately large area. Even with graves oriented east-west, it would be easy to not detect an echo from some graves. In some cases it does appear possible that the same object has caused echoes on parallel lines; these four groups are connected in Figure 2 with dotted lines. A grave oriented north-south, along the profile direction, is expected to give a broader echo. That shown in Figure 11 could, in principle, be a longitudinal echo from a grave. The likely grave at echo 1 was profiled along its apparent length, in the east-west direction. While Figure 12 shows a pattern similar to that of Figure 11, the naturally dipping planar strata around echo 1 prevent this from being a clear example.

A 20 by 30 ft area around echo 1 was given a thorough geophysical examination. Two radar antennas were compared and Figure 13 shows that the model 3105 antenna was superior. The radar information gave the echo pattern shown in Figure 14 which suggests a possible grave as indicated in Figure 15.

After the radar resurvey was completed, the area was scanned with an audio-indicating fluxgate magnetometer (Schoenstedt GA-52B). This quickly located about a dozen iron objects near the surface, ranging from barbed wire to a heavy duty chain cutter; a grave marker was also found at N50E364. These objects were removed and an electromagnetic induction meter measured the apparent electrical conductivity of the earth. The maps, Figures 16 and 17, show that there is still a lot of buried metal in the area; the normal operation of this instrument is greatly affected by iron and also metals such as sheet aluminum and copper wire. This instrument detected no distinctive pattern at the possible grave location.

A recorded magnetic survey was made with a proton magnetometer. The strong magnetic low at the bottom of Figure 18 shows that at least one iron object could be just south of the measurement grid. There is also a weak magnetic low at the radar anomaly, but it is not clear enough to be reliable.

Five resistivity profiles were made across the possible grave; with different electrode spacings, different depths were emphasized. Figure 19 indicates that there is a region of high electrical resistivity at the area of the possible grave. This effect is apparent for electrode spacings of 6, 8, and 10 ft, which is reasonable for a 4 ft object depth, as indicated by the radar.

In general, a grave could cause either a high or low resistivity anomaly, depending on soil stratification and the condition and compaction of the backfilled earth. The resistivity data, as analyzed in Figure 20, also show the rapid increase in resistivity with depth.

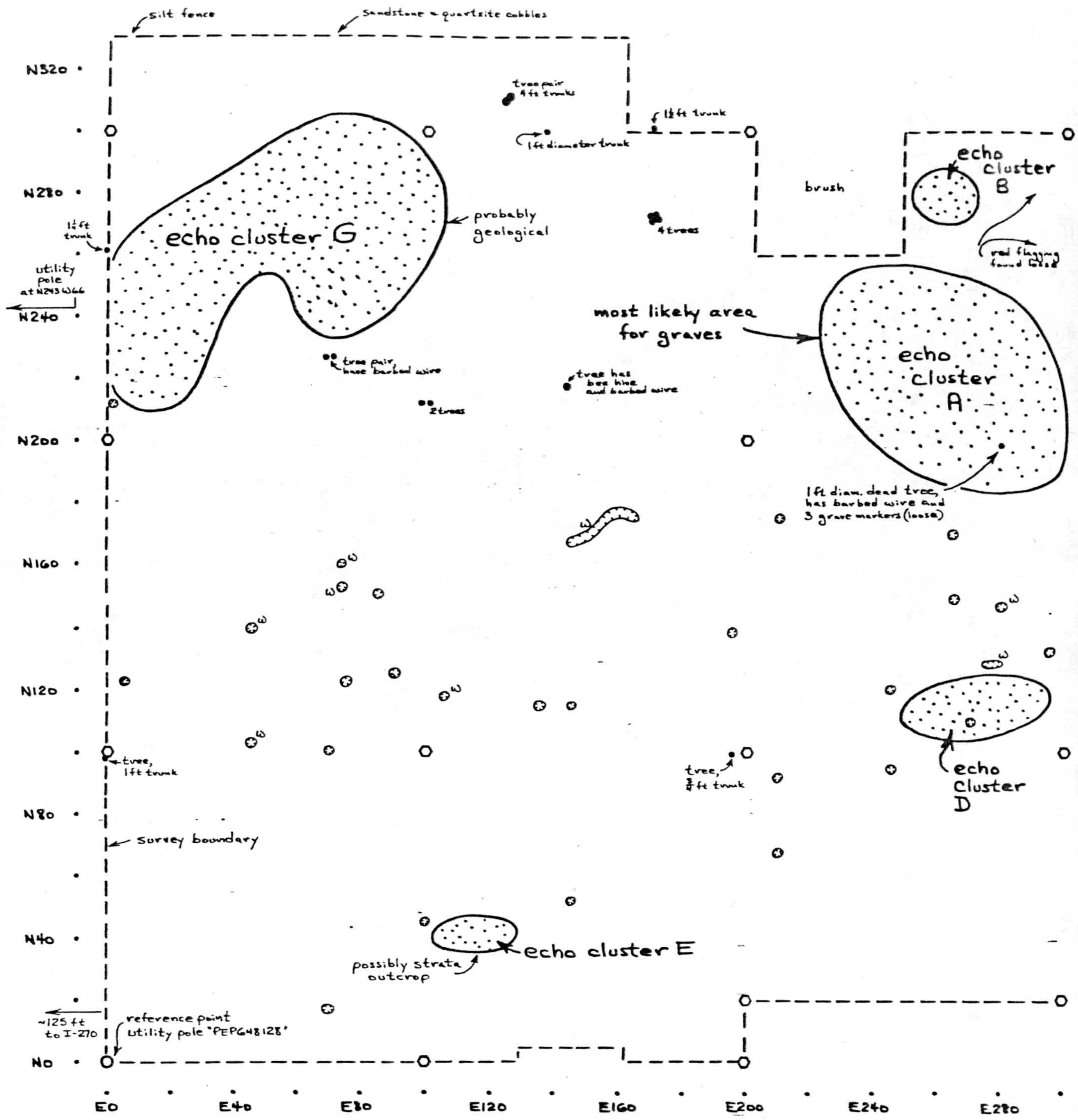
Conclusion

It appears certain that a good number of graves have been detected by the radar survey. A certain, but unknown, fraction of the echoes which have been mapped are caused by graves. Other echoes could be caused by lenses of contrasting soil, rock pinnacles, buried trees, trash pits, or other sources. It is also surely true that some graves have not been detected by this survey.

The certainty of detecting graves decreases from echo 1 and then 2 and then echo cluster A through G. This could be the priority for testing. It would be desirable to sample test the different echoes, considering echo type, depth, and location. The large scale (1" to 20') copies of Figure 2 give a good mapping of the echoes; a full scroll of the radar profiles is furnished with this report and the annotations on it are the source for Figure 2 and are therefore more reliable.

After some initial testing, these profiles can be re-examined to see if any further echo characteristics can be derived to aid the search for graves.

It is hoped that the reliability of these geophysical findings will be sufficient to be a good guide for the excavation of the graves. If it is not, one more involved option remains. The soil could be removed to a depth of a foot or so; this would remove trash and surface roughness. Grave shaft outlines could be visible; if not, clear surface conditions would enhance the reliability of a radar resurvey of selected areas.



Site setting and geophysical summary
poor farm cemetery, Rockville, Maryland
survey 27 April - 4 May 1986

- o blue-flagged wire
- • tree (only a few shown)
- ⊙ depression; w = contained water

50 ft

N (magnetic)

Figure 1a

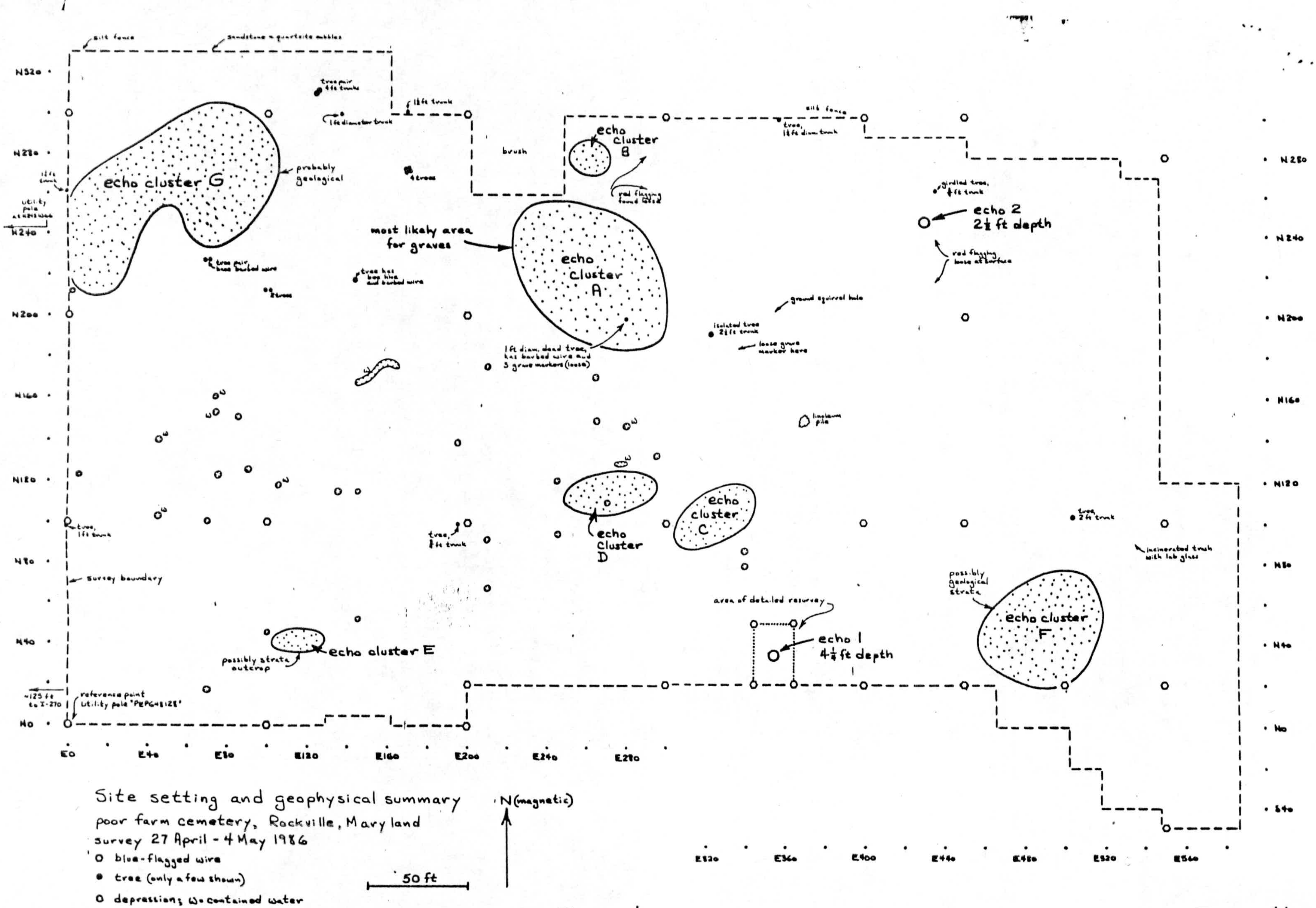
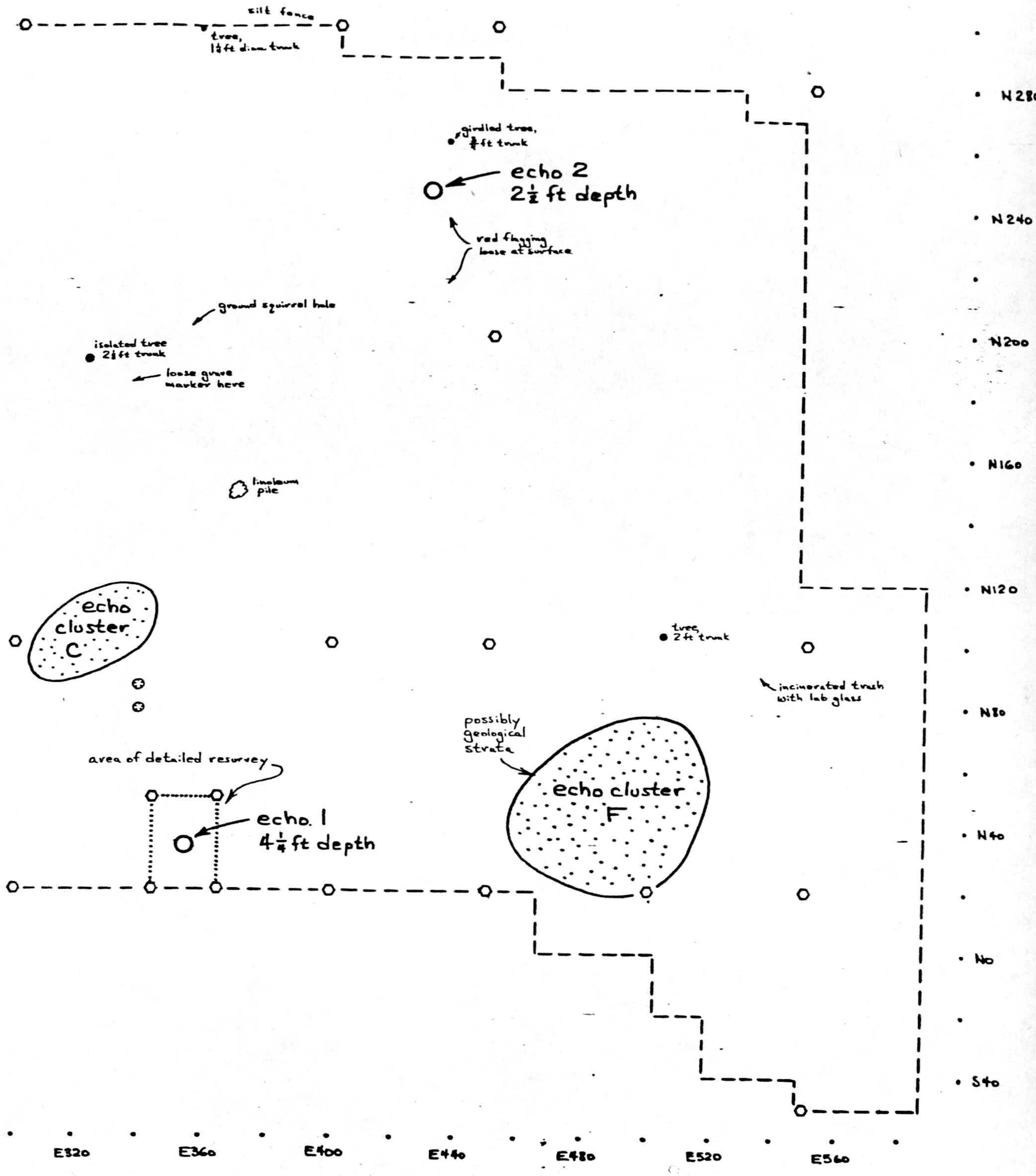


