REPORT
GEOPHYSICAL INVESTIGATION
BEACHWOOD HISTORICAL CEMETERY
BEACHWOOD, OHIO

prepared for

City of Beachwood, Ohio
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by

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1 INTRODUCTION

This report presents the results of a geophysical investigation conducted at the Beachwood Cemetery in Beachwood, Ohio (Figure 1) as a service undertaken on behalf of the City of Beachwood and also as a service to the Beachwood Historical Society. The cemetery is situated northwest of the intersection of South Green Road and Halburton Road and also adjacent to the Canterbury Golf Club.

The objective of the investigation was to identify graves within the cemetery on the basis of geophysical measurements. Although the cemetery is well cared for, records have been lost and some tombstones have fallen over or may have been moved. Some graves are in danger of falling over where there is an embankment on the northern side of the cemetery. A comparison of an old (1930s?) map of the cemetery with the current configuration of roads (Figure 2) suggests that the plots in the northwest corner of the cemetery are actually past the edge of the ravine. In summary, there is considerable uncertainty as to the actual extent of the cemetery and whether or not there are burials that do not have associated tombstones. Accordingly, the mapping of burials requires a means to detect them where there is no evidence at the surface.

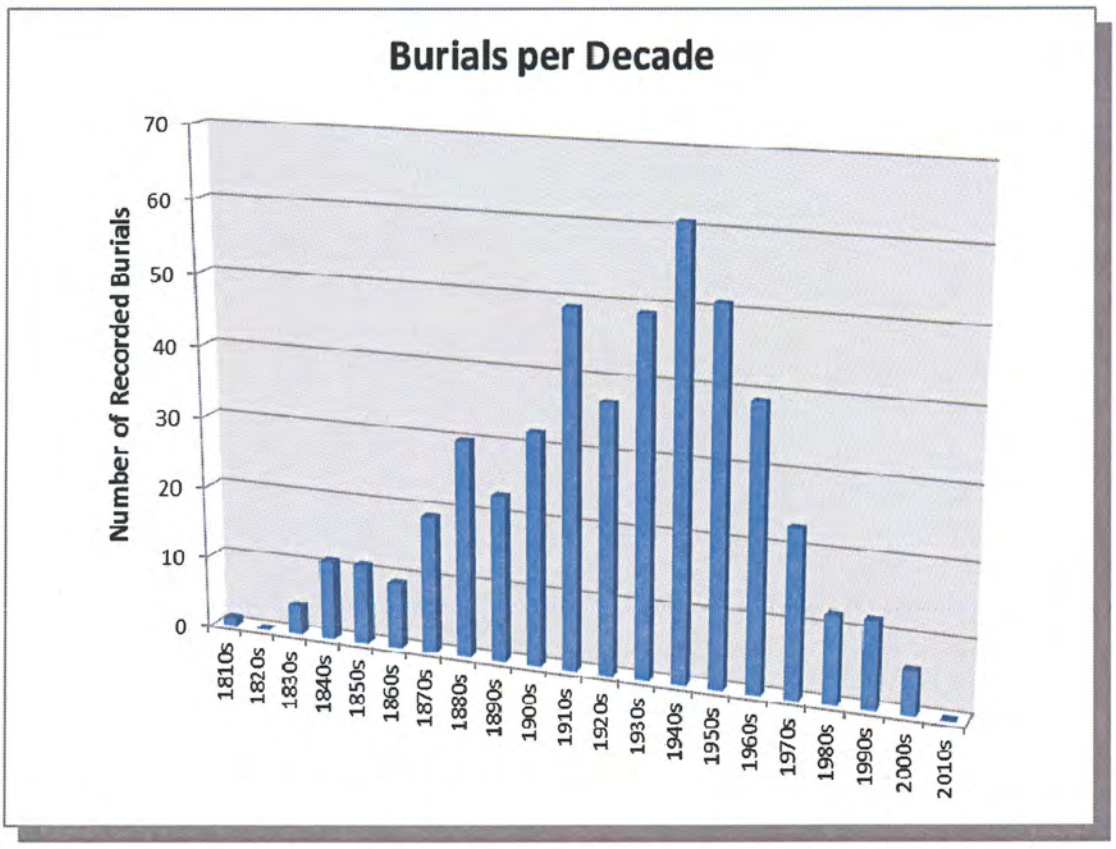
The survey was conducted by means of ground penetrating radar (GPR) on three days over by means of eight individual survey blocks shown in detail on Figure 1. The survey was initiated on October 5 and 6, 2013, but inclement weather prevented completion of the survey at that time. The remainder of the survey was undertaken on October 19. Special mention is due to Nancy Hart and Jared Hyams who assisted with the survey and provided background information of the history of the cemetery.

The results of the survey are shown on the basis of a field grid that is georeferenced to aerial imagery obtained from Google Earth taken April 6, 2012. The grid in the field can be located on the basis that the N – S direction is defined as the eastern edge of the cemetery access road that enters from Halburton Road. The intersection of the eastern edge of the access road with the northern edge of the sidewalk along Halburton Road is considered as 0 feet East – 0 feet North (0E – 0N) on the site grid. The north direction is not true north, but an arbitrary north used to establish the survey grid, although there is little difference. The survey grid was laid out by extending a baseline perpendicular to the 0E line (the N-S baseline) at the position of 190 feet North.

