

# A ground-penetrating radar survey at Aspen Lawn

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The yards on the southern and eastern sides of this house are dense with archaeological features. To the east of the house, an area that is 50 ft wide contains a high concentration of artifacts; this area is on a slope that goes down to the east, and the archaeological debris may have been placed there to level that slope somewhat.

In the southern yard, there are two broad lenses of fill soil that contain some debris, but nothing like the concentrations east of the house. These soil lenses are 25 - 50 ft in diameter, and they are located in [Figure 3](#) with the color red. Between this pair of lenses, there is a cluster of 4 - 5 objects that are unusually deep underground (their depth appears to be 3 ft or more); these objects are revealed by the echoes in the middle of the radar profile in [Figure 8](#), where they are marked below with circles.

In addition to these two soil lenses, there are about 15 other concentrations of artifacts or archaeological features that were revealed by the radar in the southern yard; their locations are shown in [Figure 3](#). Some of these features may have a modern origin, for landscaping soil was recently applied over parts of the southern yard to cover the remains of animal pens and similar constructions.

Blue text in the electronic version of this report locates hyperlinks to the figures that are at the end of this text.

## The Site

Aspen Lawn is a historic house and property that is located about 6 miles east of Emporia, Virginia, and just south of highway 58. Its geographic coordinate is about W77° 26' N36° 40.8' and its address is 4438 Hicksford Road, in Drewryville. The house has been preserved and returned to its historical origin by its owners, Robin and Jamie Rawles. As part of their study of this property, they are investigating how the buried evidence of archaeology can aid their historical research. This geophysical survey has been designed to

aid the following archaeological excavation.

Robin and Jamie Rawles supplied me with important historical information about this property: Many potsherds have been visible in the soil to the east of the house. Before the photograph in [Figure 1](#) was taken, and in about 1970, the southern yard of the house was more densely wooded; many trees were then removed by uprooting them. There was then a hog pen in this rear yard also. That also was removed and a layer of fill soil, about a half foot thick, was added to smooth the surface of the yard. The well that was formerly used, in the southern yard, was filled with the soil that was removed during the digging of the new well to the east of the house; [Figure 2](#) locates the new well and approximates the location of the former well, which is now visible by the brick rubble at its surface. At an earlier time, there was a barn near the southeastern corner of the area of this survey; this was perhaps near the concrete slab that is now seen at the surface; see [Figure 2](#). I thank the Rawles family for their helpful hospitality during this survey.

Other features that are visible are included in [Figure 2](#). Some of the large trees that remain are located there; their trunk diameters are approximated by green circles. While there are bushes at the eastern and southern edges of the area of survey, there are none within the working area. The ground surface is covered by closely-mowed lawn, with a few leaves fallen from the trees; pine cones had been removed from the ground.

The pattern of the house is approximated in [Figure 2](#). The shed is shown with a dashed line, since its size, orientation, and exact location were not measured.

A slight ridge extends to the south from the house (whose shape is approximated in [Figure 2](#)); while this ridge drops down toward the south, the land dips by a greater amount to the east and west. The total relief in the area of survey is probably less than 3 ft; the elevation of the surface is about 130 ft. Holes about 2 ft in diameter and 4" deep were found along line N4867.5 near E4045 and E4057; however, no unusual radar echoes were detected at those locations. Except for these holes the ground surface was quite smooth. A broad and smooth rise was faintly visible on the surface near E4930 N4840.

Measurements of the electrical conductivity of the soil indicate that it must be quite sandy. However, several pools of water (marked in [Figure 2](#) with blue triangles) remained after earlier rains; this indicates that surface soils could contain enough silt and clay to slow the infiltration of that water. While the radar antenna was lifted over these shallow pools, strong echoes from the water surface were still recorded. Bedrock is probably over 50 ft underground here. No rocks were visible at the surface.

An archaeological grid was set up at the site by the James River Institute for Archaeology. This grid was aligned with the house, and a reference point was defined at the outer southeastern corner of the foundation of the house; see [Figure 2](#). Grid north is a magnetic bearing of 14.0°. Nails at intervals of about 50 ft define the archaeological grid in the southern yard; orange plastic flagging on these nails lists the coordinates of those points.

## The geophysical survey

Buried utility lines appear to exit from the southern side of the house near its western side; since none could be traced to the south by this geophysical survey, perhaps they bend around and go to the north from the house. A drain pipe can be seen by a slight trench on the eastern side of the house. Its path is approximated by a line in [Figure 2](#). The western end of that line is at an iron drain cover; the eastern end is along the slight trench. This pipe surfaces farther to the east. There are no overhead utility wires in the area of survey; however, the anchor for a guy wire to a power pole was found at E5073.5 N5052.5 in the archaeological grid. No trash is visible in the yard, and objects that had been there, such as some picnic tables, were moved to aid this survey.

The surrounding land is rural; it is either wooded or devoted to farming, but it includes a scatter of houses. There are no industries, railroads, high voltage electric wires, or transmitting antennas in the vicinity. A local airport is about 3 miles to the west. While passing traffic on highway 58 can be heard, it caused no difficulty for this survey.

### The geophysical survey

This survey was done with a ground-penetrating radar, a model SIR System-7 that was manufactured by Geophysical Survey Systems. This is an analog-recording radar, and its images are displayed on paper as the radar antenna is pulled along each traverse.

An initial test was made with a moderate-resolution radar antenna; this is the larger antenna shown in [Figure 15](#). However, a higher-resolution and smaller antenna was found to define underground features with greater clarity, and this antenna was applied to the entire survey. The lines that were profiled are located in [Figure 7](#). Recorded traverses always went toward the east. They usually started at coordinate E4855 (tall grass and a scatter of bushes are found about 5 ft farther west) and ended where an obstruction was found on the east.

The traversing speed of the radar antennas was held constant with a metronome. With this speed fixed so that a 5-ft span was traversed in 9.1 s, the radar recorded a depth scan every 2 inches along each traverse (in the paper prints shown here).

The spacing between parallel lines of profile was initially 5 ft; this was reduced to 2.5 ft at the southern side of the yard in order to allow a better resolution of features that were revealed.

An example of a radar profile is included in [Figure 8](#). This shows the findings for line N4820, which extended from E4855 to E5070. This profile is an approximation of the stratigraphy of the soil along that line. The horizontal scale of this image is compressed by a factor of about 11 compared to the vertical scale; this compression causes slight slopes to appear steeper than they actually are.

The depth scale on this and the other profiles was estimated from a geometrical analysis of some radar echoes, and the results are shown in [Figure 16](#). The velocity of the radar pulse in the soil at this site was assumed to be 0.25 ft/ns; this is a quarter of the speed

of light in air.

While the radar was the primary geophysical instrument that was applied to this survey, two additional instruments were used for a reconnaissance of the area. A test was made with a Dunham and Morrow model DML2000 audio-indicating fluxgate magnetic locator. Surprisingly, this revealed no extra concentration of magnetic objects (iron or brick) at either of the two soil lenses (L1 and L2). There was clearly a greater density of iron objects in the soil near the house, as compared to farther south in the yard; this is the same finding that the radar had. The greatest indication of iron from this test was in feature C1 to the east of the house.

The soil was also tested with a Geonics model EM38 electromagnetic induction meter, shown in [Figure 15](#). This instrument revealed that the electrical conductivity of the soil was usually about 5 mS/m; this low value is typical of much of the coastal plain of the Atlantic states and it is excellent for a radar survey. The conductivity at the two soil lenses (L1 and L2) appeared to be about 1 mS/m lower than this background value; this could suggest that there is cleaner sand within those lenses. The conductivity of the soil distinctly increased in the southeastern corner of the yard, in the vicinity of the concrete slab; the readings there were about 10 mS/m. There are two possible causes for this: It is the lowest part of the yard, and perhaps the soil is siltier there; however, the barn may have been there also, and manure can increase the conductivity of the soil.

This geophysical survey was done over the period of November 21 - 23, 2011. Temperatures were warm each day; no jacket was needed. There was a slight amount of rain in the morning of November 22.

### **Findings of the geophysical survey**

The most important results of this radar survey are plotted in [Figure 3](#). This summary is derived from [Figure 4](#) by noting concentrations of similar radar echoes. Areas with few echoes may also be important, although [Figure 7](#) should be checked to be certain where radar profiles were made.

Two lenses of soil were located in the southern yard. These are identified as L1 and L2 in [Figure 3](#); they are colored red and the areas have diagonal hatching. The radar detected shallow V-shaped stratigraphy at both locations; an illustration is at the left third of [Figure 9](#). There appears to be a buried soil surface that is covered by differing soil, and this lens contains some debris (see, for example, the pattern in the left third of [Figure 10](#), or in the right third of [Figure 8](#)).

The western feature, L1, appears to be centered at a very slight rise in the surface; therefore, it is likely that the original ground surface has been elevated by fill soil. The eastern feature, L2, is on the side of a slight slope, and no rise of the surface is apparent there.

## Findings of the geophysical survey

Tests at these two features found no additional quantity of buried iron at either. It was anticipated that the soil might be more conductive at these locations; however, it appeared to be slightly less conductive. While it is still possible that one or the other of these two lenses might reveal the remains of a former hog pen, the conductivity and magnetic tests do not suggest this.