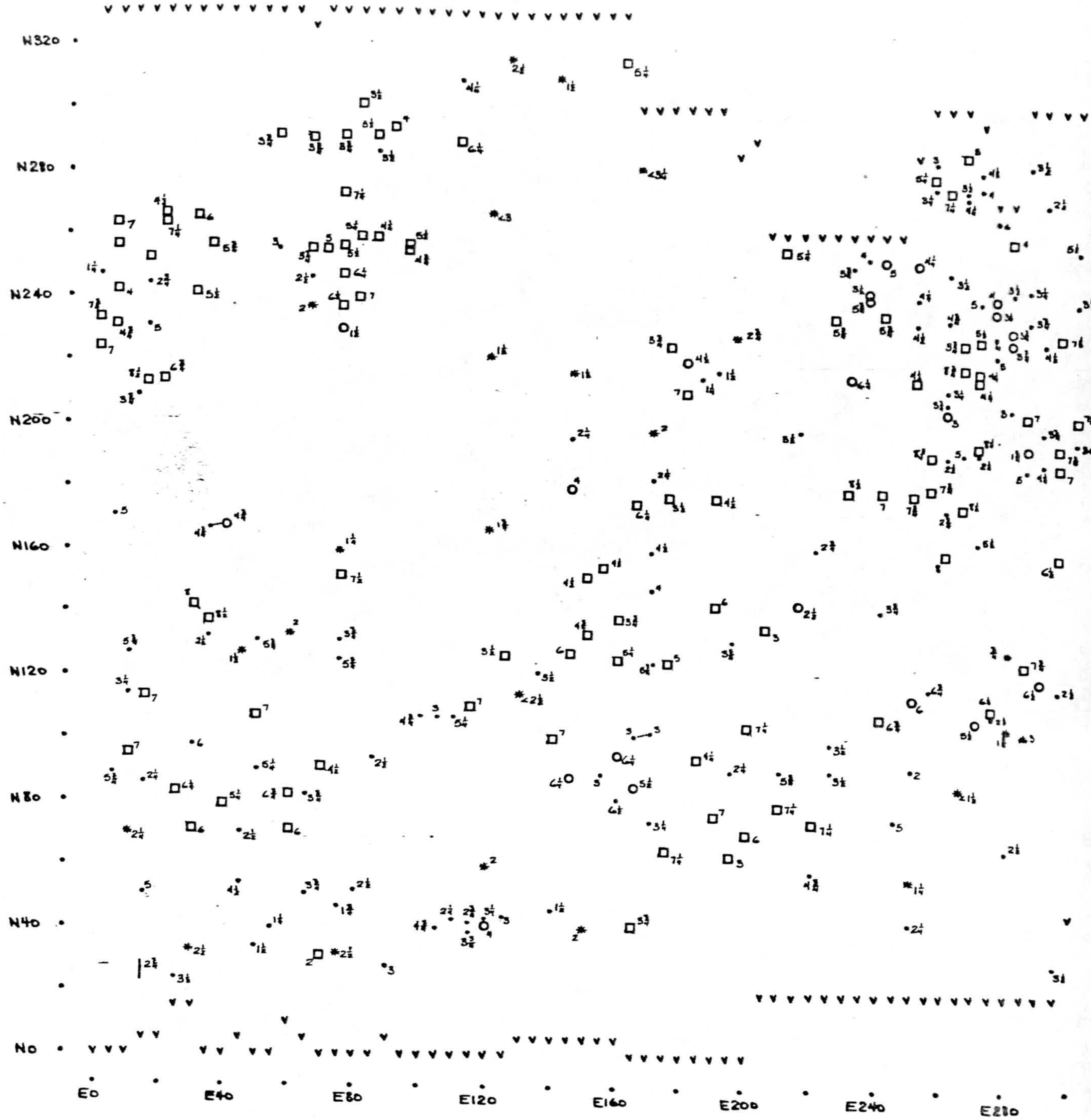
Figure 1a

Figure 1b



silt fence
tree,
$1\frac{1}{2}$ ft diam trunk
girdled tree,
$\frac{3}{4}$ ft trunk
echo 2
$2\frac{1}{2}$ ft depth
red flagging
loose at surface
ground squirrel hole
isolated tree
$2\frac{1}{2}$ ft trunk
loose grave
marker here
linoleum
pile
echo
cluster
C
tree,
2 ft trunk
incinerated trash
with lab glass
possibly
geological
strata
echo cluster
F
area of detailed resurvey
echo 1
$4\frac{1}{4}$ ft depth
N280
N240
N200
N160
N120
N80
N40
N0
S40
E320
E360
E400
E440
E480
E520
E560

Figure 1b



Radar echo map

poor farm cemetery, Rockville, Maryland

survey 27 April - 4 May 1986

SIR System-7, model 3105 (180MHz) antenna

- ● very distinct echo
- o distinct echo
- • weak echo
- □ possibly geological strata
- — planar echo
- * near-surface metal

50 ft

N (magnetic)

v end of traverse

numbers indicate echo depth, in feet, assuming V=0.24 ft/ns

Figure 2a

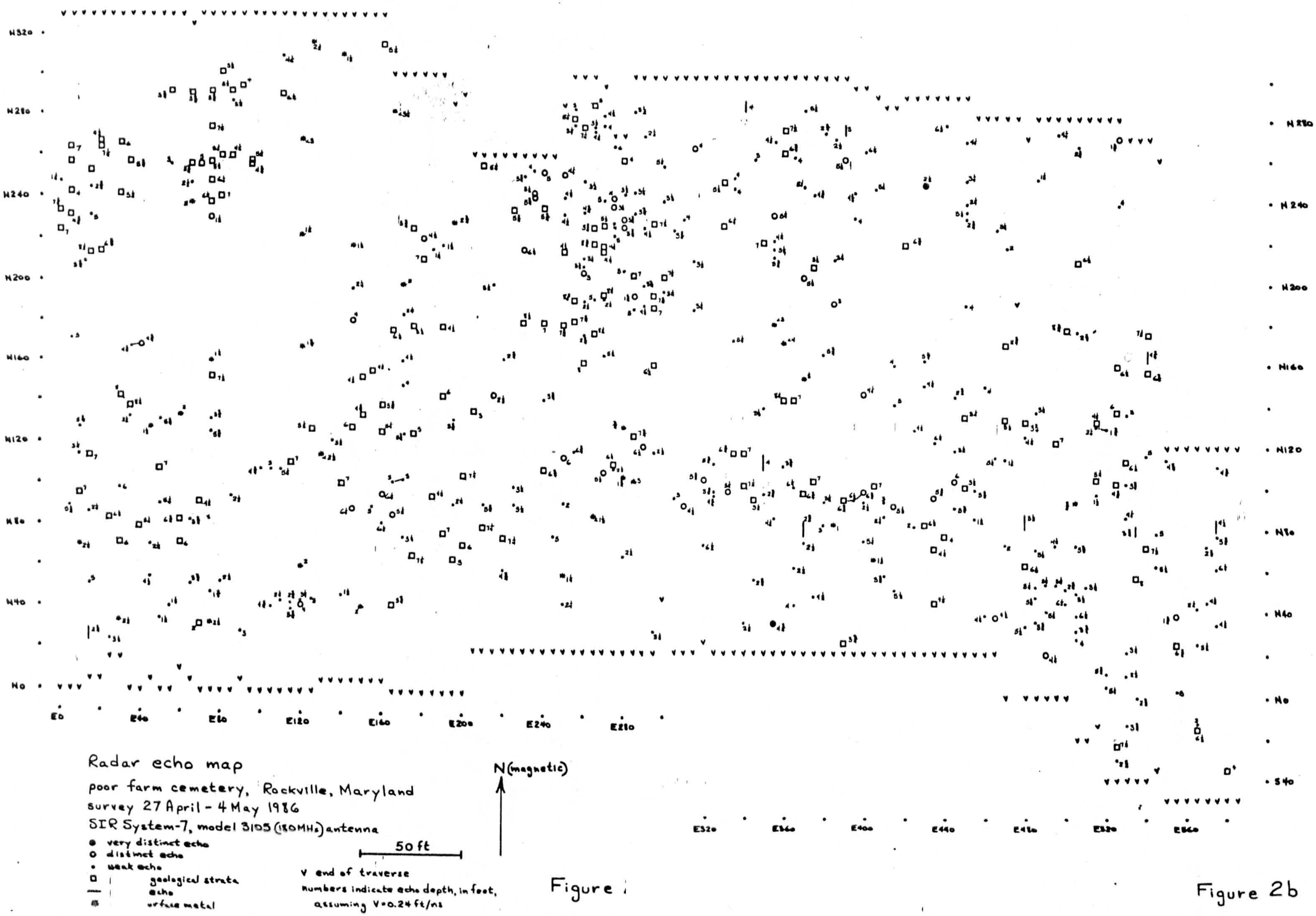

Radar echo map
poor farm cemetery, Rockville, Maryland
survey 27 April - 4 May 1986
SIR System-7, model 3105 (180MHz) antenna
very distinct echo
distinct echo
weak echo
geological strata
echo
surface metal
50 ft
V end of traverse
numbers indicate echo depth, in feet, assuming V=0.24 ft/ns
N (magnetic)
N320
N280
N240
N200
N160
N120
N80
N40
N0
S40
E0
E40
E80
E120
E160
E200
E240
E280
E320
E360
E400
E440
E480
E520
E560
Figure