2 HISTORICAL BACKGROUND

Beachwood Cemetery in Beachwood, Ohio is a site with a rich history, extending back to the early 19th century. The early history of Beachwood dates back to the establishment of the state of Ohio. One of the original townships was Warrensville Township which lost land over the course of a century to seven cities and villages, including Beachwood.

Early state legislation permitted incorporation of villages with a minimum of 30 inhabitants. In 1915 Beachwood Village, with a population of 151, seceded from Warrensville Township following a decision by the Township to close a local school. The City of Beachwood was born. Beachwood received its name from the Beech trees that once covered the majority of the City.



Beachwood Cemetery, formerly known as the Warrensville East Cemetery, is owned by the city. The cemetery is historically significant because several groups of individuals are buried there including veterans of numerous wars starting with the Revolutionary War.

Records vary on when the cemetery was first created. According to Dorothy A. Loeby in her 1962 thesis for Western Reserve University Beachwood, Ohio – Past and Present, a tombstone in Warrensville East Cemetery was marked "1813 – Cooper – 14 days." In 1857, John Proper sold Henry Corlett 80 acres of land in Warrensville where " three fourths of an acre (was) deeded and occupied as a burying ground." For many years "Proper's Cemetery" is listed on death certificates and in death notices as the place of burial. Additional land was added in 1876 and 1899.

Cemetery records, although probably incomplete, show a pattern of burials beginning with the first known burial in 1813 and increasing in number of burials per decade to a peak in the 1940s (see insert above). Since that time the rate of burials has decreased to the point that the cemetery is effectively no longer being used. Part of the reason for this lack of use relates to the uncertainty in knowing whether or not a location has been previously occupied. The total number of known recorded burials in the Beachwood Cemetery is 567. Many of these are not expected to be associated with coffins or vaults, as records indicate that cremated remains were interred. There are also many infant burials that may or may not have been associated with significant underground containment.

The use of burial vaults whereby a coffin is placed in a concrete or brick box was occasionally followed in the 19th and early 20th century, but the use of vaults did not become commonplace until about the 1930s. Today the use of a concrete vault is standard practice. 253 graves have been documented that are 1930 or more recent in the Beachwood Cemetery. An air-filled concrete vault is a good target for ground penetrating radar, whereas coffins not contained in a vault can decay to the point where they are difficult to detect. Accordingly, based on the history of burials in the Beachwood Cemetery, it was expected that the GPR signal would range from obvious to subtle, depending on the age of the burial and whether or not a vault was used.

3 GROUND PENETRATING RADAR

Ground penetrating radar (GPR) has evolved over the past two decades into one of the most commonly applied techniques for imaging the shallow subsurface. The method offers the highest resolution of geophysical techniques commercially available today. In many cases, the time required for the acquisition of GPR profiles is minimal and subsurface profiles can normally be obtained in real time, making this tool very cost-effective. GPR works best in non-conductive soils, such as dry sand or sand saturated with fresh water.

Surveying with X3M system at Beachwood Cemetery

The typical result of a GPR survey is a profile that presents radar wave amplitude as a function of distance along the line and two-way travel time. To know the depth to a reflector, it is necessary to know the average propagation velocity from the ground surface. The velocity of a radar pulse in an earth material is dependent on the relative dielectric constant (er) of the material according to the following relationship:

$$V = c/(er)^{1/2}$$

where:

V = velocity in a propagating material

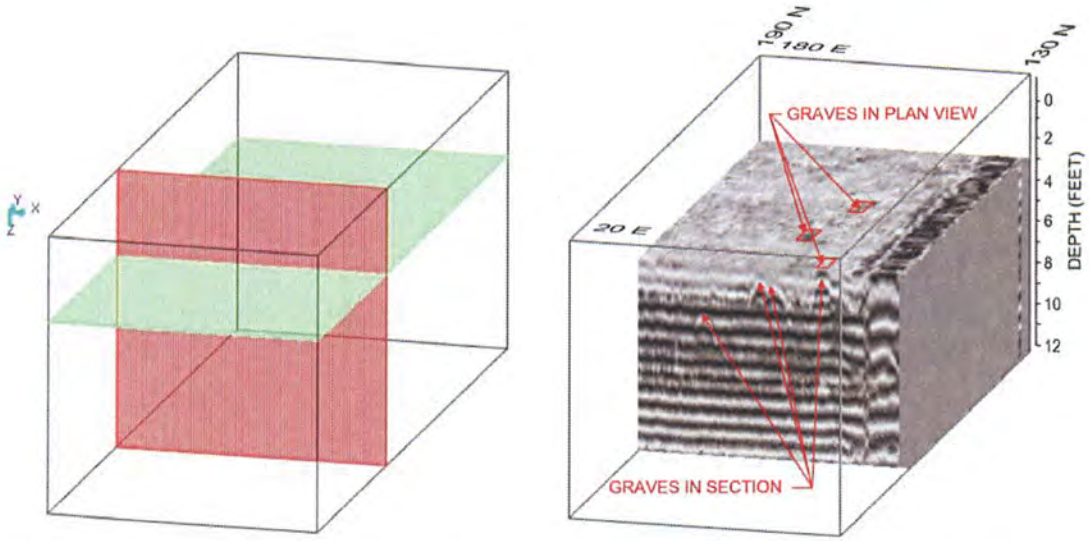
c = speed of light (3×10^8 m/sec)

This velocity can sometimes be estimated from knowing the characteristics of the subsurface lithology. An average velocity of 0.1 meters/nanosecond is a typical velocity and this is the velocity calculated from the data gathered.