Several deep features or objects were detected between these two soil lenses; these objects are located just south of feature I5 in [Figure 3](#), and the radar profile of [Figure 8](#) shows two examples near the middle of the profile. These two objects appear to be about 3 ft or deeper underground; no larger concentrations of features with this depth were detected in other areas (minor concentrations were found near E4915 N4970 and E4985 N4945).

A listing of the locations and depths of these deep objects is given below:

Line N4825:	E4956 at 2.7 ft	E4960 at 3.8 ft
Line N4822.5:		E4964 at 2.3 ft
Line N4820:	E4948 at 3.4 ft	E4960 at 3.0 ft

It is possible that there are five separate objects in this group, one object at each echo. In principle, the echoes that were detected at E4960 could be caused by a single object, located at a depth of 2.3 ft at E4960 N4822. However, since there was no echo at E4960 on line N4822.5, it must be assumed that there are actually two objects at E4960, and not one.

The objects at these locations cannot be identified; they may be metal or simply refilled holes. While it is possible that some of these might result from holes that were created when trees were uprooted, the echoes appear to be too strong for that interpretation. The objects are all 2 ft in diameter or smaller.

While no other small groups of objects were found during this survey, many areas were defined by their dense concentrations of artifacts or debris. These areas are labeled C in [Figure 3](#), and they are marked with blue plus symbols. The most distinctive of these areas is 50 ft east of the house; [Figure 13](#) includes a typical radar profile. While sherds are too small to be detected by the radar, that radar will readily detect metallic objects (larger than about 4" in size); many other objects (such as a dense cluster of sherds) in the soil also cause echoes, simply a mixture of differing soils is enough to be detected. [Figure 3](#) shows six additional regions of debris in the southern yard; none is as distinctive or clear as that of feature C1, to the east of the house.

The radar survey also revealed areas where the stratigraphy of the soil was unusual; these areas are marked with green zig-zag lines in [Figure 3](#). While there may be some debris at these locations, they were detected primarily because there appears to be a mixture of contrasting soils at these locations. This can mean that there were once holes or excavations at these areas, and the depressions were later filled again. It is also possible that additional soil (perhaps containing some debris) was placed on top of an original soil surface at these locations.

## Conclusion

A few linear features could be traced. The clearest was line U1, going south from the house; see [Figure 3](#). The span of U1a was most distinct, and it is likely that U1b and U1c are continuations of this line. This must be a pipe or wire that goes to the former well. Short linear spans were mapped at U2 and U3, but these might be coincidental alignments of echoes.

While depths are not listed in [Figure 3](#) or [Figure 4](#), these estimates are included with [Figure 5](#) and [Figure 6](#). Most of the depths that were determined by the radar were between 0.7 and 1.7 ft underground.

There was little detection of the former well. This may be because of the moderately shallow depth of exploration of the radar antenna that was applied to this survey. This radar survey does not appear to have detected natural and geological strata; that is fortunate, for these somewhat deeper patterns can confuse the archaeological findings.

Excavation tests might be made at a sample of the features of the three types: Soil lens, dense debris, irregular strata. The middle of each anomalous area in [Figure 3](#) will probably find the most significant or distinctive difference; these features usually have tapered boundaries at their edges (that is, their boundaries cannot be defined precisely).

Additional findings from the echo map of [Figure 4](#) might also be tested by excavation, and excavations may also be placed where few or no features have been revealed by this survey, for some classes of features may remain invisible to the radar.

## Conclusion

While no rectangular shapes of buildings or cellars were found by this survey, there appears to be many pockets of archaeological remains in the southern yard, and a sheet of debris in the eastern yard. The images from the radar suggest that this was a good site to have applied this technique.





Figure 1: Aspen Lawn. The historical house, with its red roof, is near the middle of this photo. Hicksford Road is at the upper (northern) side of this image. This aerial image from Google Earth was acquired during the winter, on 1 February 2007. There may be some changes since that date, and it appears that the southern shed was not constructed when this photograph was taken. The adjacent fields had crops of cotton that were being harvested at the time of this geophysical survey in November 2011. This image was kindly supplied by Nicholas Lucchetti.

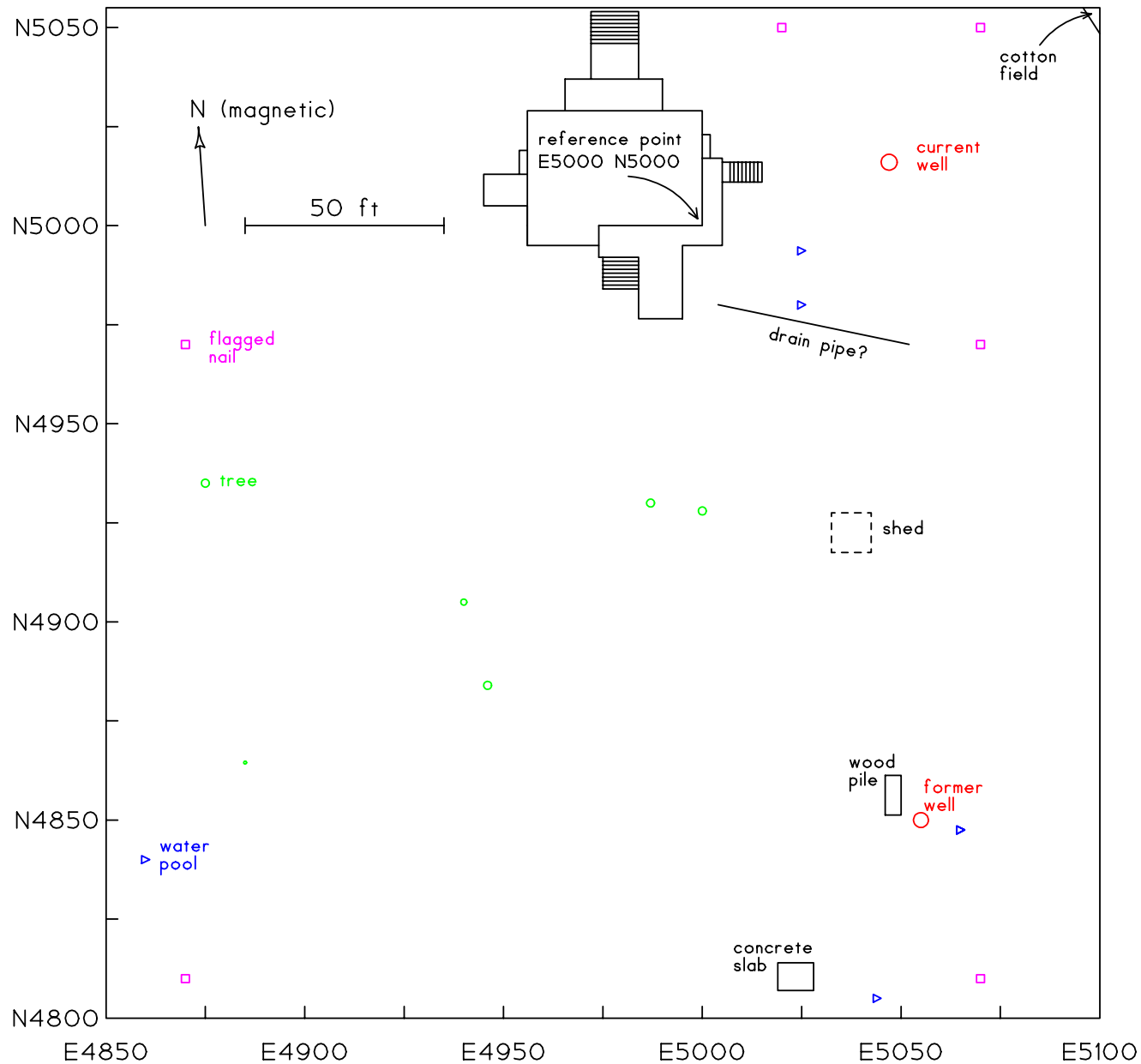


Figure 2: The area of survey. The southern and eastern yard near this house were profiled with a ground-penetrating radar. Features that are known or visible at the surface are located here with a moderate accuracy. Six of the largest trees are included in this map; at least ten additional trees are in the survey area. Small squares mark the nails of the coordinate system; flags on these nails list the coordinate at these points. Additional coordinate nails are in the area.