Figure 2b

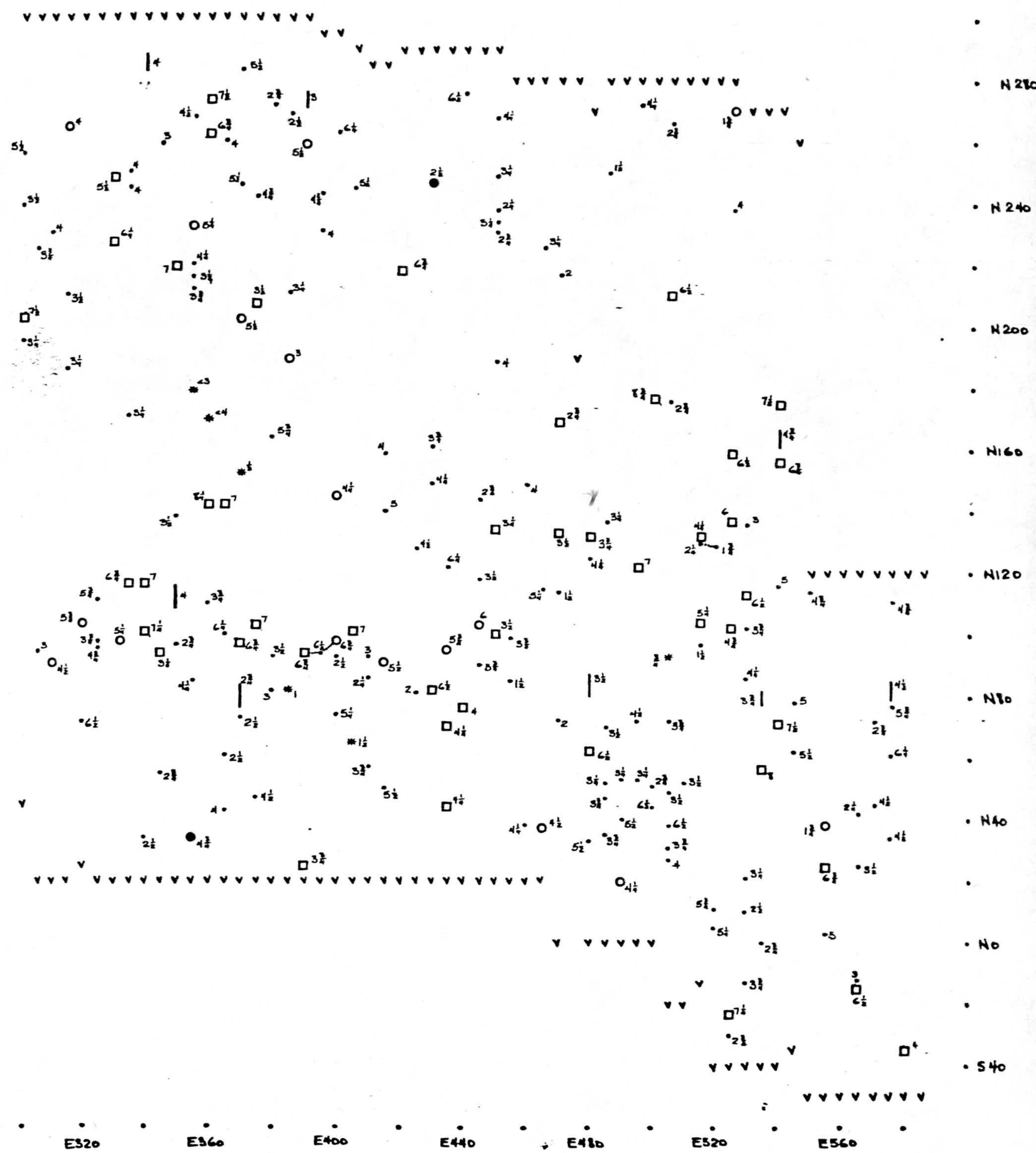

N280
N240
N200
N160
N120
N80
N40
N0
S40
E320
E360
E400
E440
E480
E520
E560

Figure 2b

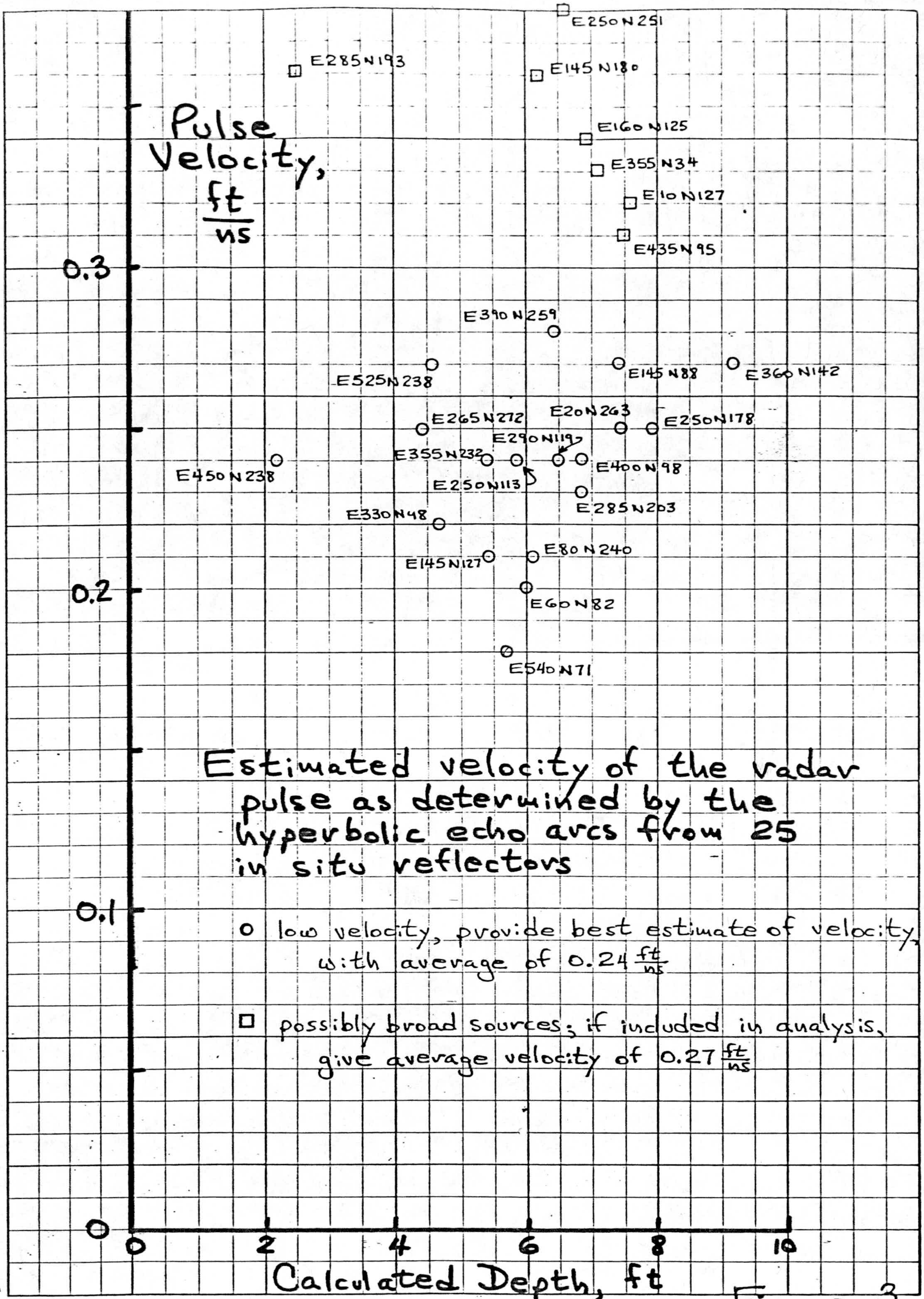

Pulse Velocity, ft/ns
0.3
0.2
0.1
0
Calculated Depth, ft
0
2
4
6
8
10
E250N251
E285N193
E145N180
E160N125
E355N34
E10N127
E435N95
E390N259
E525N238
E145N88
E360N142
E265N272
E20N263
E250N178
E290N119
E355N232
E450N238
E400N98
E250N113
E285N203
E330N48
E80N240
E145N127
E60N82
E540N71
Estimated velocity of the radar pulse as determined by the hyperbolic echo arcs from 25 in situ reflectors
o low velocity, provide best estimate of velocity, with average of 0.24 ft/ns
□ possibly broad sources; if included in analysis, give average velocity of 0.27 ft/ns

Figure 3

line E355
markers at 5 ft intervals
model 3105 (180 MHz) antenna
survey 1 May 86

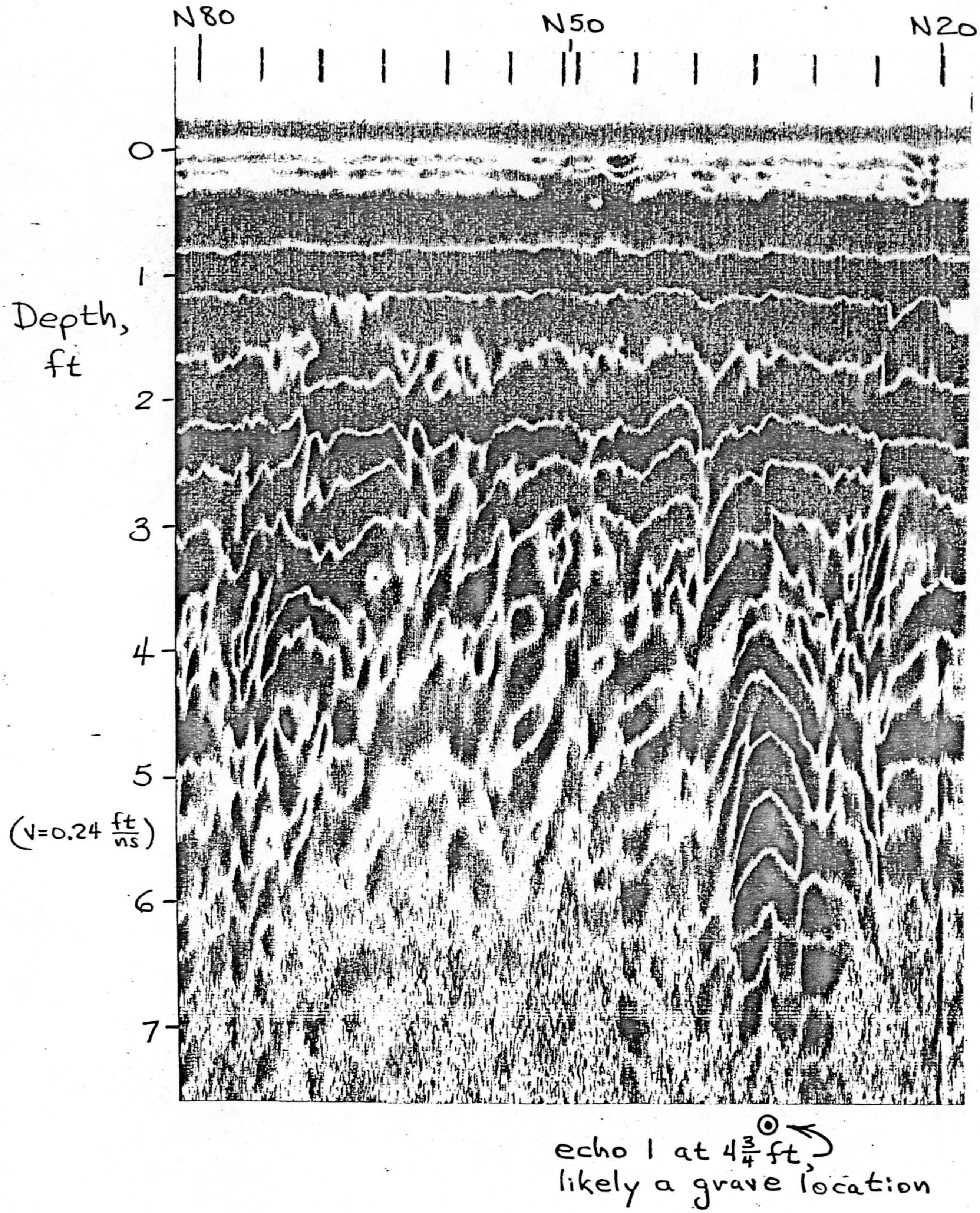
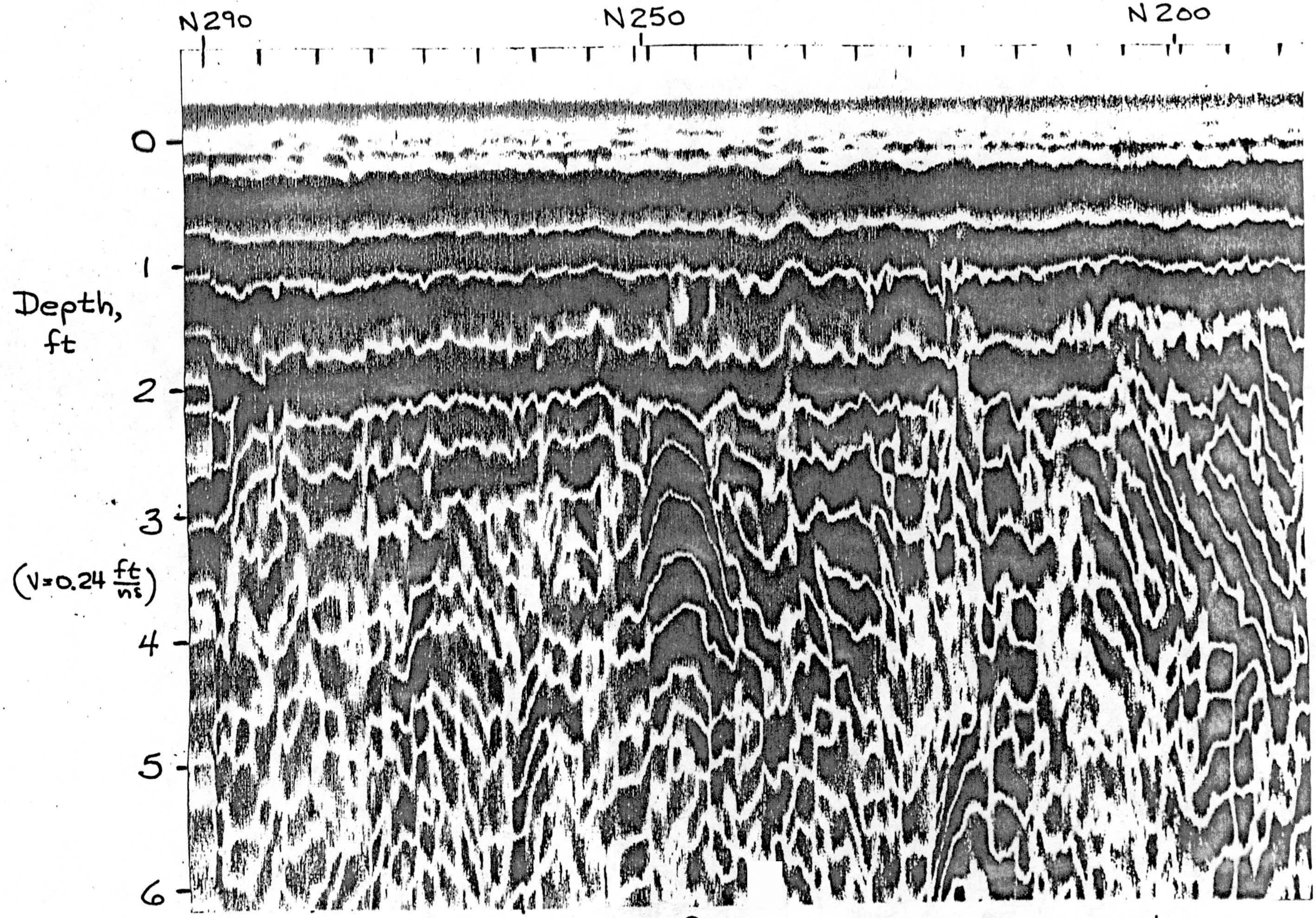