Another factor affecting the depth of penetration of the radar signal is attenuation. Attenuation is caused by spreading and scattering losses, as well as electrical losses. Scattering and electrical losses are due primarily to the electrical conductivity of the subsurface materials, which in soils is due mainly to clay and moisture content. The soil conditions within the area covered by this investigation were variable although not enough to

affect the depth of investigation across the site. The GPR method was able to investigate to a depth up to about 6 feet, and in some places more, over this site.

A MALÅ Geoscience X3M radar system was used for this investigation. The antenna was a shielded 250 MHZ antenna. The data were acquired along profiles separated by two to three feet. In total, the length of survey line was close to 8,000 feet. The data were processed such that interpretation could be made on the basis of visualizing the data both in terms of individual GPR profiles, as well as three-dimensional blocks. Data viewed as a horizontal surface depict the variations of the amplitude of reflected radar waves corresponding to a specific reflection time and are referred to as time slices. Each time slice corresponds to a specific depth in the soil.

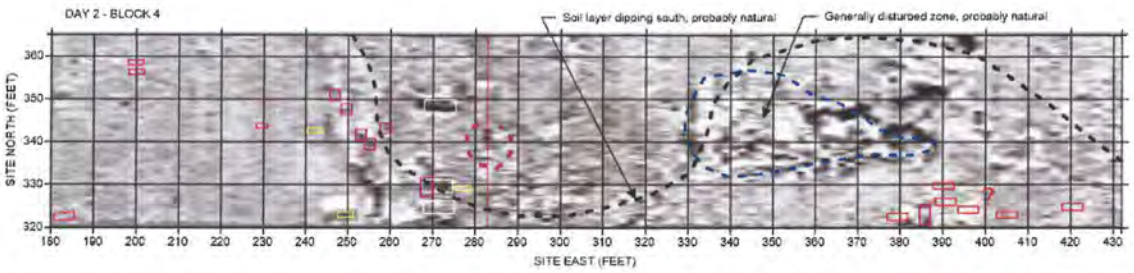


Example 3D block (Block 1) from Beachwood Cemetery Survey – time slice from depth of about three feet. Graves are identified by their hyperbolic reflections in cross section and the size and orientation of the grave is identified in plan view by looking at horizontal slices that intersect the grave reflections.

4 INTERPRETATION

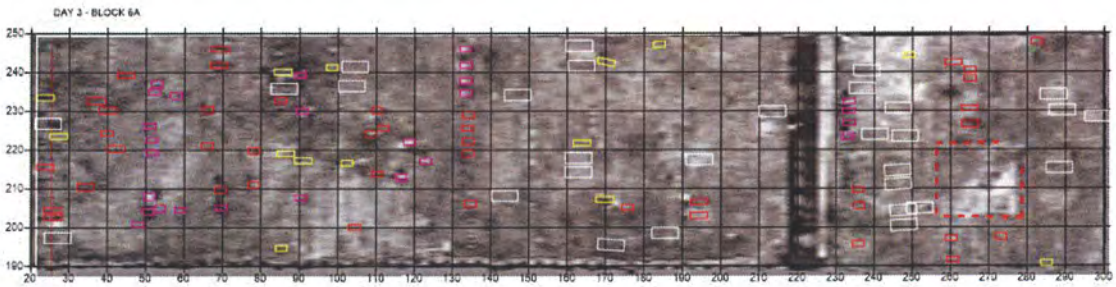
Results of the survey are depicted in terms of the individual survey blocks on Figures 3 through 6. The overall results for the cemetery are plotted on Chart 1. Results are depicted in terms of category of the GPR response. The highest quality GPR reflections are interpreted as well-defined burials, probably vaults or intact coffins. Some strong reflections near (less than about two feet from the surface) are interpreted to most likely to be burials based on their shape in plan view and constitute a separate category. Similar reflections, but buried deeper than about two feet, are also designated as a separate category. An additional category represents GPR reflections that are at or near the surface. In some cases these surficial reflections represent where the GPR antennas crossed over the top of a tombstone lying flat on the ground surface, but in other cases may represent tombstones that are not visible at the surface. Some may represent burials such as the placement of shallow urns containing ash.

The interpretation of geophysical data is based on the recognition of patterns in the distribution of anomalies when plotted in a plan view or other appropriate map. The patterns are due to variations in the physical properties of the ground that result from natural conditions (geology and stratigraphy) and from cultural activities (historic and prehistoric). It is sometimes difficult to determine which of the observed variations are natural and which are not. Nevertheless, the identification of graves was relatively straightforward, as soil conditions within the cemetery appear to be relatively uniform. An exception to this finding is in the northern part of Block 4 (Figure 4) where there is soil disturbance that follows a sinuous line that follows a soil horizon dipping to the south. Subsurface information would be required for a final interpretation, but this feature appears to be natural, possibly a buried stream channel (see inset below).



