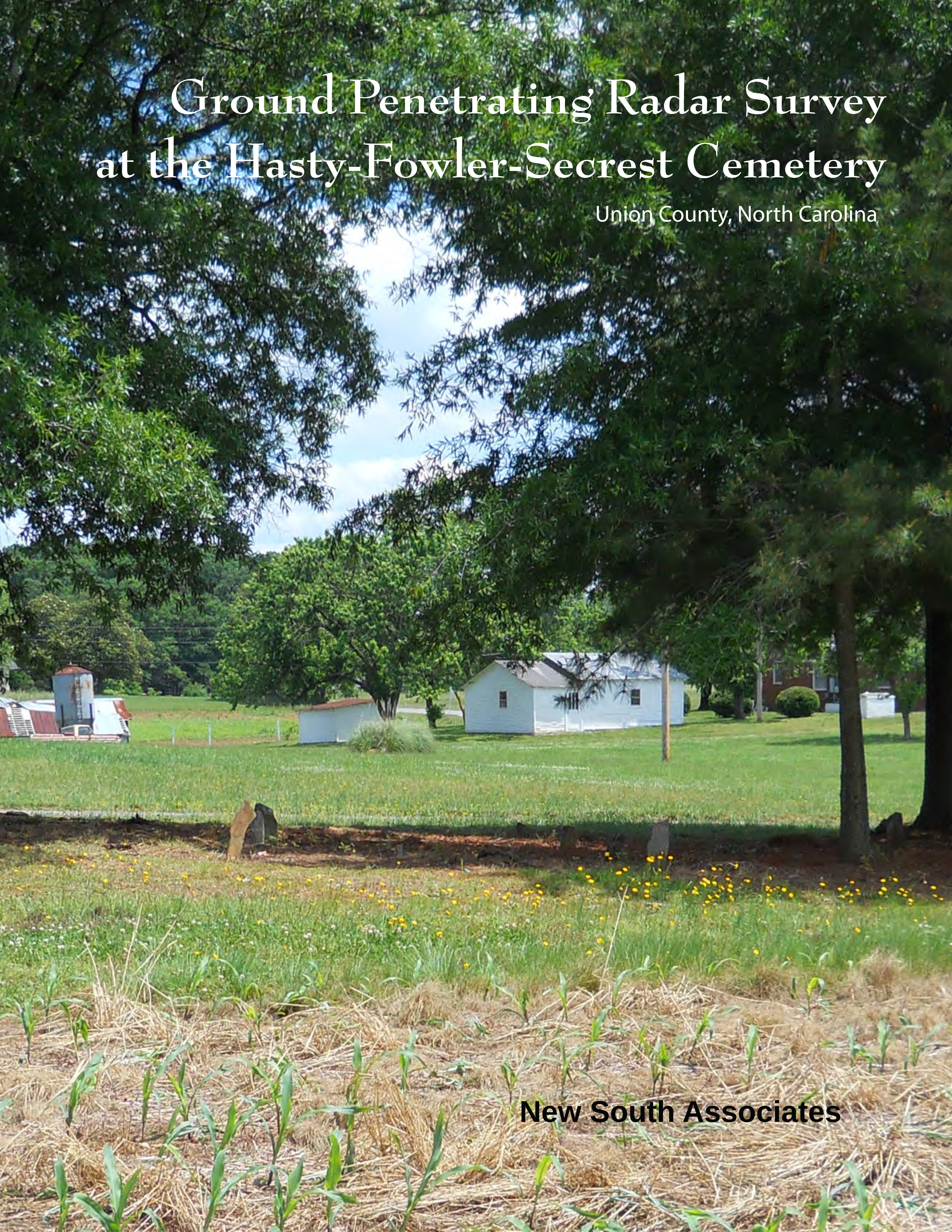
Ground Penetrating Radar Survey at the Hasty-Fowler-Secrest Cemetery

Union County, North Carolina



New South Associates

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Union County, North Carolina

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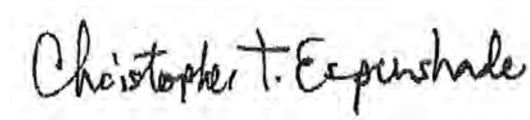

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ABSTRACT

New South Associates conducted an intensive ground penetrating radar (GPR) survey at the Hasty-Fowler-Secrest Cemetery in Union County, North Carolina. The survey was conducted for the North Carolina Turnpike Authority (NCTA) and North Carolina Department of Transportation (NCDOT) in support of environmental studies for the proposed US 74 Bypass Extension. The survey covered approximately 1.4 acres.

Results indicate at least 19 anomalies consistent with the expected signature for historic-era graves. The anomalies occur in three areas. Two of the anomalies spatially correlate with existing grave markers and the remaining 17 have no surface expression. In addition, there are four marked graves without a geophysical anomaly. New South Associates recommends that the 23 anomalies be treated as potential human graves and investigated through additional work. If the anomalies near the existing house are verified as human graves, it will be appropriate to examine the area beneath the house once the structure has been removed.