Figure 4

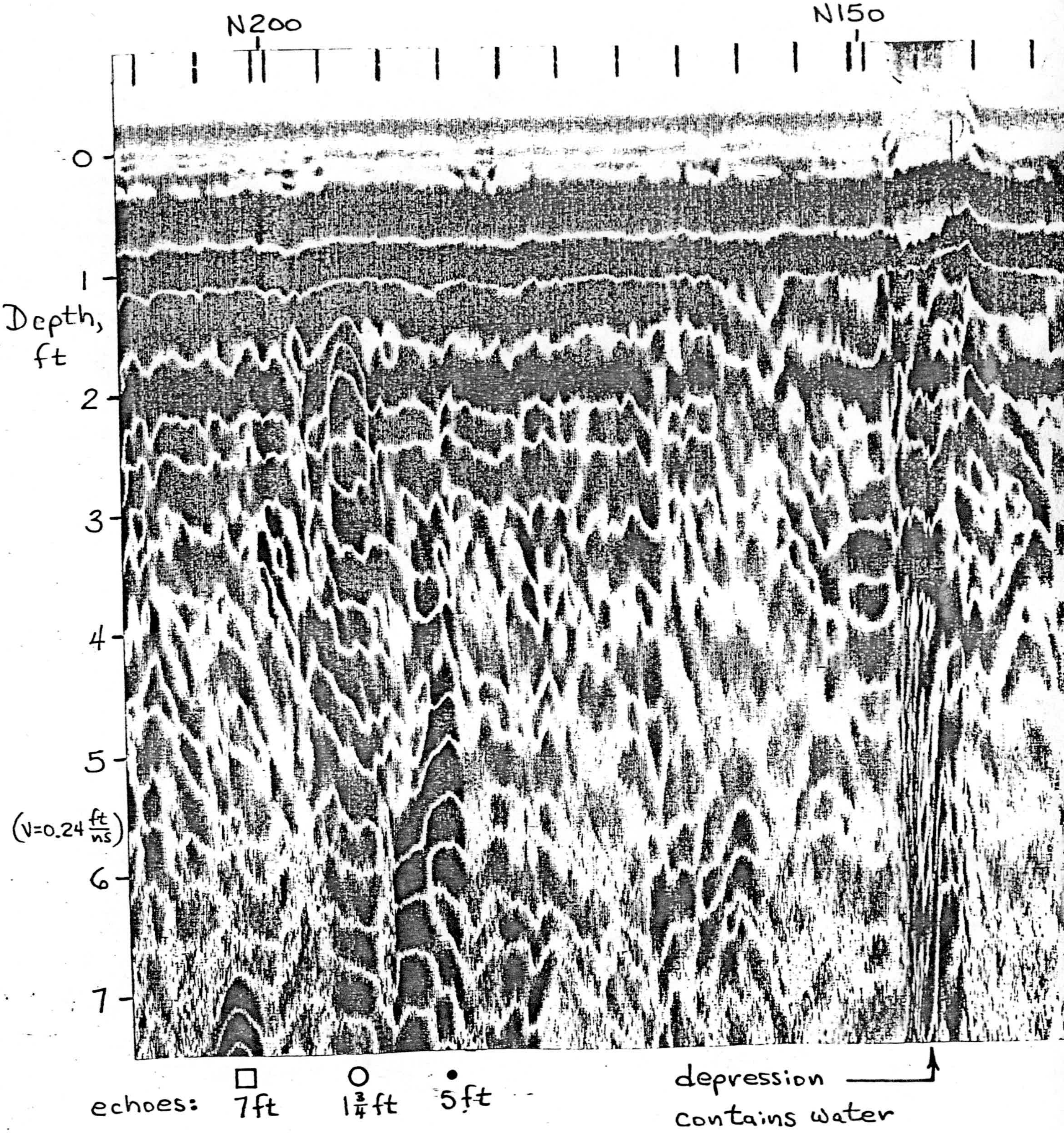
line E430, markers at 5ft intervals, model 3105 (180 MHz) antenna, 2 May 86



echo 2: ⊙ ← very distinct echo at $2\frac{1}{2}$ ft,

Figure 5

line E285
model 3105 (180 MHz) antenna
markers at 5 ft intervals
survey 30 Apr 86



echo cluster A

Figure 6

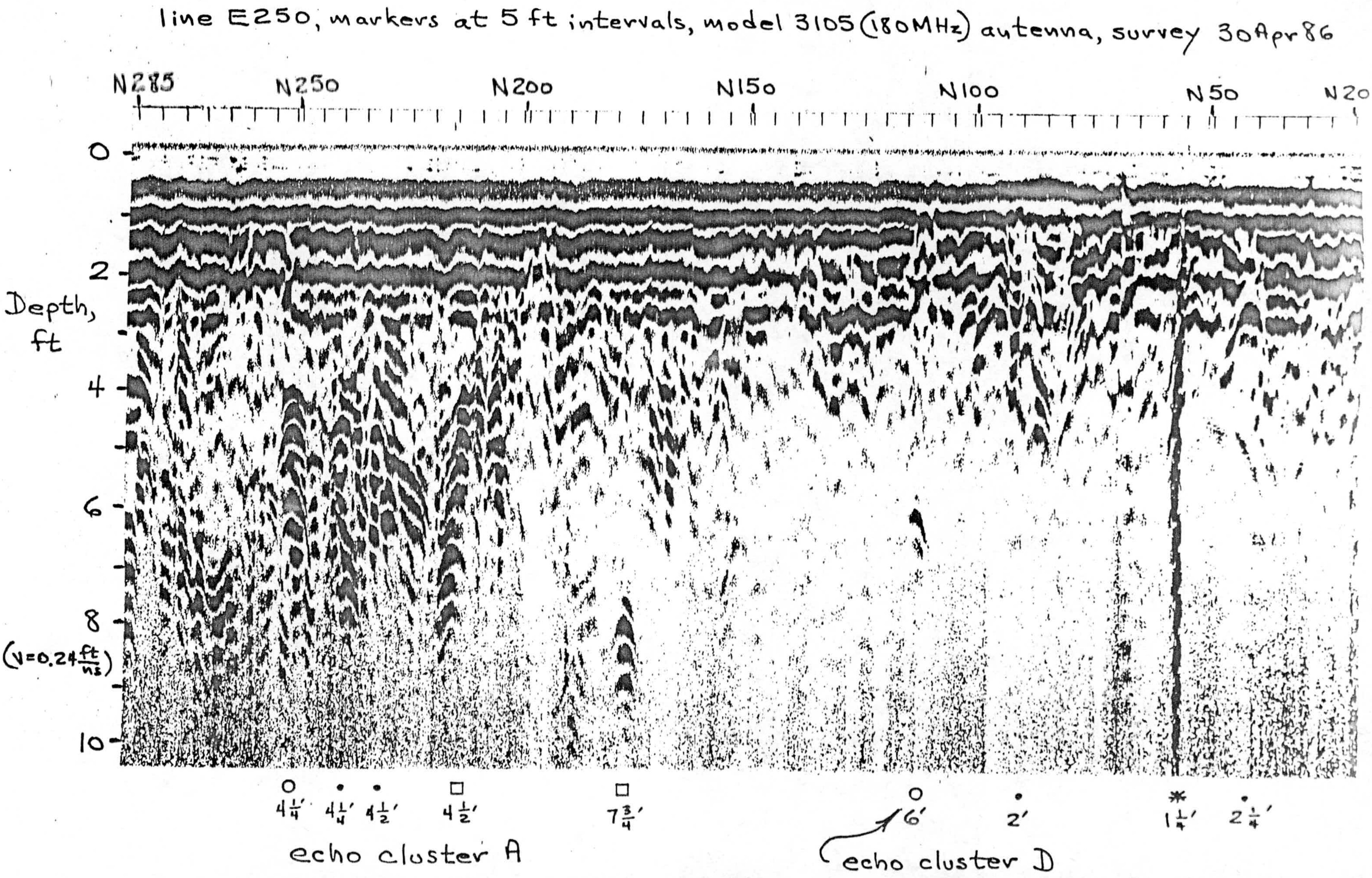
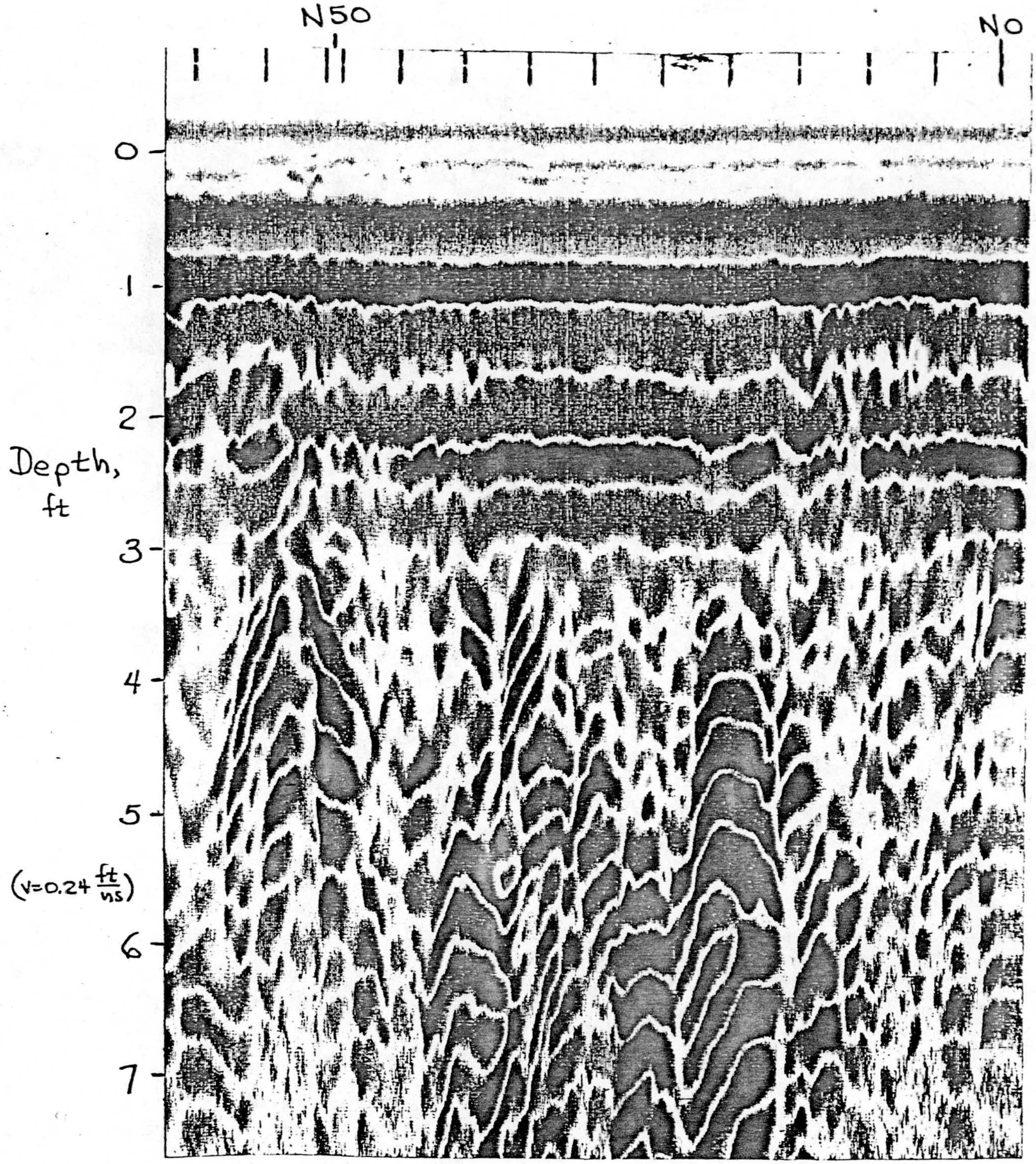