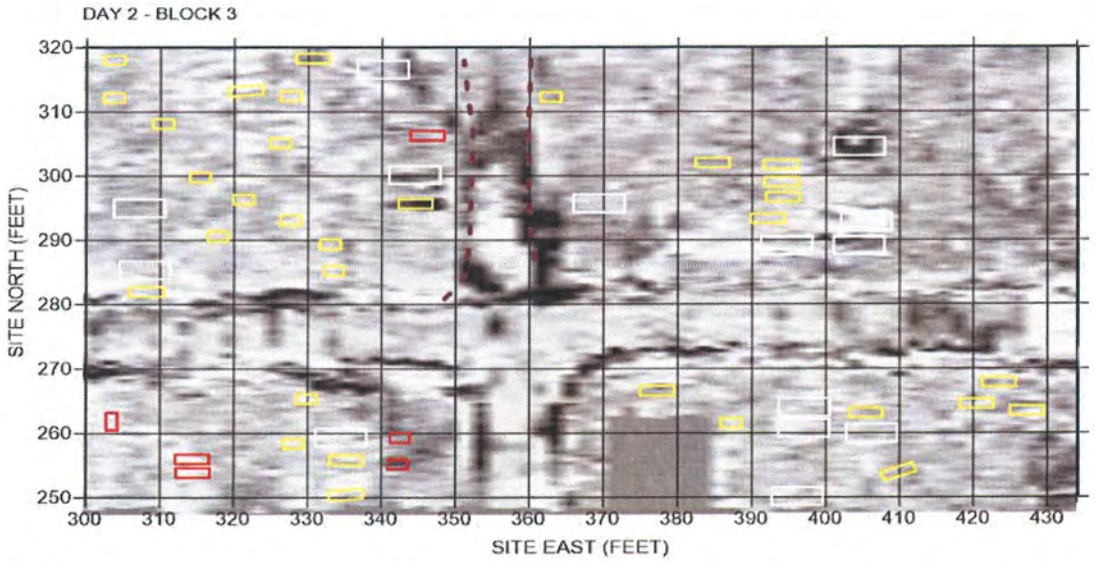
Amplitude of radar reflections from a depth of about five feet in Block 4 – the pattern does not appear to relate to burials, but most likely to natural soil variations.

Linear patterns were observed at a variety of different depths from the time slices. Some linear features from depths less than about two feet are shown on Figure 3 from Block 1, but the best linear feature is a rectangular anomaly from a depth of about one to two feet from Block 6A on Figure 6. The shape of the rectangle corresponds closely to the outline of one of the Corlett family plots shown on Figure 2 and may represent stones, posts or some other buried marker placed to define the plot.



Amplitude of radar reflections from a depth of about 1.5 feet in Block 6A – the rectangular pattern centered at about 270E – 210 N appears to relate to a Corlett family plot.

The paved roads are easily recognizable on the basis of reverberating reflections from the ground surface. Former roads that at one time were part of the cemetery are visible on Figures 3 and 5, and the Block 3 time slice from a depth of about a foot is shown in the inset below.



GPR data indicate that roads extended northward from the modern cemetery road intersections.

These roads extend for about 40 – 50 feet north of the current paved road, but do not appear to have extended farther north.

Land south of the known cemetery was surveyed by means of two long survey lines extending the entire length of the cemetery and located at approximately 10 feet south of the border (just at the south side of the tree line (Figure 1) and approximately 20 feet to the south of the first line. These lines did identify strong reflectors, but they invariably were from sources at or near the surface and suspected to be buried rocks (many of which were observed at the surface) or tree roots, as many trees are present, as well. Although it would be necessary to conduct a 3D survey comparable to the survey at the known cemetery to be sure, there was no obvious indication to suggest that the cemetery ever extended into the property to the south. The available cemetery map (Figure 2) also indicates that the southern limit of the cemetery is the tree line and that the southern property was not part of the Beachwood Cemetery.

5 DISCUSSION

The total number of probable burials at the Beachwood Cemetery identified by the GPR technique is 503. The total number of known burials including infants and burials of ash where subsurface evidence of burial might not be obvious is 567. Accordingly, the number of identified graves is reasonably consistent with the historical record. The number of high quality GPR reflections interpreted to originate from vaults or coffins that are still intact is 121. The number of burials since 1930 is reported to be 253, so either vaults were not always used in the 1930s and 1940s, or else some of the relatively deep reflection were not correctly identified to be possible vaults.

The cemetery is close to full capacity, but there are areas where the presence of an existing grave is highly unlikely. Specifically, the area where there used to be two roads extending north of the current road intersections does not appear to be where burials were ever made. The second area where obvious burials were not observed is in the northeastern part of the cemetery (eastern half of Block 4 on Figure 4). The difficulty with interpreting this area is that there appears to be natural disturbance that could mask the presence of graves. There are burial markers present, but obvious graves were not observed from the GPR data. A collection of shallow graves is mapped in the southeastern part of Block 4, but there is a question mark associated with this interpretation as this area might also be where there is a natural disturbance of the soil. Conversely, this could be an area of shallow burials as might be associated with infants. The existing cemetery map does not identify family names with the plots in the eastern part of Block 4 and in general they do not appear to be present.

The existing cemetery map fits with the general distribution of graves in the sense that where family names are assigned to the plots, graves are present. Where names are not assigned, graves are not generally present. In addition to the eastern part of Block 4, plots 77, 78, 99 and 100 on Figure 2 where names are not assigned does not have any evidence of graves, except for two shallow GPR anomalies that could originate from something other than a grave. A curious aspect of the exiting map is that the northwestern plots (155 through 162 on Figure 2) are located north of the scarp that slopes down to the golf course and would not be suitable ground for burials. The question is whether or not the ground was suitable at the time of the preparation of the map and soils has been removed or has slumped northward. At least one tombstone appeared to be about to fall over the edge of the slope.