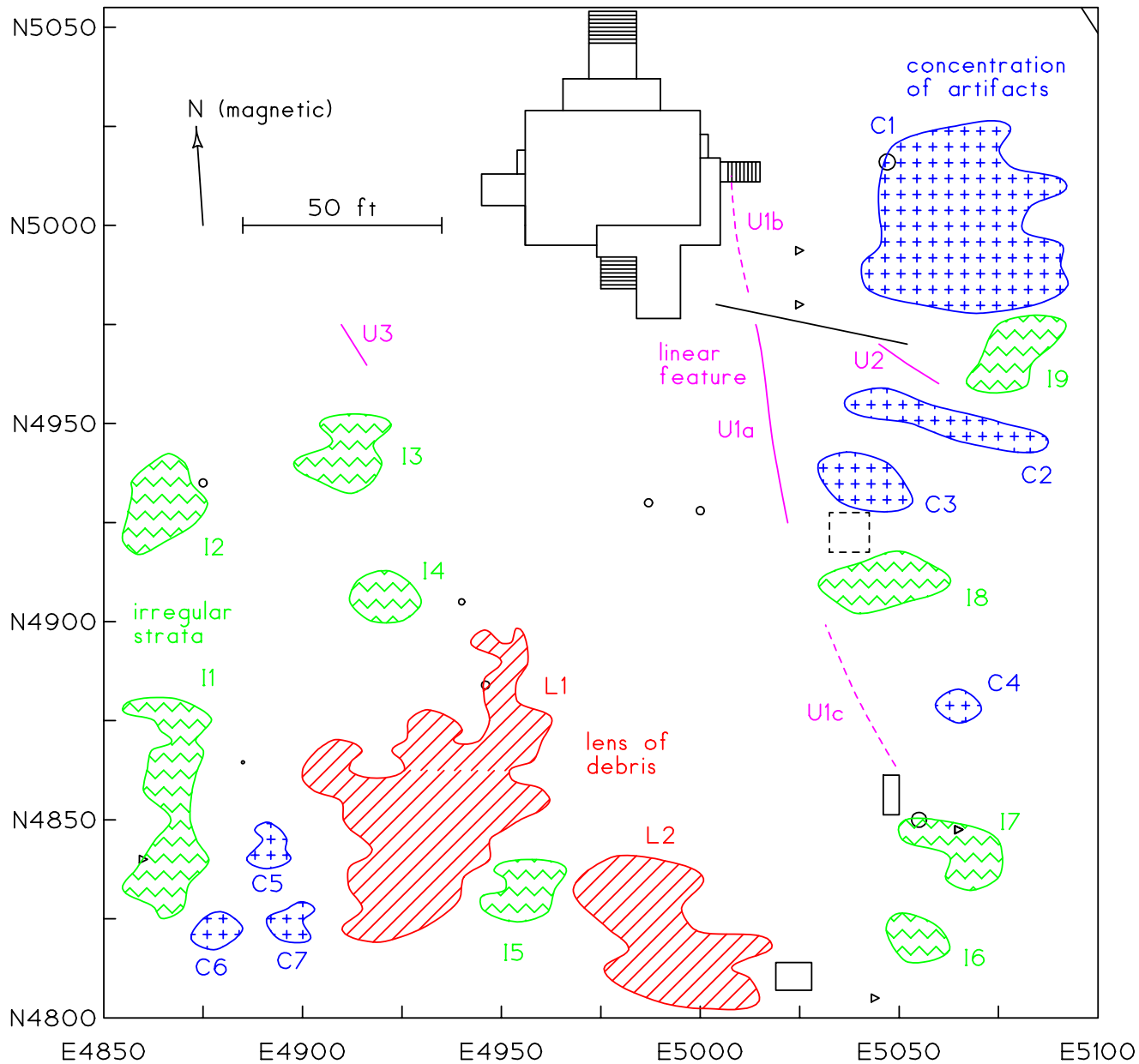


Figure 3: The findings of the survey. Colors and their patterns distinguish four different types of features that were revealed. The red areas locate two lenses of debris. The blue areas show where objects and artifacts are very dense in the soil. Green areas indicate where the soil strata were unusual; prior excavations and fill are likely there. The purple lines may indicate buried pipes or wires, or other linear features.

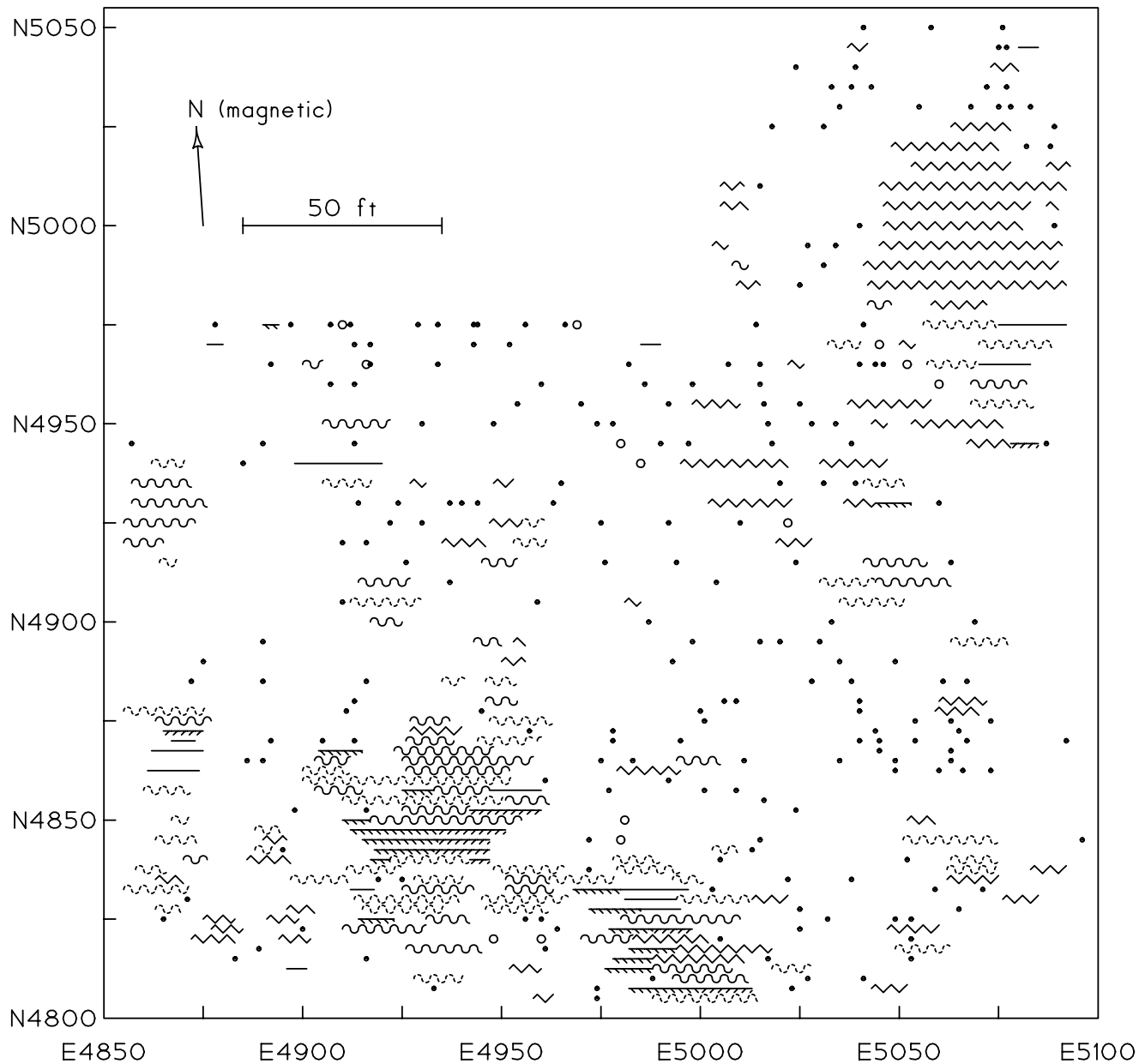


Figure 4: The radar echoes. This figure has been the source for the interpretation in [Figure 3](#). The symbols characterize similar echoes and allow clusters to be noted; a key to the classification is given in [Figure 14](#). Zig-zag lines locate where many objects were detected in the soil; these objects were too dense to show here individually; objects that can be isolated are marked with circular symbols. A total of about 433 echoes are plotted in this figure.