line E250, markers at 5 ft intervals, model 3105 (180MHz) antenna, survey 30Apr86
N285
N250
N200
N150
N100
N50
N20
0
2
4
6
8
10
Depth, ft
($v=0.24\frac{ft}{ns}$)
$4\frac{1}{4}'$ $4\frac{1}{4}'$ $4\frac{1}{2}'$ $4\frac{1}{2}'$ $7\frac{3}{4}'$ $6'$ $2'$ $1\frac{1}{4}'$ $2\frac{1}{4}'$
echo cluster A
echo cluster D

Figure 7

line E490
markers at 5 ft intervals
model 3105 (180 MHz) antenna
survey 2 May 86



echo cluster F: • $3\frac{1}{4}$ ft • $5\frac{1}{2}$ ft ○ $4\frac{1}{4}$ ft

These echoes could result from natural, geological strata or from graves.

Figure 8

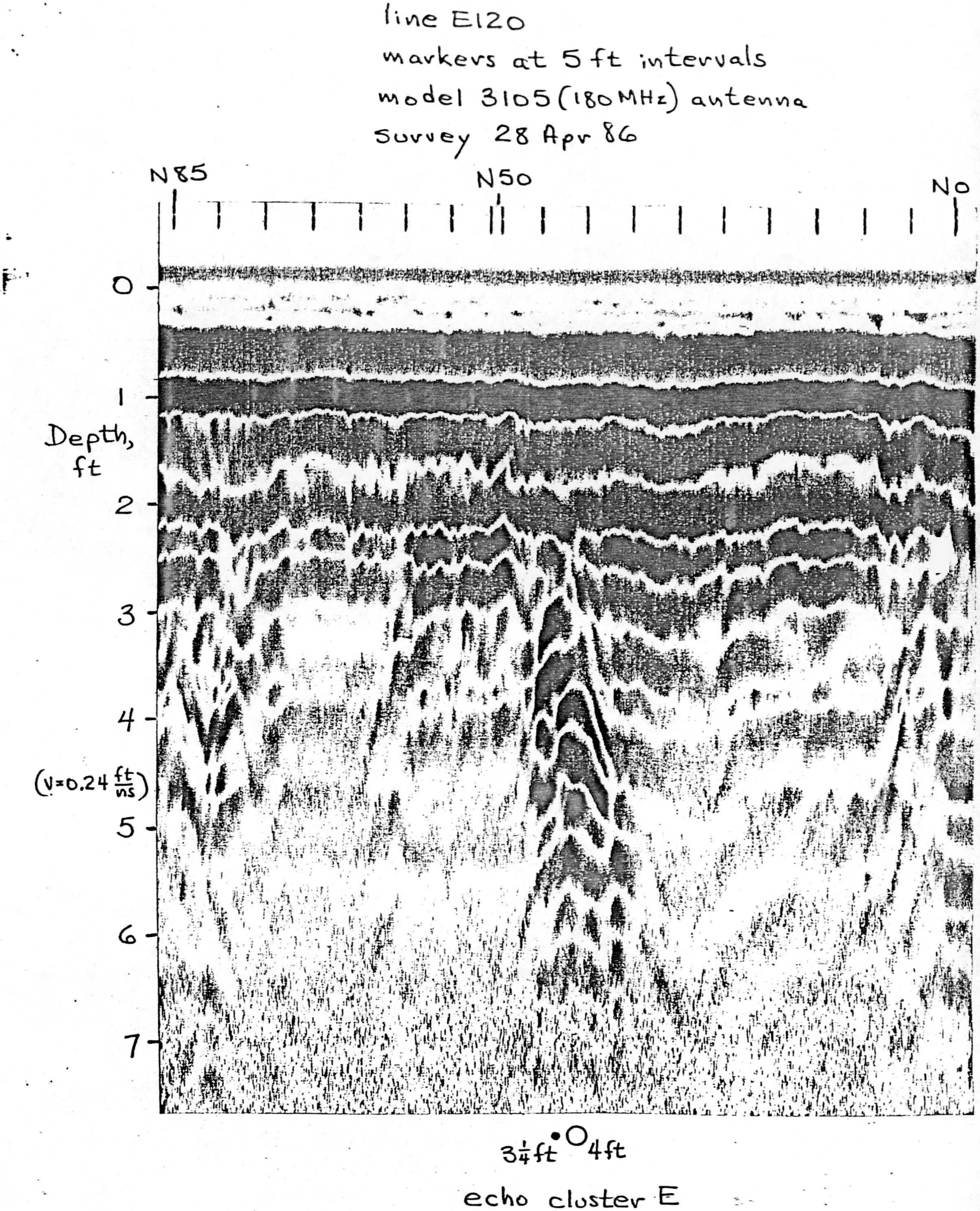
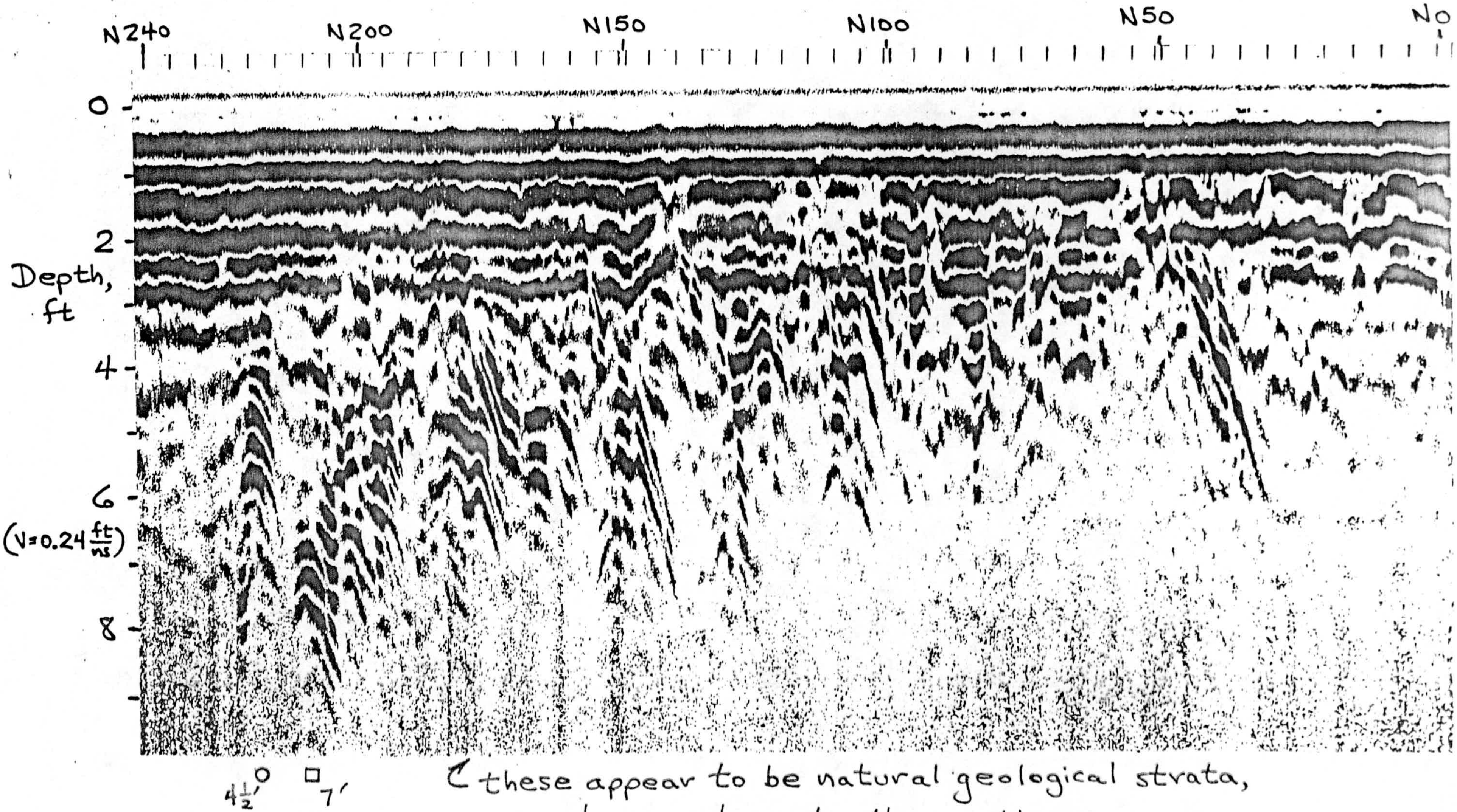

line E120
markers at 5 ft intervals
model 3105 (180 MHz) antenna
survey 28 Apr 86
N85
N50
N0
Depth, ft
0
1
2
3
4
5
6
7
(v=0.24 ft/ns)
3¼ft
4ft
echo cluster E

Figure 9

line E180, markers at 5 ft intervals, model 3105 (180MHz) antenna, survey 29 Apr 86