Additional work beyond the scope of this study would be to compare individual family plots with the number of identified burials in each plot. This step could confirm the presence of individuals, even if markers are no longer present. The areas where surficial anomalies are present in areas where there is no surficial evidence to indicate that anything is present could be physically probed to determine if there are lost tombstones that could be recovered. There are certainly some well-defined burials that have no surface marker to indicate their presence (for example, Block 3 – 370 E; 295 N).

This interpretation is not considered to be perfect. Subsurface features such as buried rocks could be misinterpreted to be graves. Areas where no graves have been identified could still be where burials have taken place without significant containment (ash or small infants). In particular, the areas with natural soil disturbance as found in Block 4 could mask the presence of burials and cause misinterpretations to lead to the conclusion that graves are present when they are not. Nevertheless, the overall results appear to be consistent with the known history of the cemetery in terms of the distribution and number of graves.

FIGURE 1

LOCATION OF SURVEY AREA
AT BEACHWOOD CEMETERY
(DESIGNATION OF SURVEY BLOCKS)

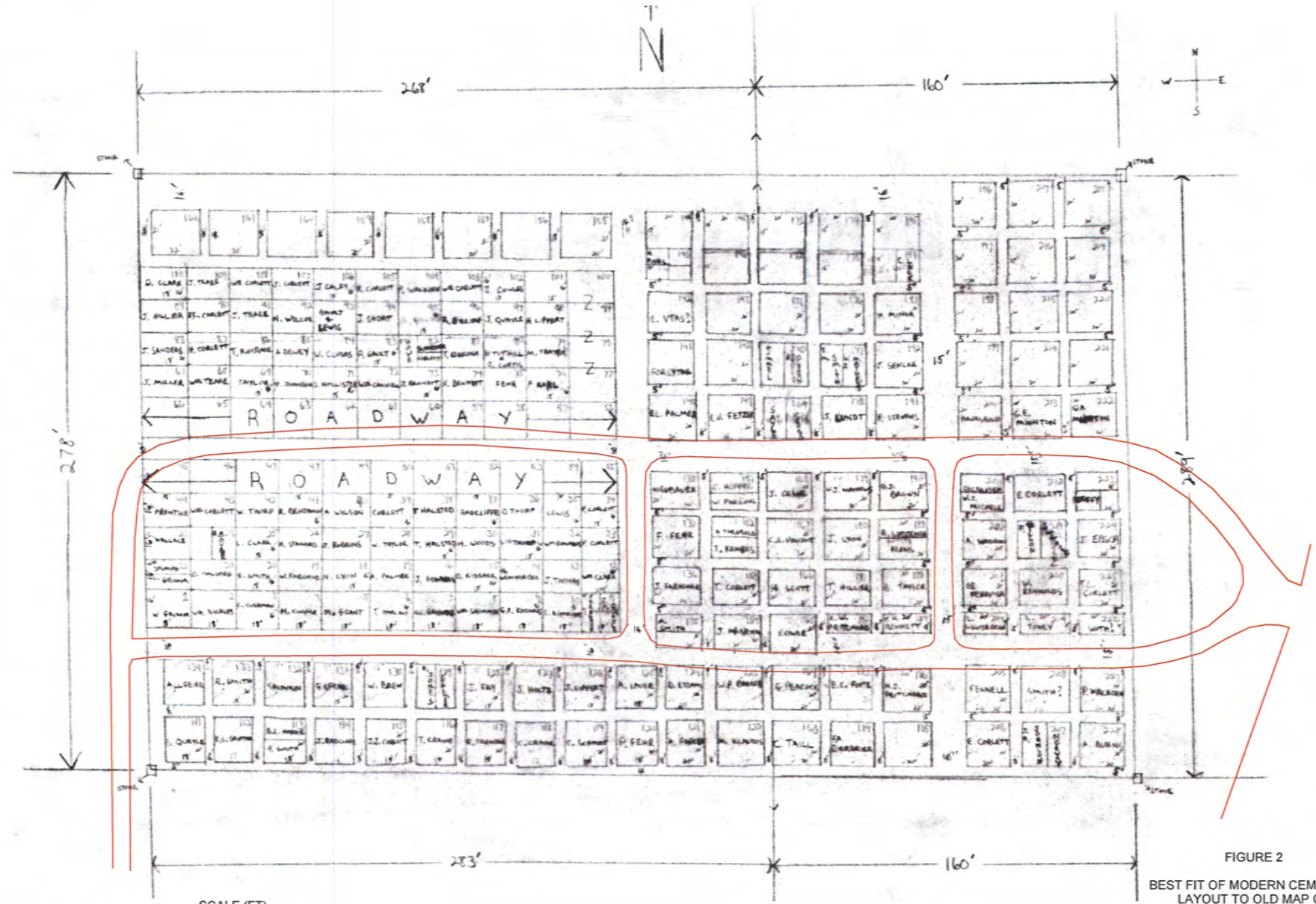
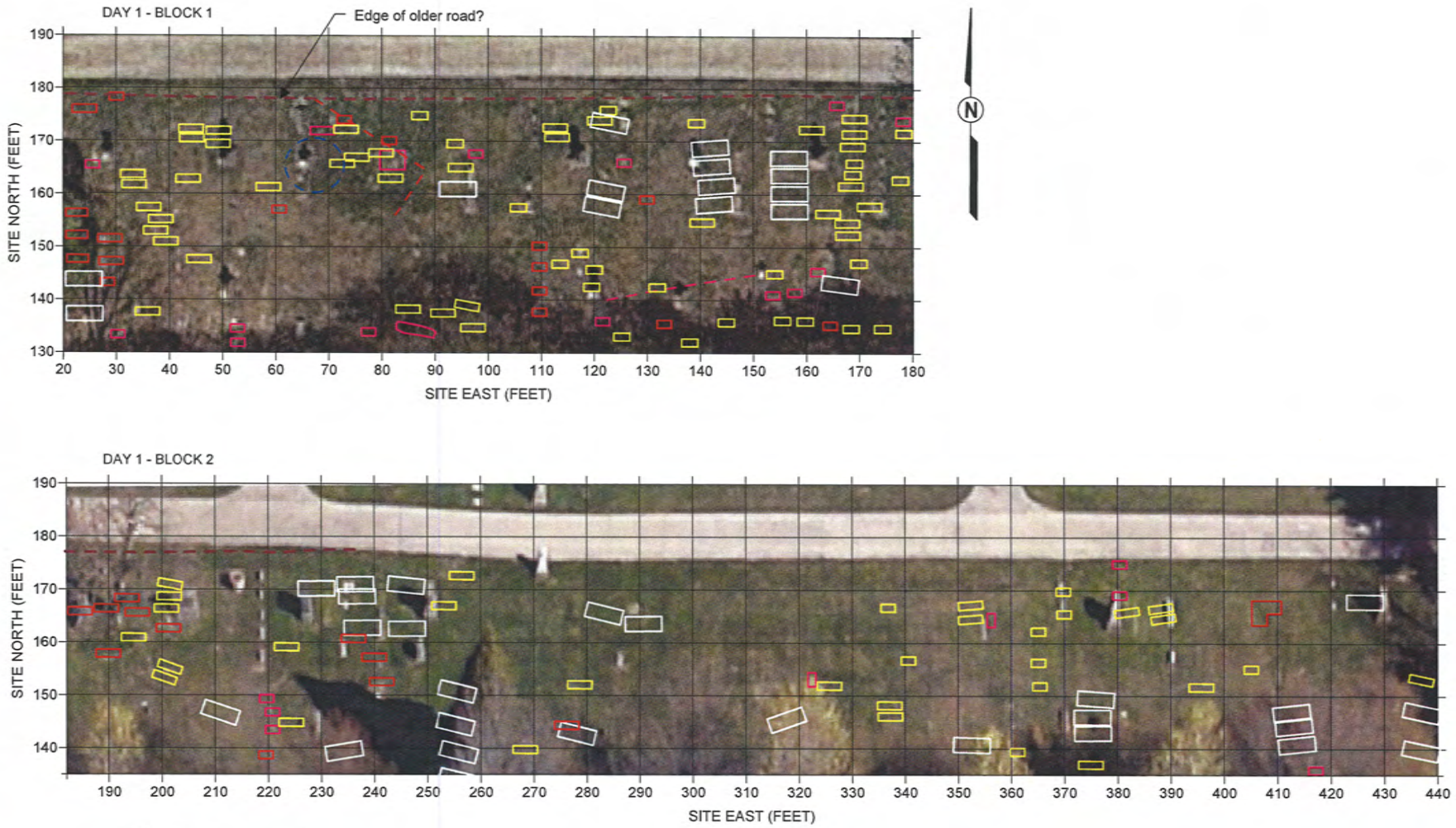