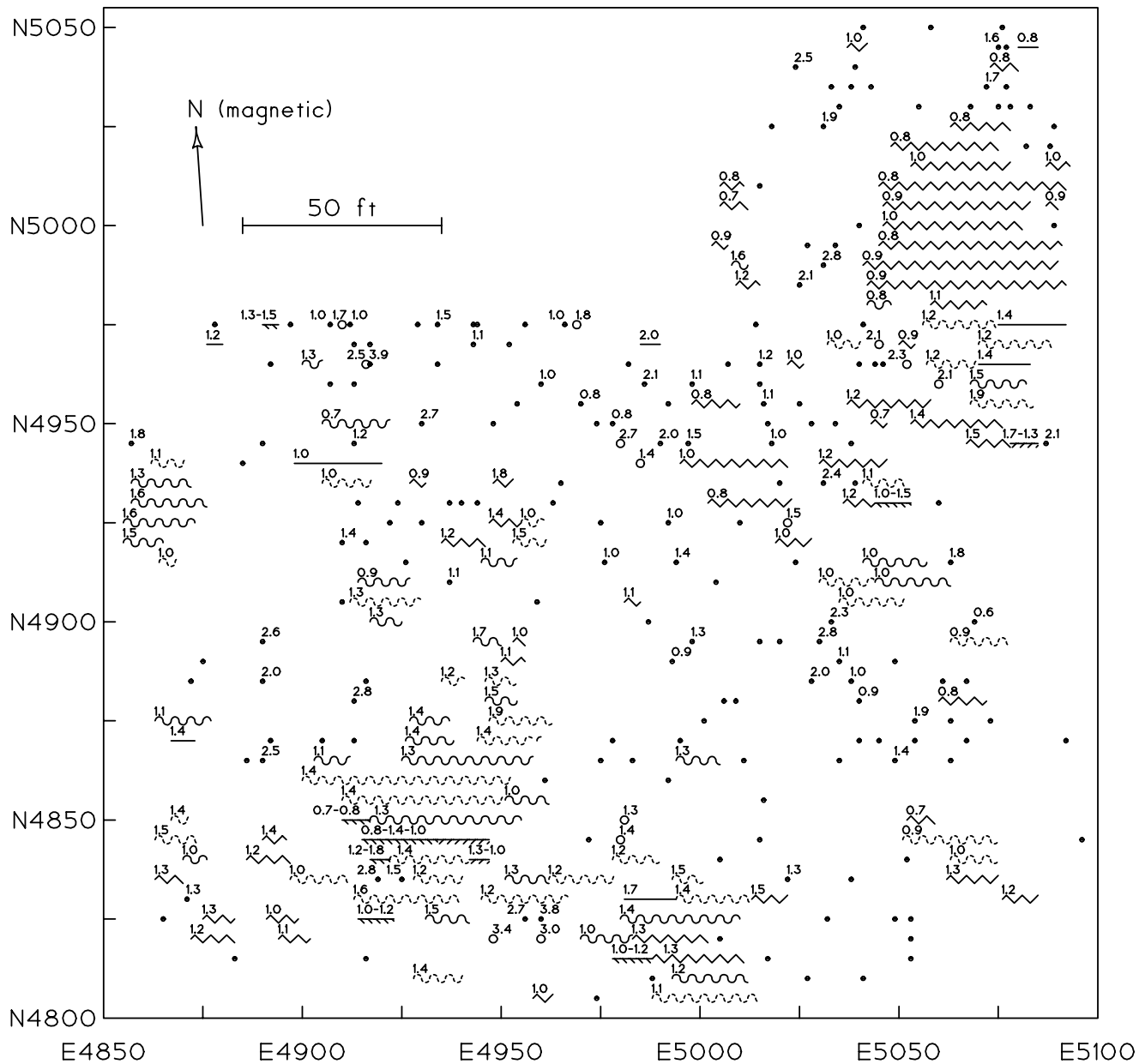


Figure 5: Radar echoes and depths. The numbers next to the symbols list the estimated depth of the features that were detected; these depths are in feet, and they assume that the velocity of the radar pulse was 0.25 ft/ns. These depths are more likely an overestimate of the actual depth than an underestimate. Only the radar profiles that were made on lines whose coordinates were a multiple of 5 ft are listed here; see [Figure 6](#) for the rest.

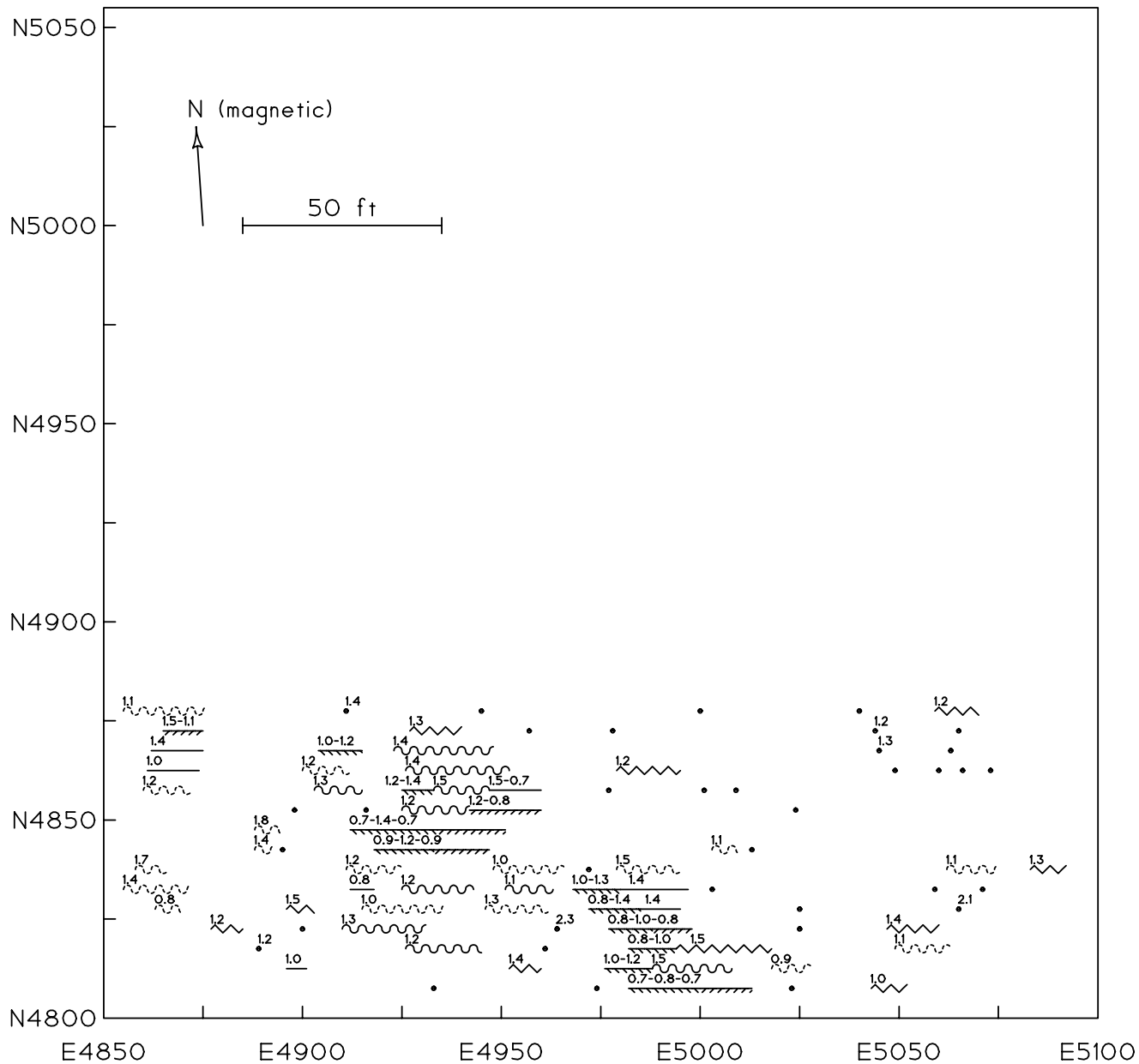


Figure 6: Additional radar echoes and depths. In the southern end of the yard, further radar profiles were made between the original set, which were spaced by 5 ft. These additional profiles were interdigitated between those original profiles, and the resultant spacing was 2.5 ft between profiles in this part of the yard. This closer spacing allowed a more reliable definition of the complex clusters of radar echoes that were found here.