← these appear to be natural geological strata, dipping down to the south

Figure 10

line E575
markers at 5 ft intervals
model 3105 (180 MHz) antenna
survey 3 May 86

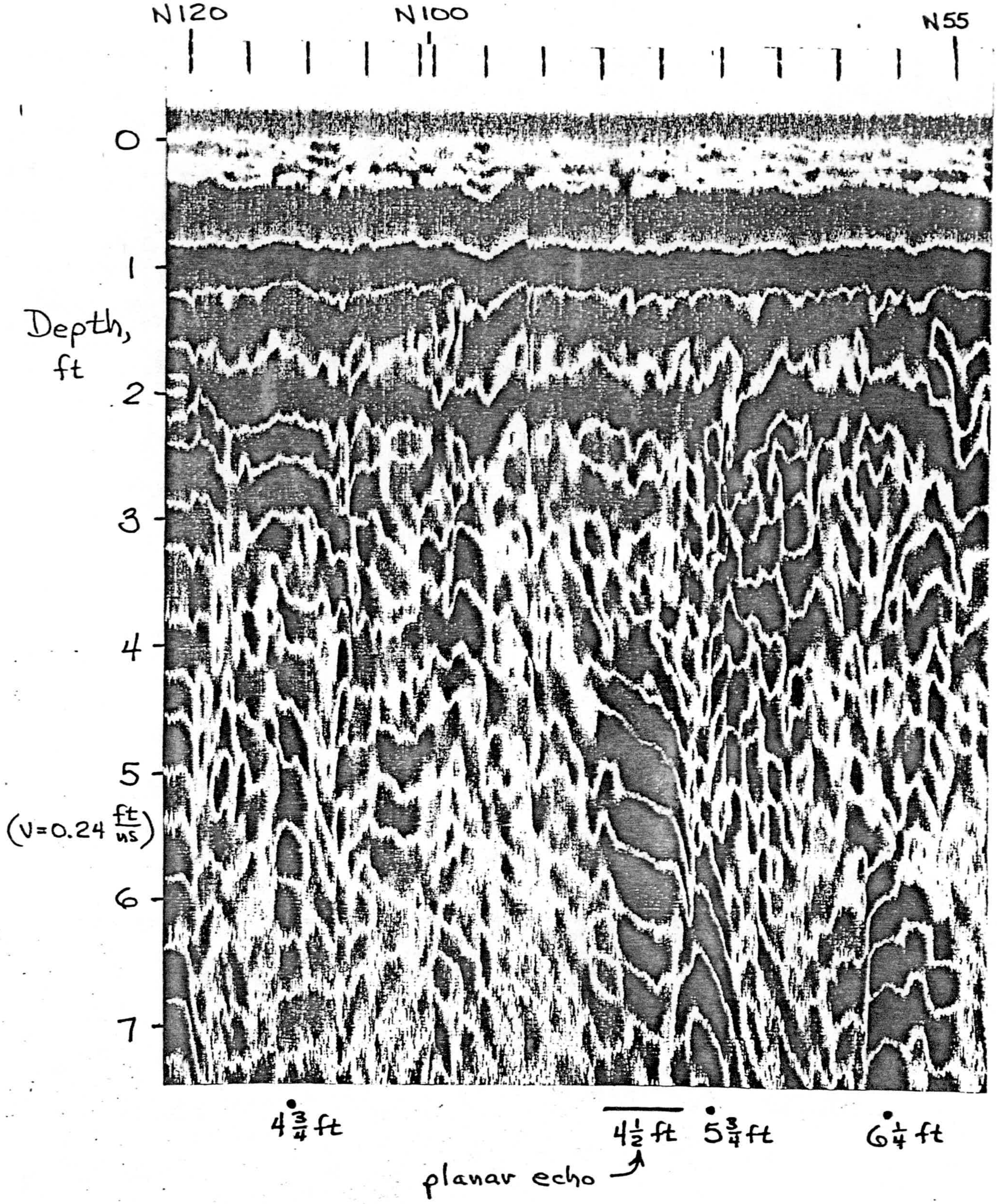
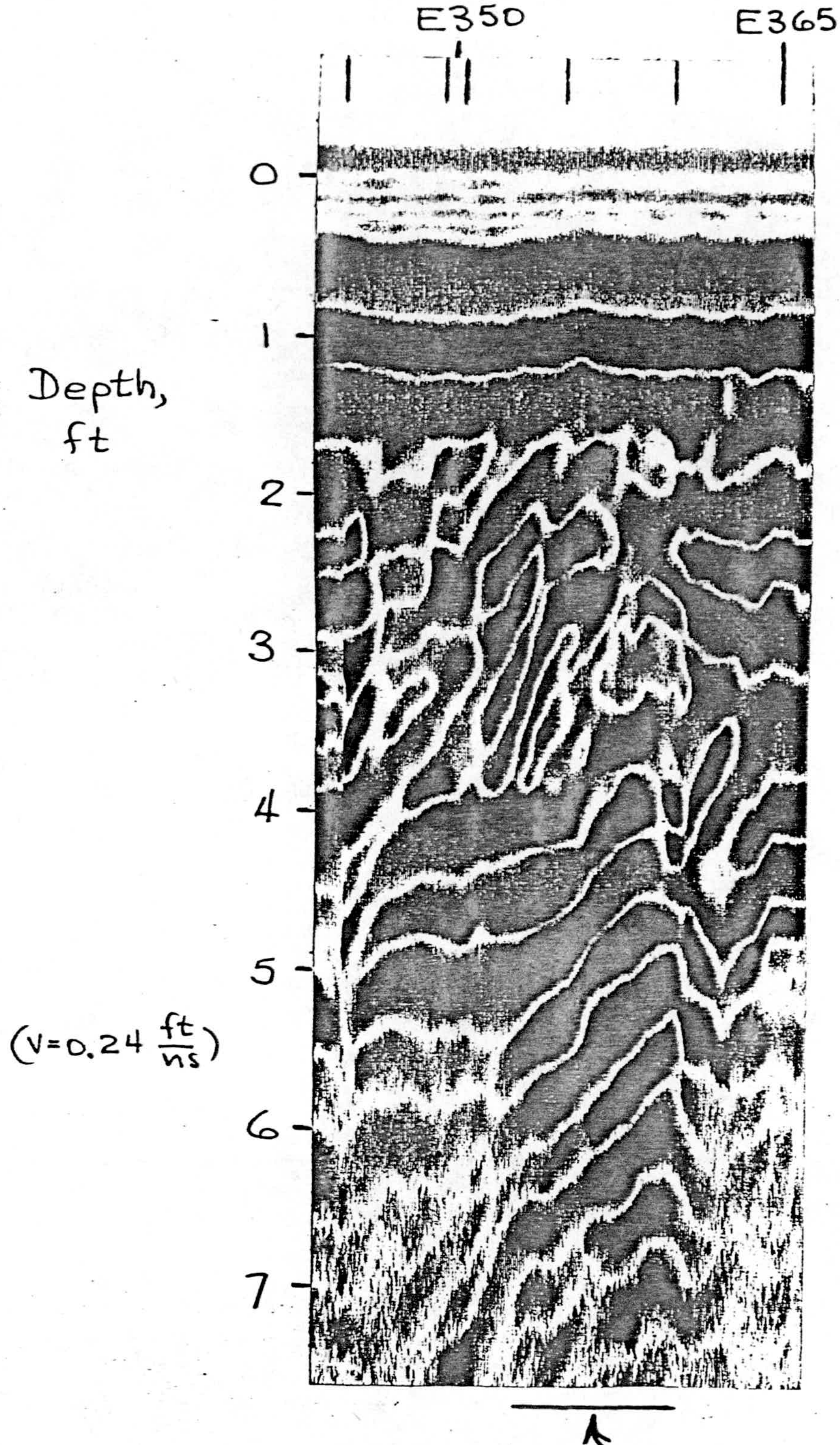


Figure 11

line N32
markers at 5 ft intervals
model 3105 (180 MHz) antenna
survey 4 May 86



dipping planar echo at 4¼ ft
could be longitudinal echo from grave

Figure 12

line E357, markers at 5 ft intervals, survey 4 May 86

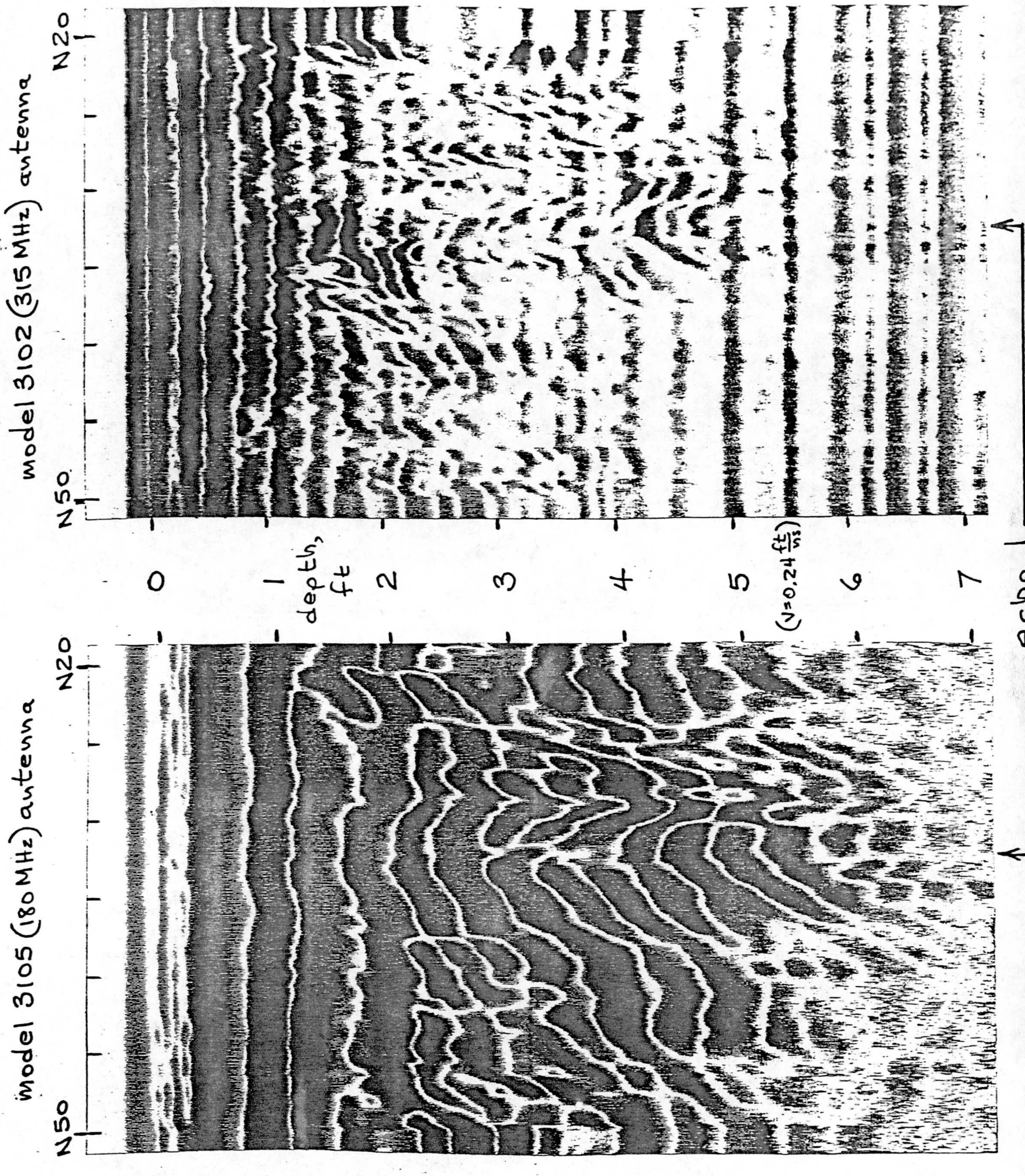
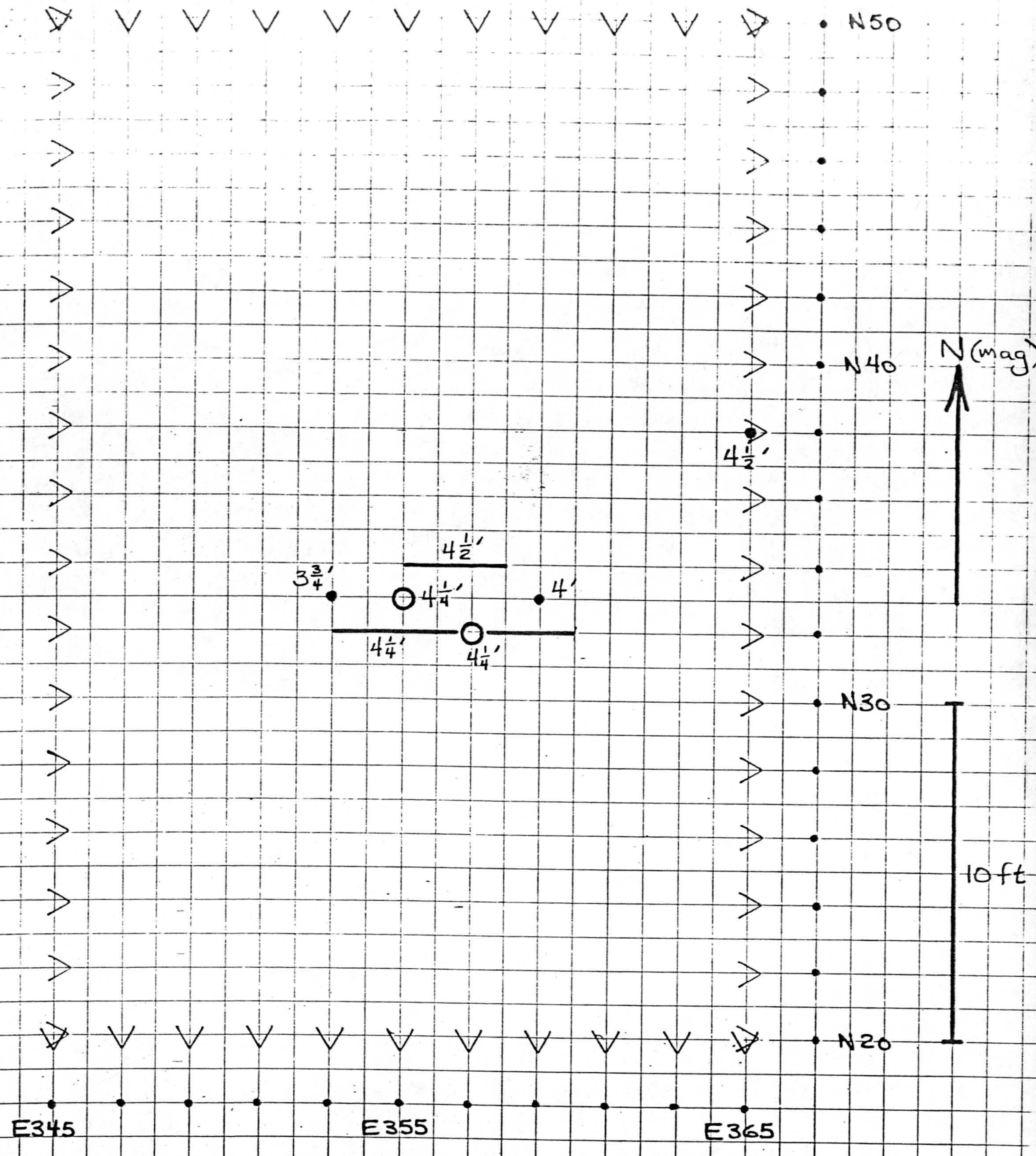