FIGURE 2

BEST FIT OF MODERN CEMETERY LAYOUT TO OLD MAP OF BEACHWOOD CEMETERY



LEGEND

- Object at or near surface (possible buried headstone)
- Shallow possible grave (less than 2 feet deep)
- Deep possible grave (more than 2 feet deep)
- Well defined grave (probably intact casket or vault)
- Possible edge of older road

SCALE (FEET)

0 20 40 60 80

NOTE: For location of blocks, see Figure 1.

FIGURE 3

INTERPRETATION OF BLOCKS 1 AND 2

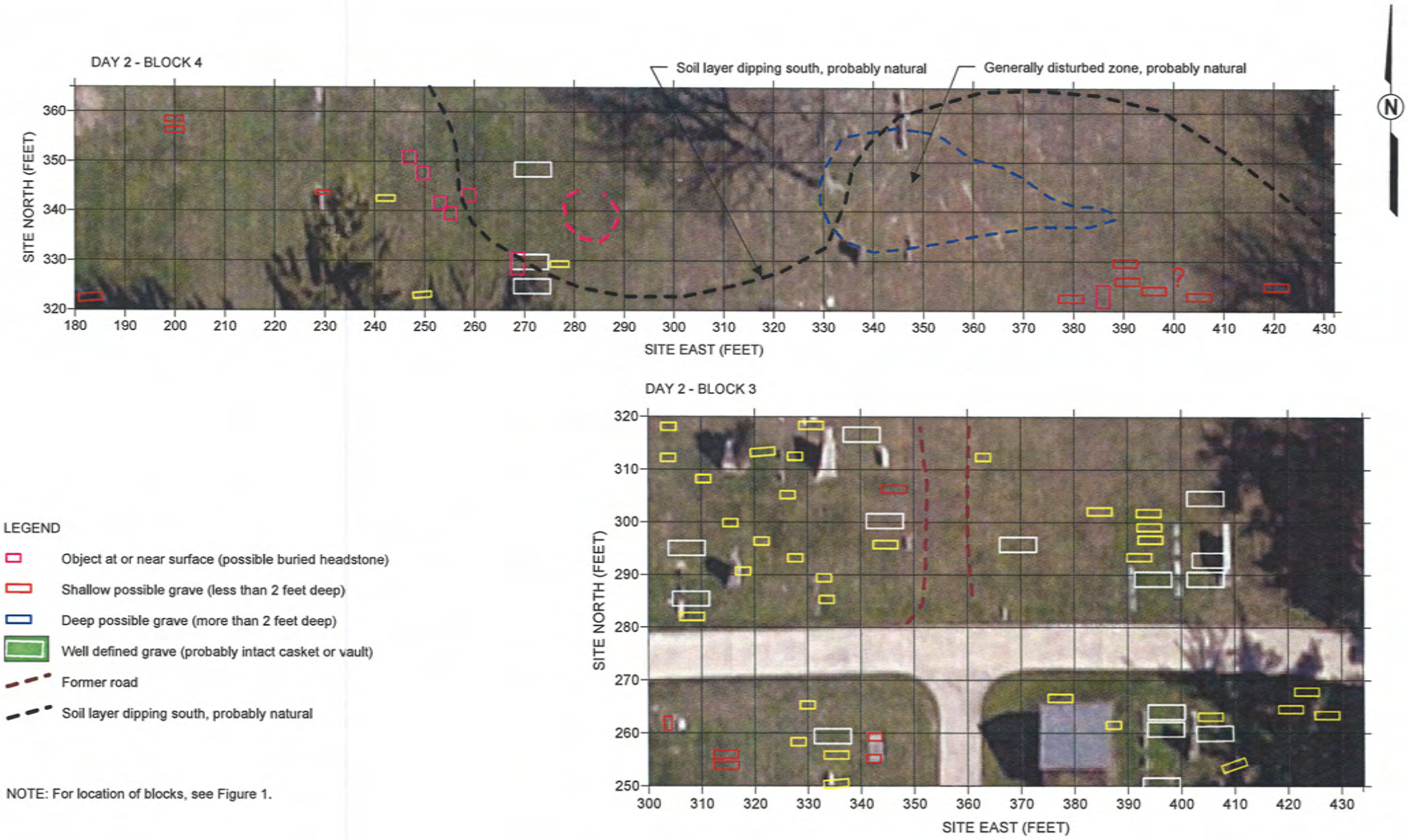
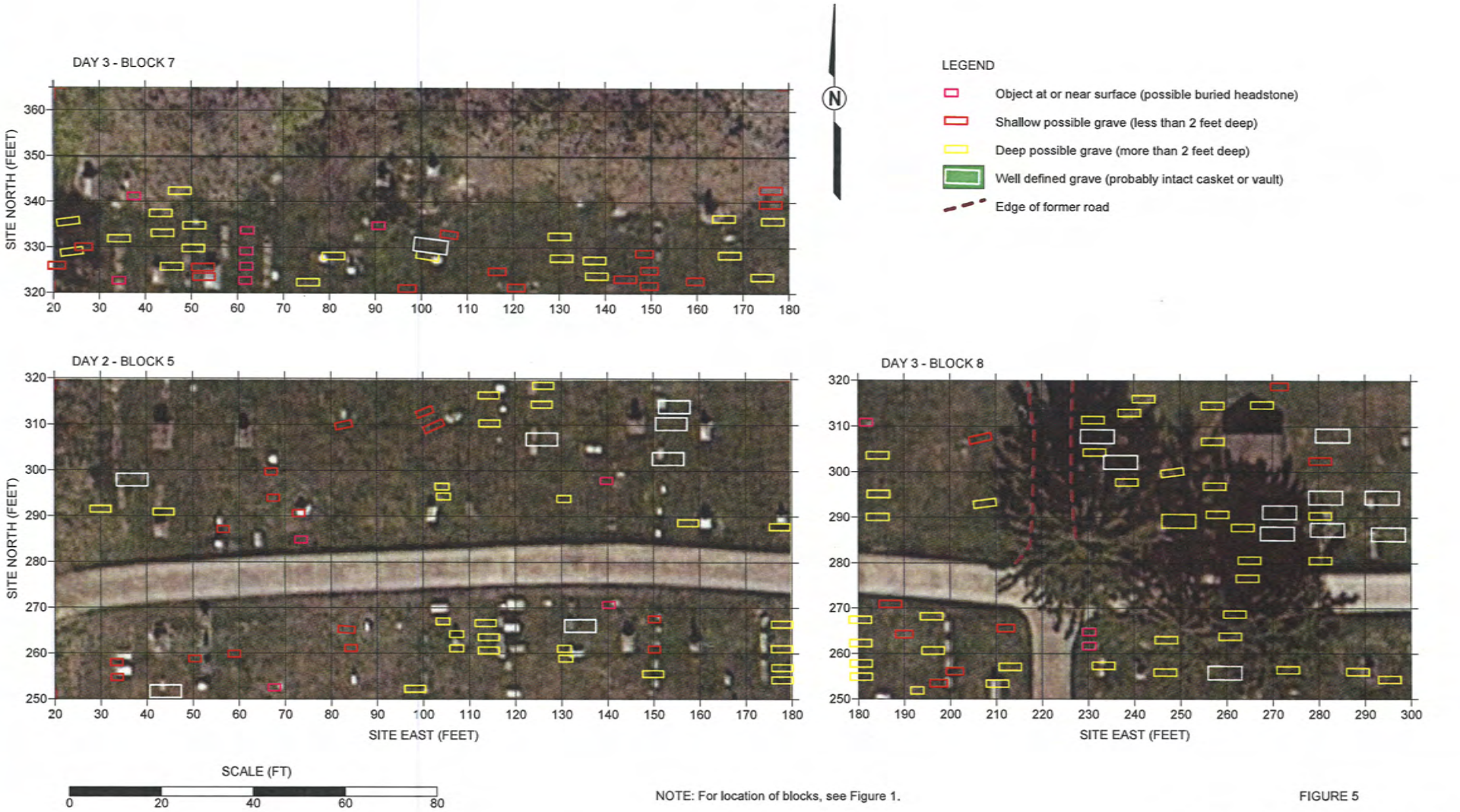