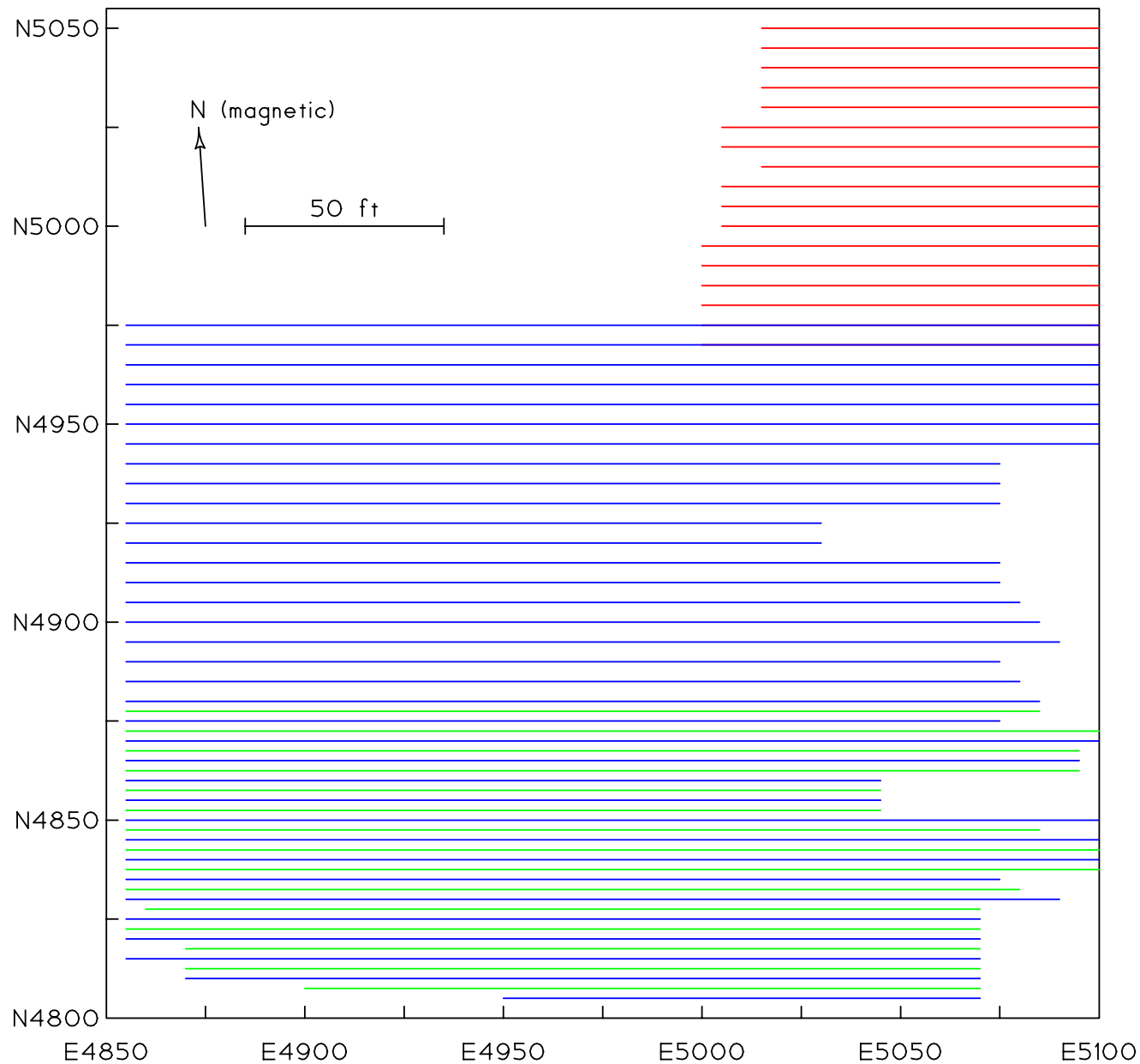


Figure 7: The 65 lines of radar profile. Their total length is 9355 ft. Blue lines mark the first profiles, which began near the house. The profile lines that are shown as green were next added for a better definition of the southern end of the yard. Finally, the red profiles were made for an exploration of the eastern yard, in an area where potsherds have been found. Almost the entire available area of the southern and eastern yards was explored.



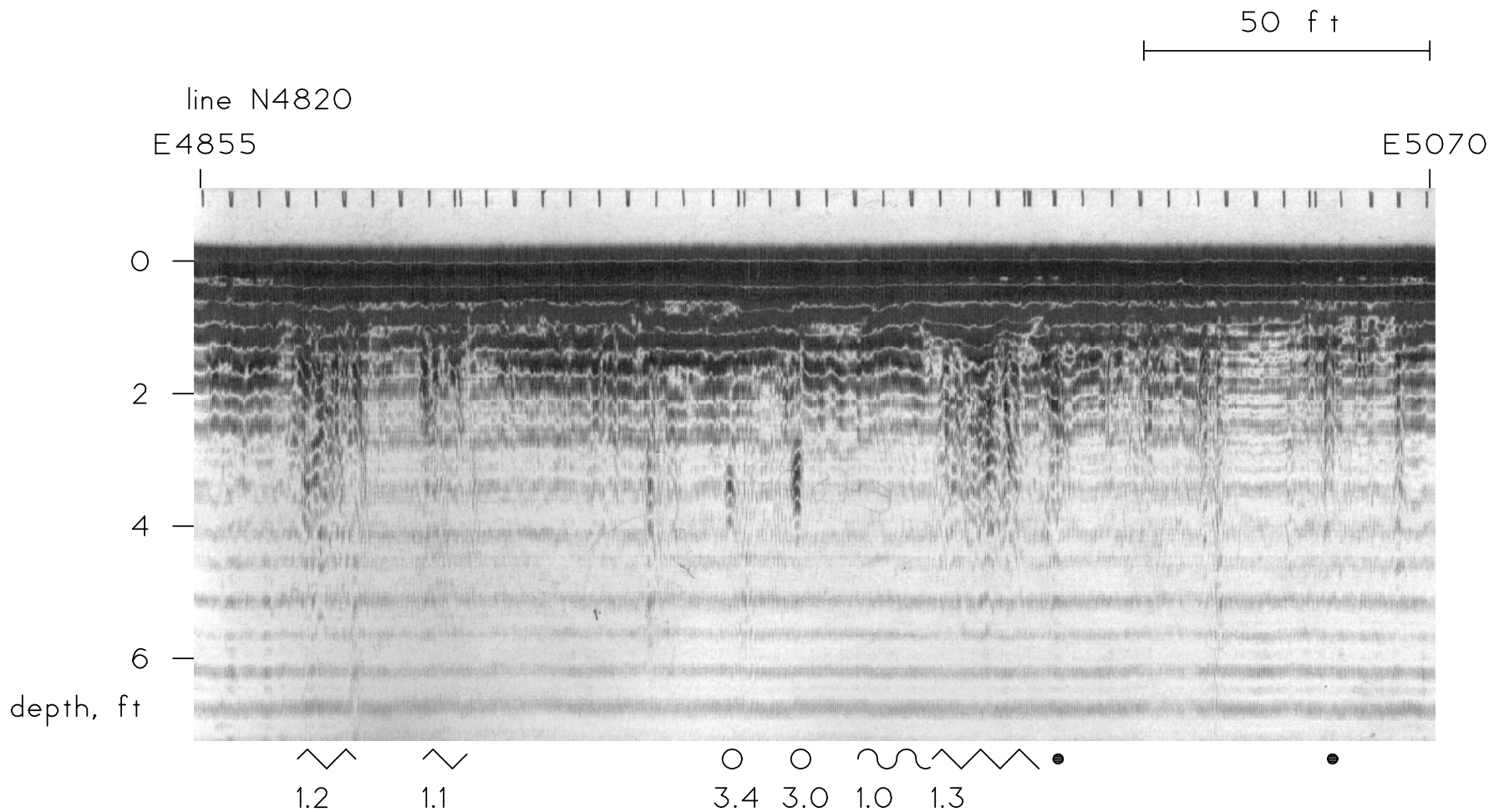


Figure 8: A radar profile. This shows the entire span of line N4820, which is near the southern end of the yard. The zig-zag pattern near the middle of this profile locates echoes from feature L2, a lens of debris-containing soil. Just to the left of that pattern, there is a pair of objects at depths of 3 and 3.4 ft; no other features were found deeper at this site. The two small zig-zag patterns on the left side of the profile reveal areas of complex echoes called C8 and C7 in [Figure 3](#). Tick marks at the top of this and the following profiles are at intervals of 5 ft; closely-spaced pairs of ticks indicate 50-ft multiples along each line. The following five examples of radar profiles progress toward the north.