Figure 13

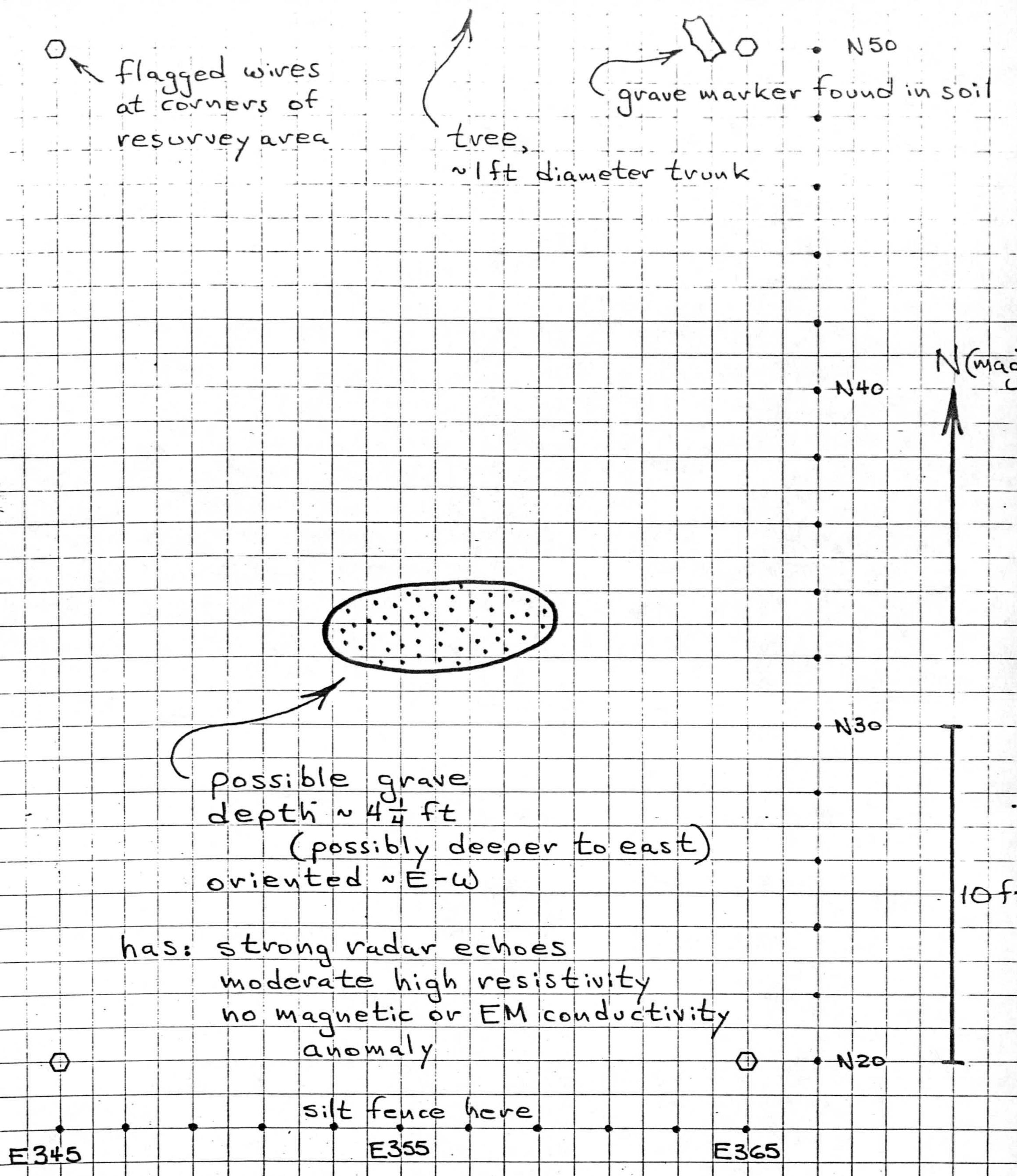


Radar echo map

SIR System-7 radar and model 3105 (180 MHz) antenna

- O distinct echo, numbers show depth, in feet,
- • weak echo assuming V = 0.24 ft/ns
- ▬ planar echo
- > end of traverse, survey 4 May 86

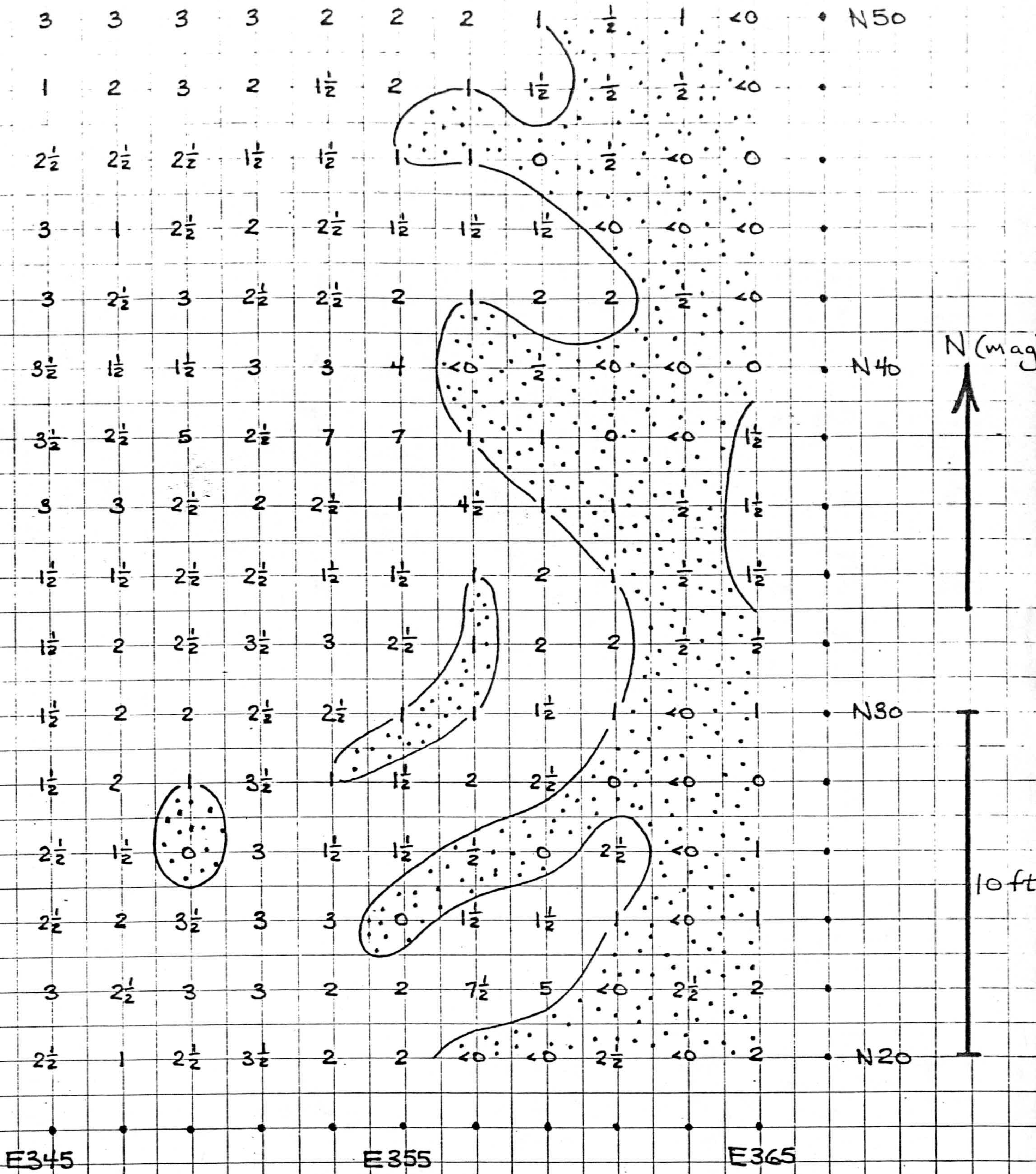
Figure 14



Site setting and geophysical summary

high resolution resurvey area
survey 4 May 86

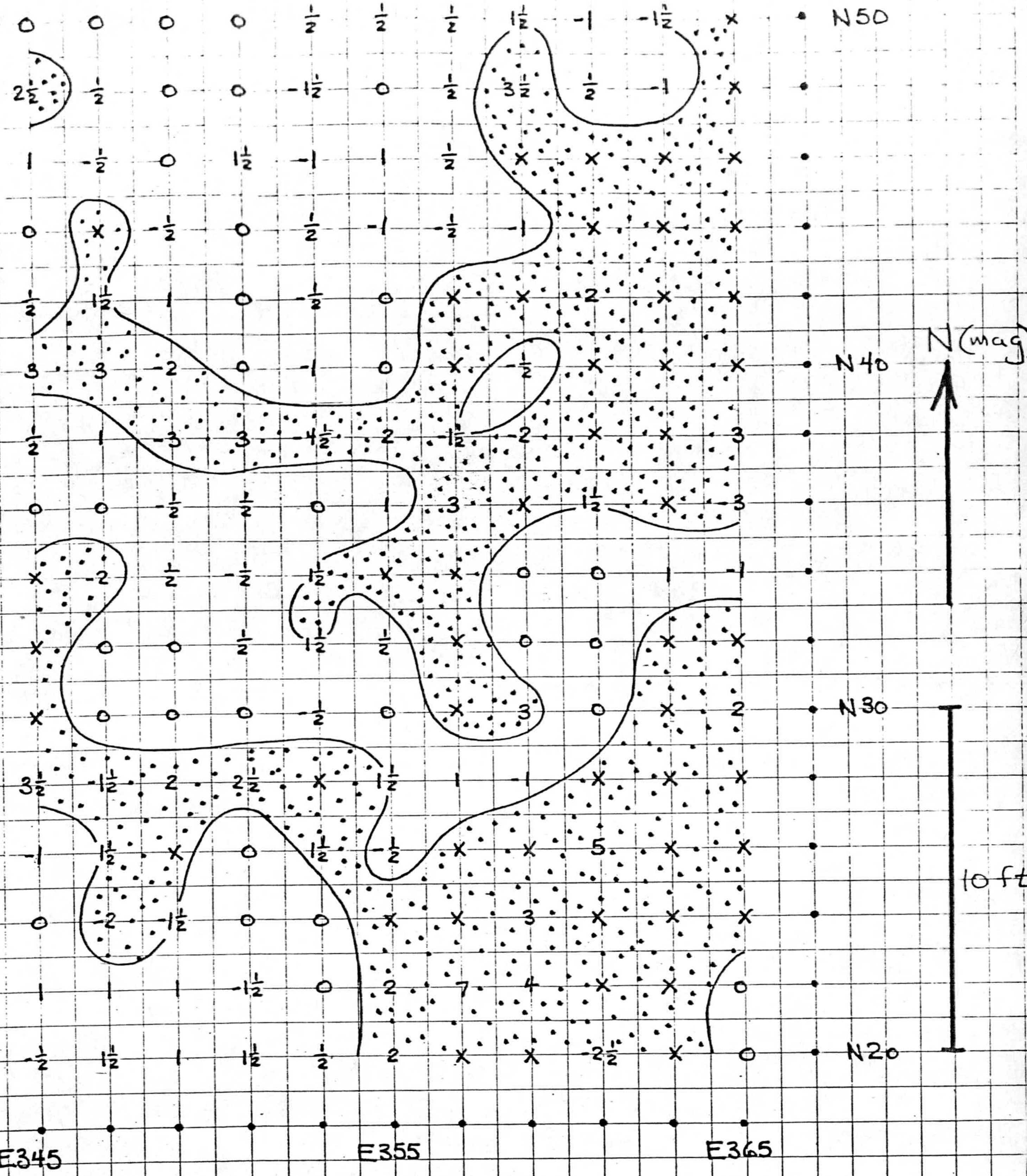
Figure 15



Conductivity map

numbers are conductivity in $\frac{mS}{m}$
Geonics EM38 electromagnetic induction meter
bar on ground, dipoles vertical, average N-S & E-W readings
survey 4 May 86, 1:41–2:32 PM
stippled areas could have metal near