FIGURE 4

INTERPRETATION OF BLOCKS 3 AND 4



NOTE: For location of blocks, see Figure 1.

FIGURE 5

INTERPRETATION OF BLOCKS 5, 7 AND 8

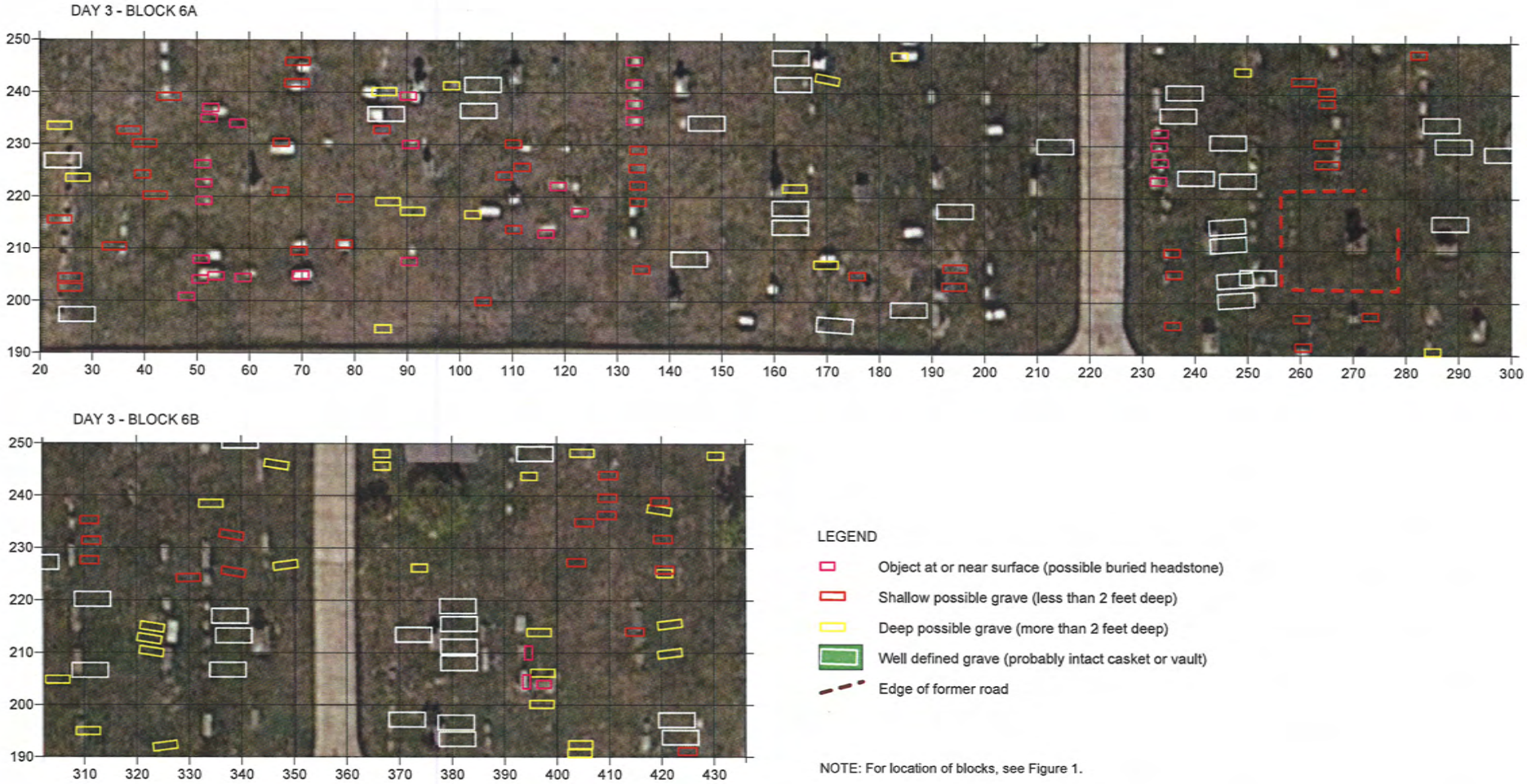


FIGURE 6

INTERPRETATION OF BLOCKS 6A AND 6B