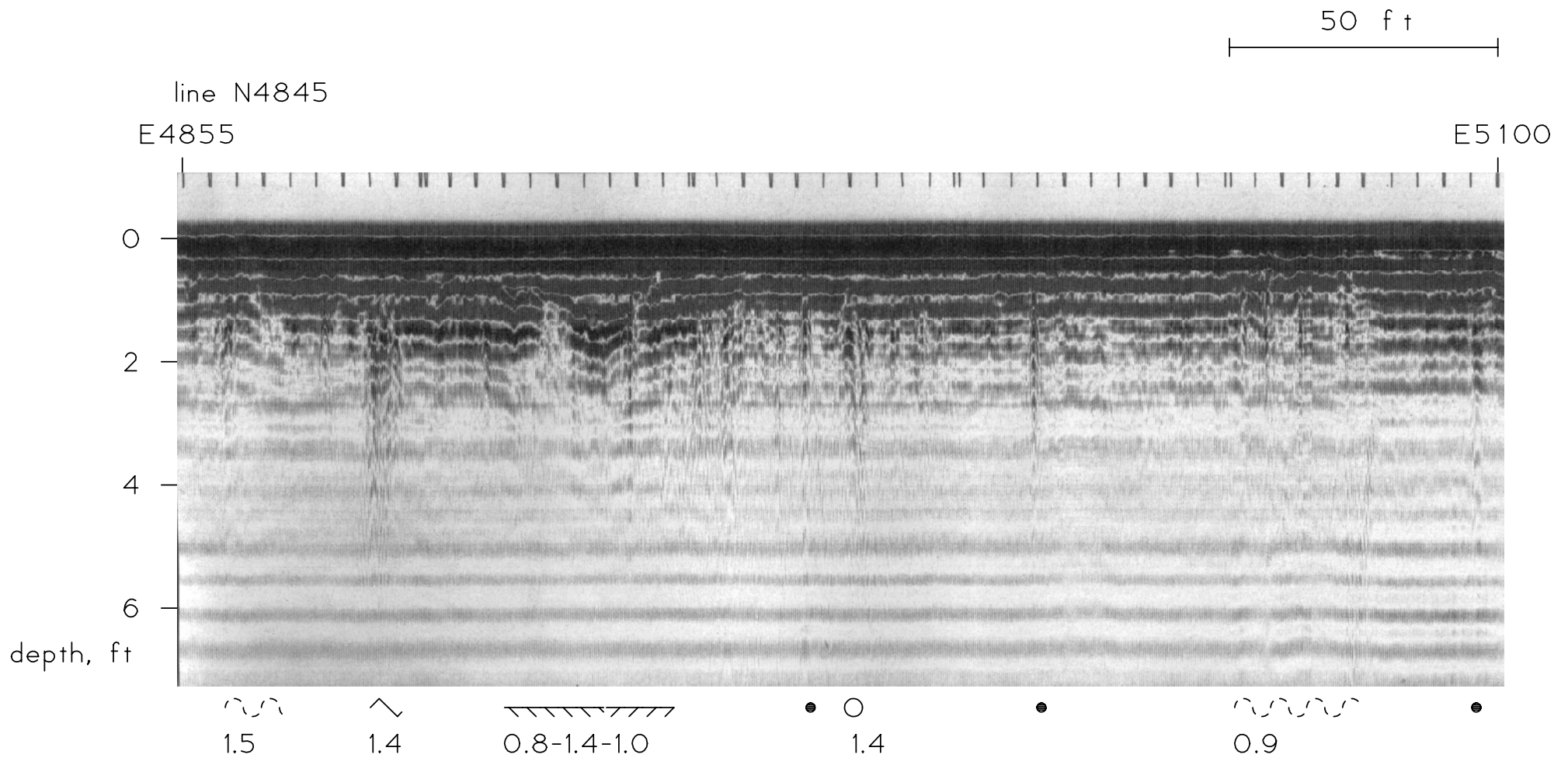


Figure 9: A radar profile of a soil lens. This is line N4845 and it reveals the soil lens called L1 near E4930, in the left third of this image. The radar profile shows a soil interface that dips underground and then rises; this is summarized by the symbol for the echo that is drawn below the profile. Note that slopes are exaggerated in this image. The radar echoes to the left of this major echo are from feature I1 (irregular soil, located with a broken, undulating curve and a depth of 1.5 ft) and C5 (a complex area, with a zig-zag symbol below the profile). The pattern that is marked on the right, near E5050 (with a broken undulating line), is found near where a prior well, now filled, is located.

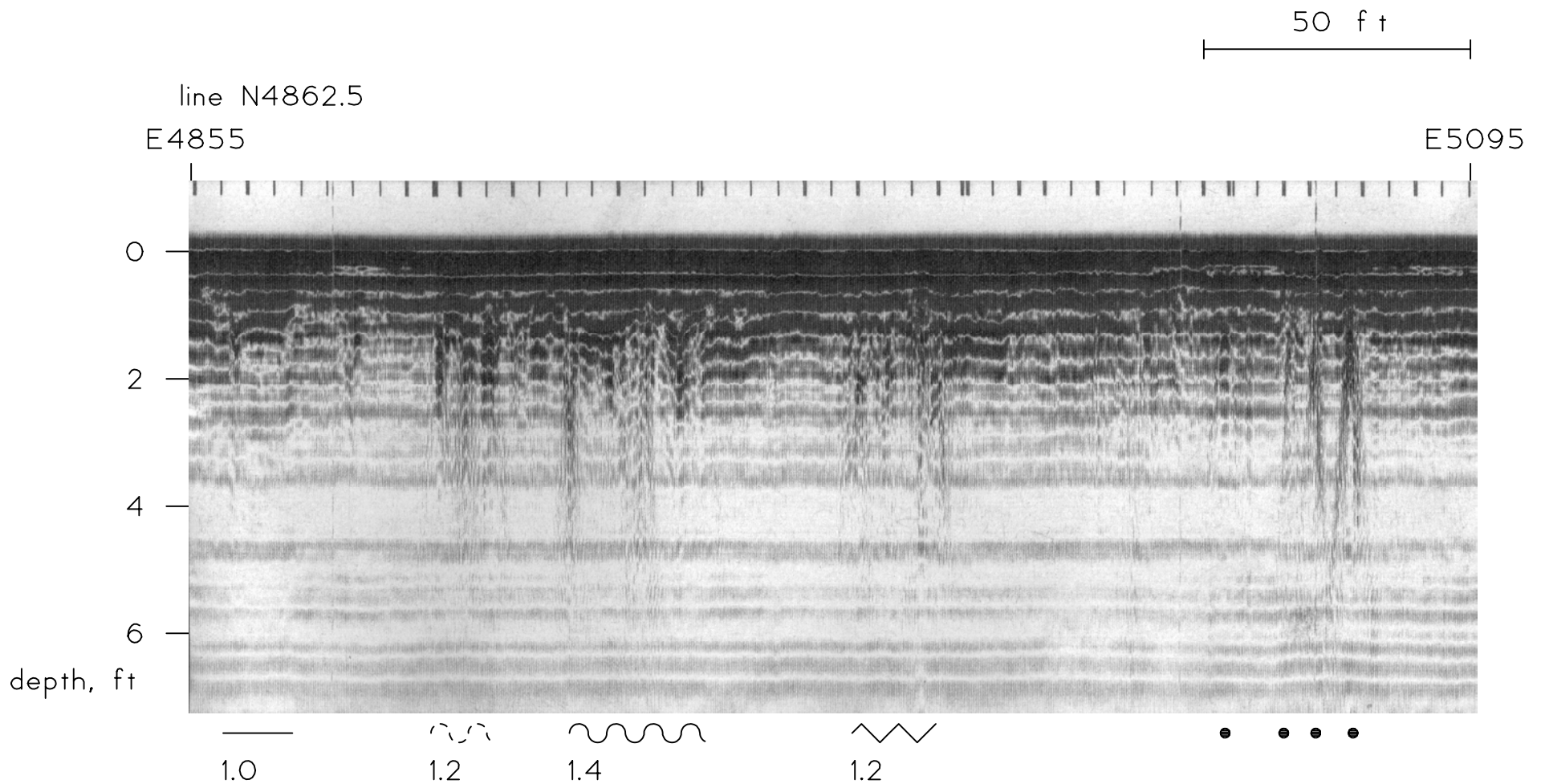


Figure 10: An interdigitated radar profile. This is line N4862.5; it was added midway between lines N4860 and N4865. The undulating curve below the profile (with an indicated depth of 1.4 ft) reveals the northern side of lens feature L1. The irregular strata of feature I1 are indicated with a straight line below the profile on the left. Several isolated objects on the right are marked with circular symbols, without a listing of depths. The arc-shaped patterns of these echoes are distinct, and these are probably metallic artifacts; the echo on the left side of these four may be a pipe or wire to the former well.

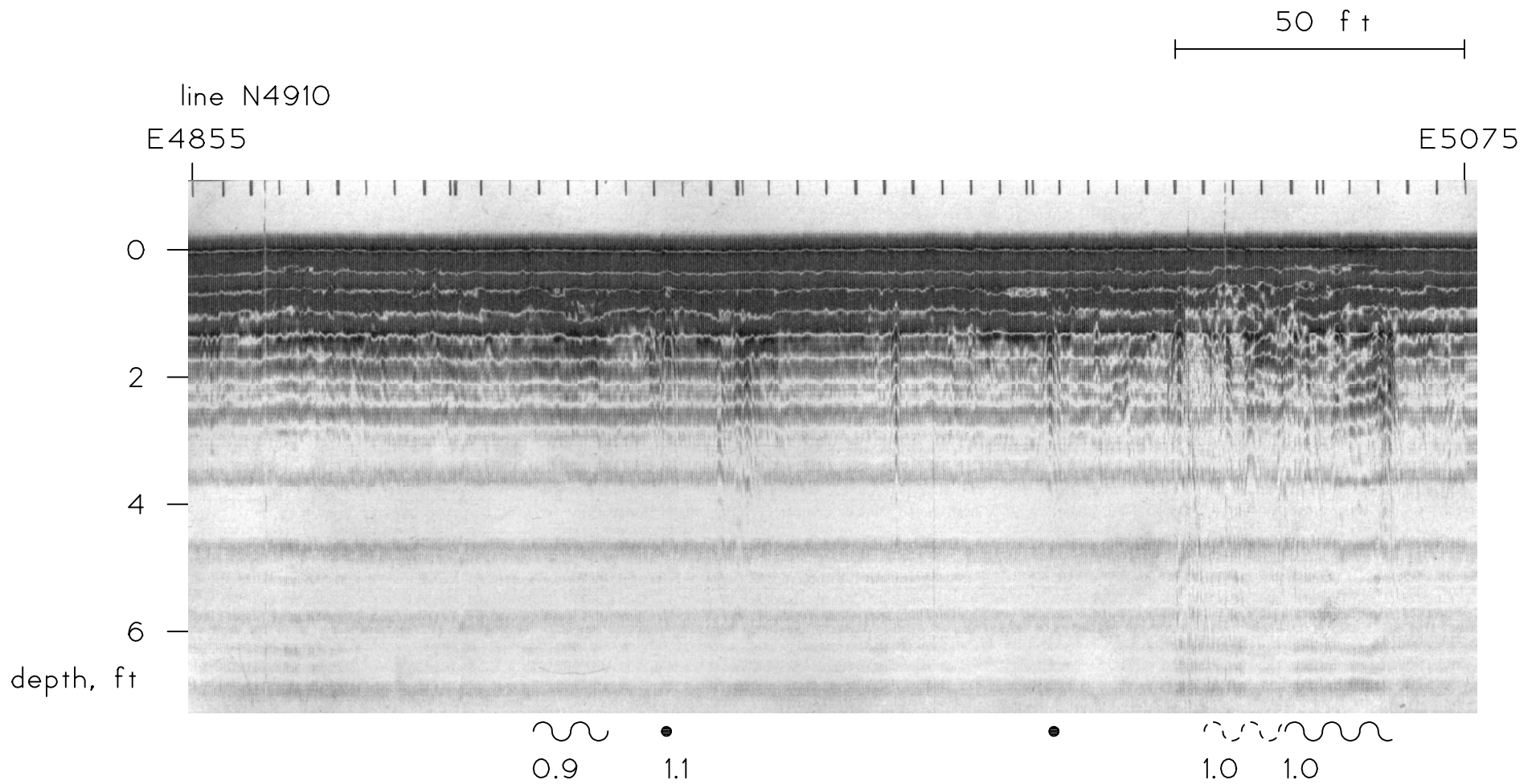


Figure 11: A radar profile of line N4910. The echo that is marked below the profile with an undulating line (feature I4) near E4925 and with a depth of 0.9 ft is west of a tree with a trunk diameter of 1.5 ft which is located near E4940 N4904; however, the roots of that tree do not appear to be the source of these echoes. The undulating curves on the right show the echo pattern at I8, which has irregular stratigraphy at a depth of about 1 ft; this feature is just south of the shed. The depth scale on this and the other profiles assumes that the velocity of the radar wave in the soil is 0.25 ft/ns.