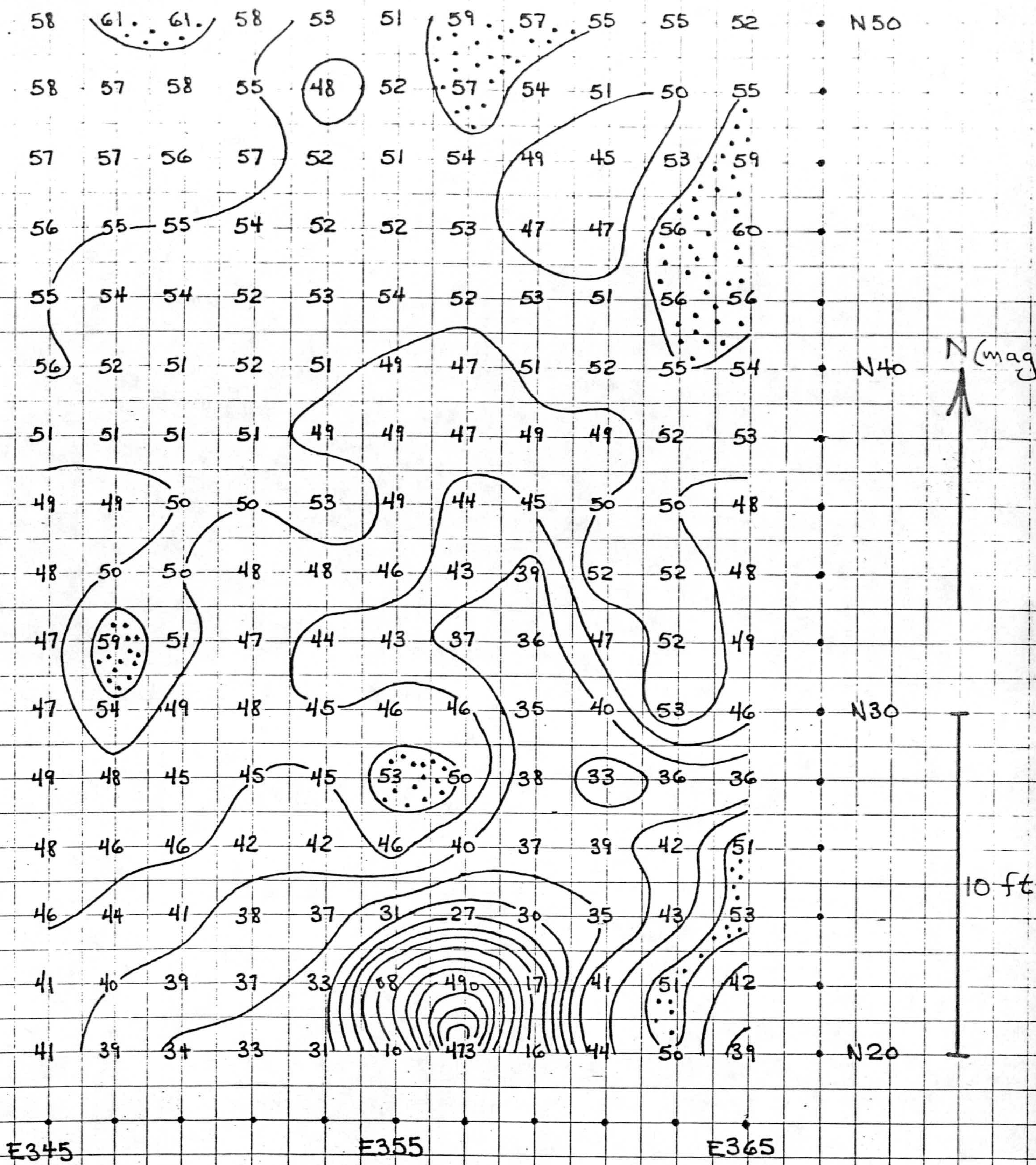
Figure 16



Directionality of conductivity

Geonics EM38, bar on ground, dipoles vertical
N = conductivity with bar N-S, E = E-W measurement
plot is difference: N - E; X indicates N or E < 0
survey 4 May 86, 1:41 - 2:32 PM
stippled areas could have metal near

Figure 17



Magnetic map

contour interval = 5 nT, sensor height ≈ 2 ft
numbers are XY in 54,5XY nT unless noted
Scintrex MP-2, survey 4 May 86, 2:57–3:18 PM
temporal shift ~3 nT, not corrected, $A_{Fred} = 18$
traverse → N, parallel → W

Figure 18

Resistivity Pseudo-section, in ohm-meters

line E355, Gossen Geohm 3 in Wenner configuration
array N-S
survey 4 May 86
3:42-4:28 PM

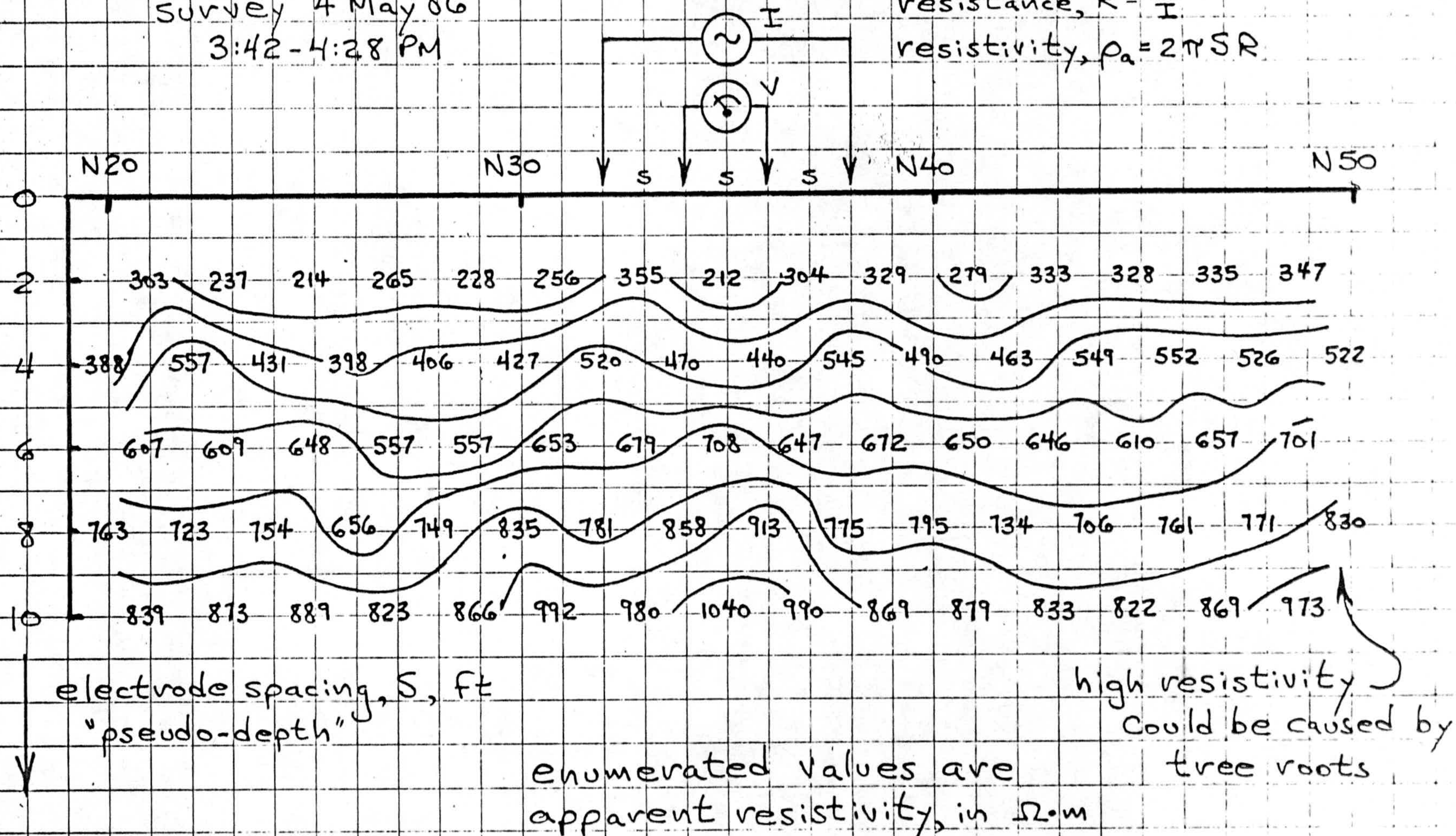


Figure 19

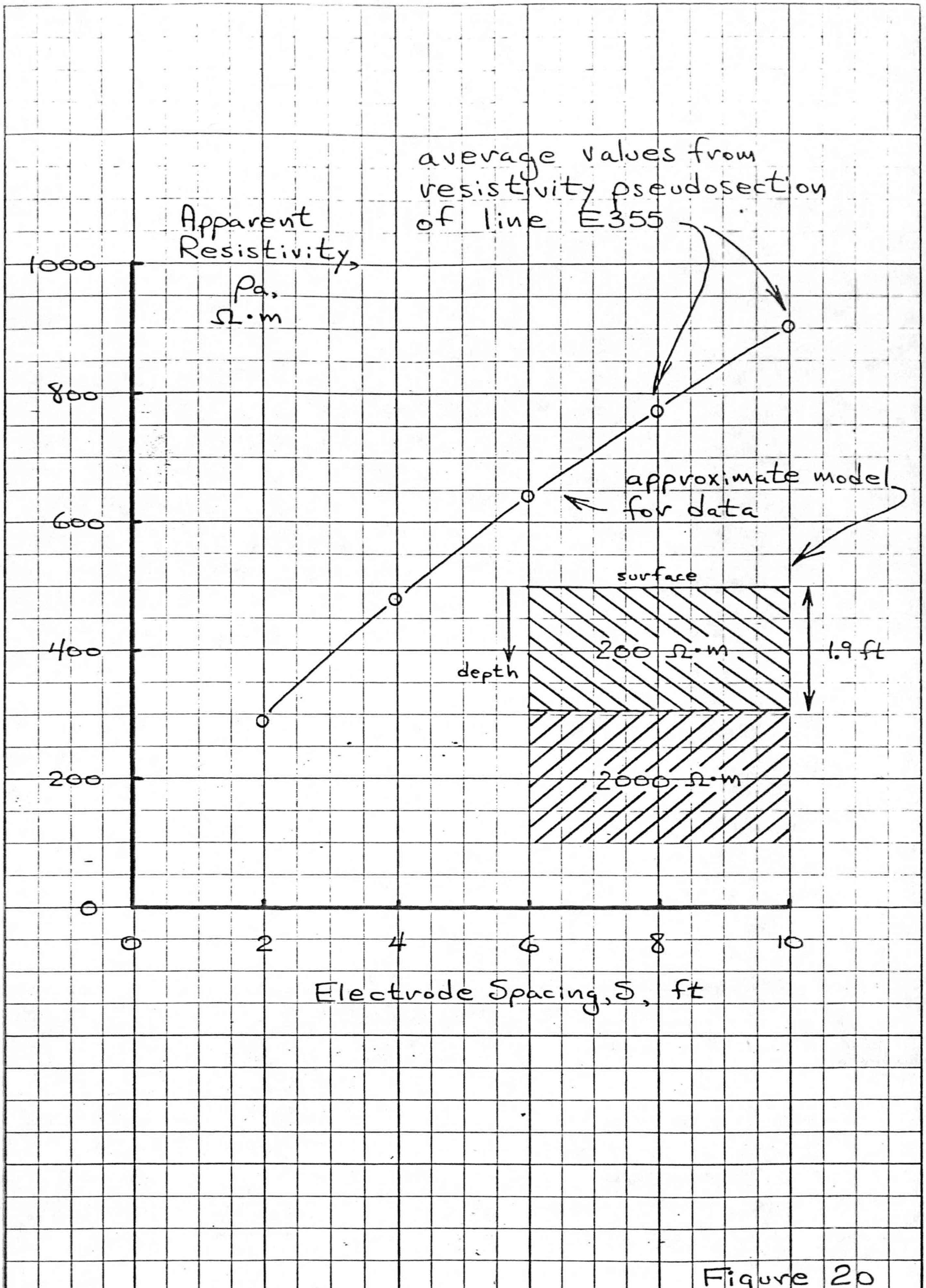


Figure 20

4 Squares
to the Inch