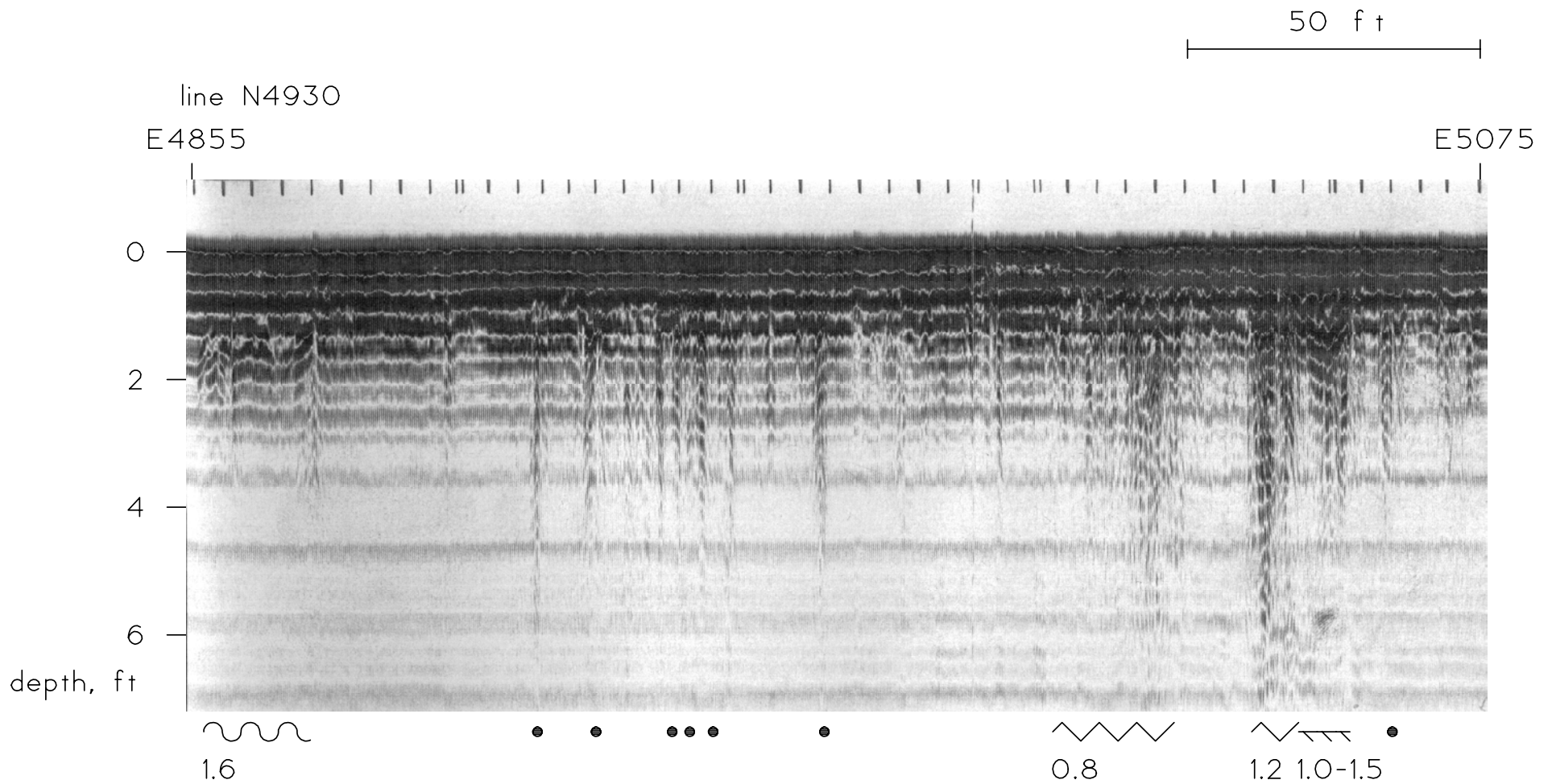


Figure 12: A number of small objects on line N4930. These echoes are marked with circular symbols below the middle of the profile. While these objects are very shallow (probably less than 1 ft underground), their depths cannot be estimated better, and so no depths are listed here. The irregular strata of feature I2 is marked with an undulating curve on the left. The echoes that are marked on the right (near E5050) are from feature C3, which is just north of the shed. There is a strong reverberation of the radar signal there, and this causes the feature to appear to extend to a large depth; the maximum depth of the feature is probably less than 2 ft.



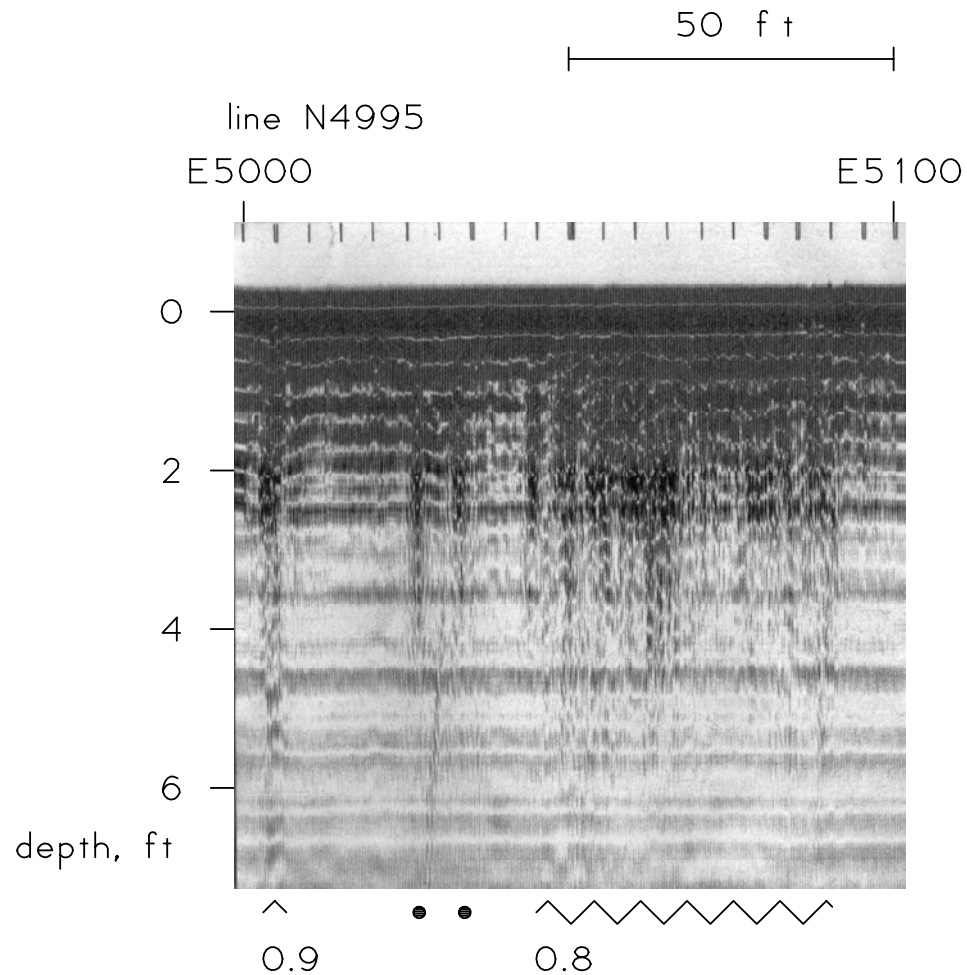


Figure 13: Debris east of the house. This is line N4995, and the eastern half of the profile is dense with underground debris. Individual objects cannot be isolated in the complex echoes that are found here. The objects that have been detected here are primarily metallic; each object is probably at least six inches long. This profile crosses the middle of the area of complex echoes that is called C1, and it is reasonably a lens of material that was discarded on the slope east of the house. The complex feature on the left is near the line of a possible pipe to the old well.

## The different radar echoes and their symbols


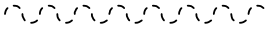

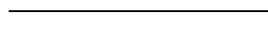
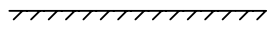
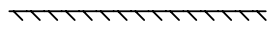




	irregular strata
	faint irregular strata
	fine-scale complexity
	planar reflector
	strata rising
	dipping strata
	very distinct echo
	distinct echo
	weak echo
	reverberating echo, metal

Figure 14: Symbols that classify the radar echoes. A zig-zag line is used to mark where many small echoes cluster to form a complex pattern; this pattern is usually caused by buried debris. The other extended symbols typically locate soil interfaces; these may be caused by fill soil, perhaps over former excavated surfaces. The circular symbols at the bottom locate echoes whose relatively-small source can be isolated. While many of these objects cause a reverberating echo, no reverberations have been marked here, for this distinction does not appear to be important.

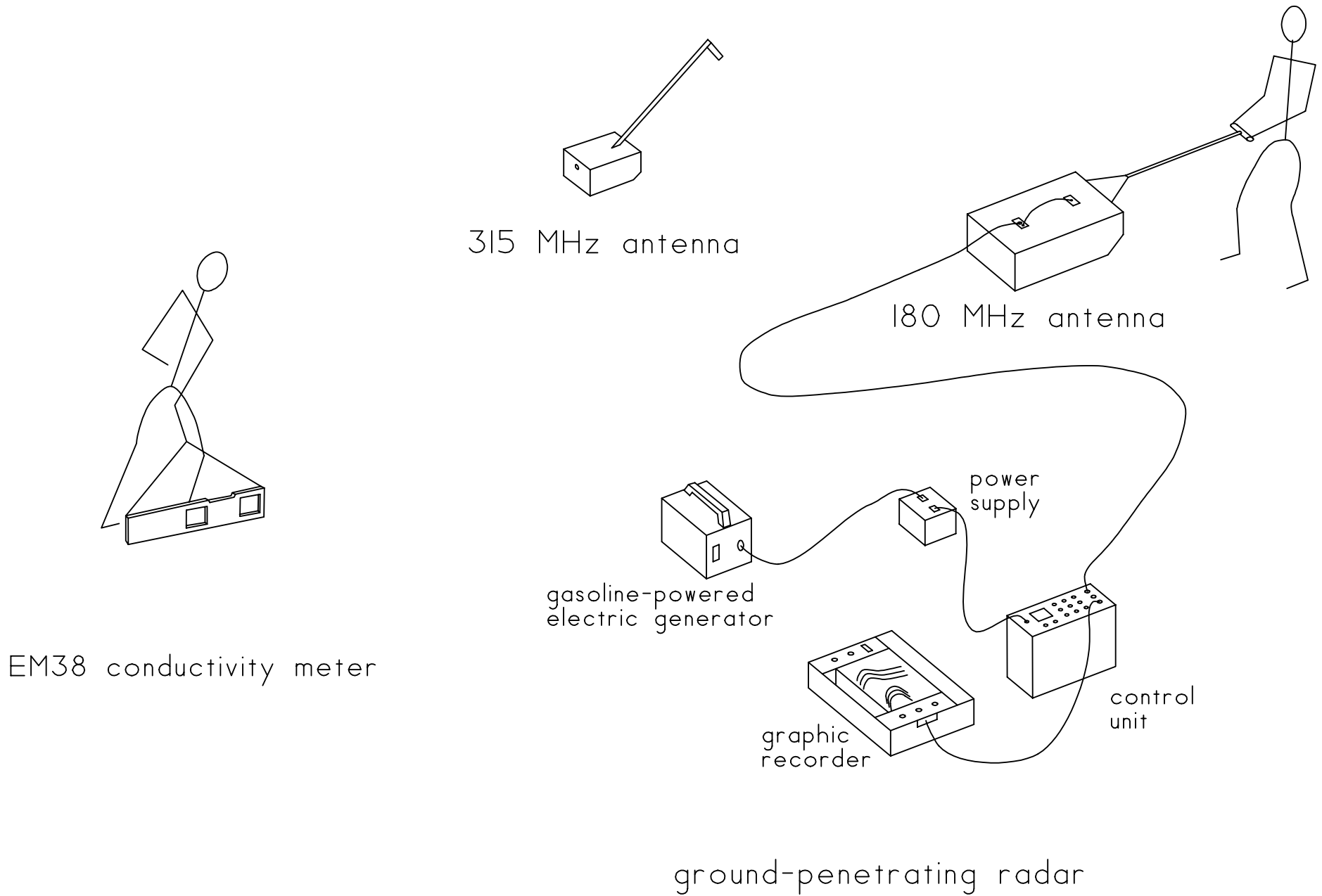


Figure 15: The geophysical equipment. The major survey was done with a ground-penetrating radar. A high resolution antenna (with a predominant frequency of 315 MHz) was found to give results that were superior to those of a larger antenna with a predominant frequency of 180 MHz. The conductivity meter was applied to a quick test of the soil here.

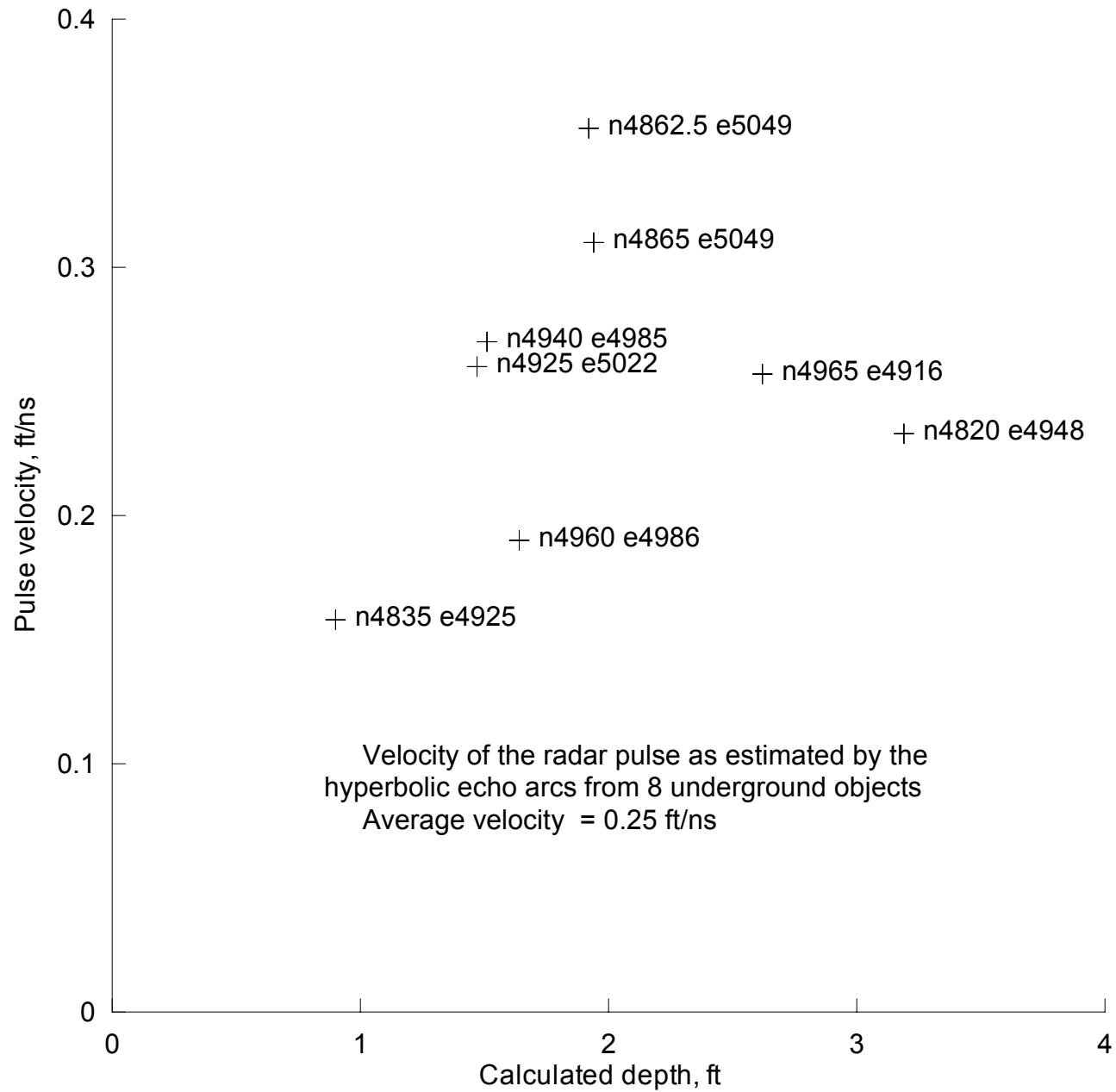


Figure 16: Estimates of the velocity of the radar pulse. While this velocity could not be determined with a high accuracy, it appears that accuracy is not very important, for most of the features that were revealed were quite shallow at this site. The locations of the echoes where the calculations were made are listed with the symbol at each estimate.