ACKNOWLEDGMENTS

Multiple individuals contributed to the successful completion of this project. First and foremost, we wish to acknowledge the cooperation and assistance of Ron and Kathy Fowler, the current property owners, for granting access and sharing information about the area. We express our sincere gratitude to the Fowlers and appreciate their help.

At New South Associates, David Diener and Diana Valk prepared the maps and other graphics and Jennifer Wilson edited the report.

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I. INTRODUCTION

New South Associates conducted an intensive ground-penetrating radar (GPR) survey at the Hasty-Fowler-Secrest Cemetery (31UN351**) in Union County, North Carolina (Figure 1). The survey was conducted for the North Carolina Turnpike Authority (NCTA) and North Carolina Department of Transportation (NCDOT) in support of environmental studies for the proposed US 74 Bypass Extension.

The proposed cross-section of the US 74 Connector is a four-lane divided facility with a 46-foot wide grass median, a shoulder section within a 350-foot right-of-way (ROW). The proposed project begins at the existing interchange between I-485 and the current US 74. The current US 74 will be widened at the starting point before swinging northward onto new location, then turning eastward until it terminates beyond US 601 at the proposed junction with the Monroe Bypass. The Hasty-Fowler-Secrest Cemetery was discovered during the archaeological survey, and falls within the proposed ROW.

The Scope of Work (SOW) for this project outlined the general research goals and objectives with an emphasis on revisiting the cemetery and further documenting the number of potential burials located within the proposed project's area of potential effects (APE) and to record any extant markers for analysis and interpretation of the cemetery. The method for achieving these goals employed GPR. All fieldwork was completed in accordance with the SOW. Fieldwork was conducted from May 7-10, 2012 by Shawn Patch and Danny Gregory. All GPR data processing was performed by Shawn Patch and Sarah Lowry.

Results indicate 19 anomalies consistent with the expectations for historic-era graves are present in the APE. These anomalies are located in three areas: one cluster around the existing markers, a second cluster in the front yard of the house, and the third is a single outlier in the rear yard. Two of the anomalies correlate with existing grave markers. In addition, there are four marked graves without a geophysical anomaly. New South Associates recommends that the 23 anomalies be treated as potential human graves and investigated through additional work. In addition, if excavation verifies that the near-house anomalies are human graves, then the area beneath the house should be examined for possible graves after the structure has been carefully removed.

Figure 1.
Map Showing Location of GPR Survey in Union County, North Carolina

Source: Bing Maps Aerial (2010)

The remainder of this report includes a brief overview of the local environment in Chapter II, Chapter III is a discussion of previous work, Chapter IV is a description of methods, Chapter V contains results and recommendations, and is followed by the References Cited. GPR amplitude slice maps are included in the Appendix A.

II. ENVIRONMENT

SOILS

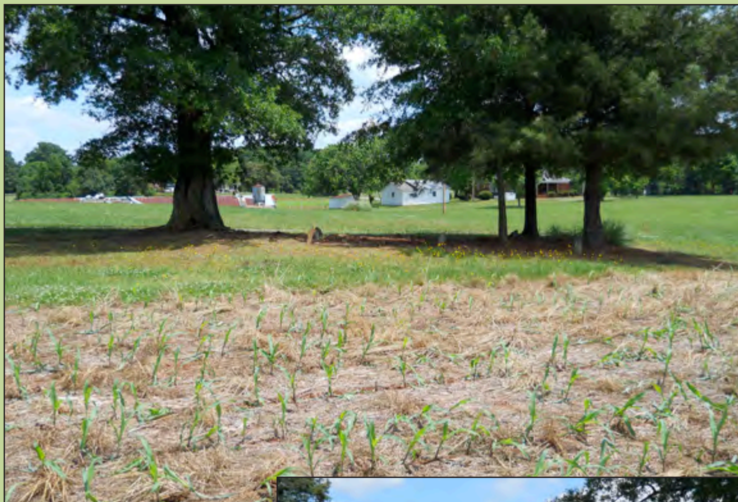
The project area is Piedmont Physiographic Province. Soils in the project area are classified as Badin channery silty clay loam, 2-8 percent slopes, moderately eroded. This type is found on interfluves and is well drained. Parent material is residuum from metavolcanics and/or argillite. Depth to bedrock varies from 20-40 inches. A typical profile consists of silty clay loam (0-6 in.), silty clay (6-20 in.), channery silty clay loam (20-28 in.), weathered bedrock (28-42 in.), and unweathered bedrock (42-80 in.).

These soils are considered acceptable for geophysical prospection with GPR.

CURRENT SETTING

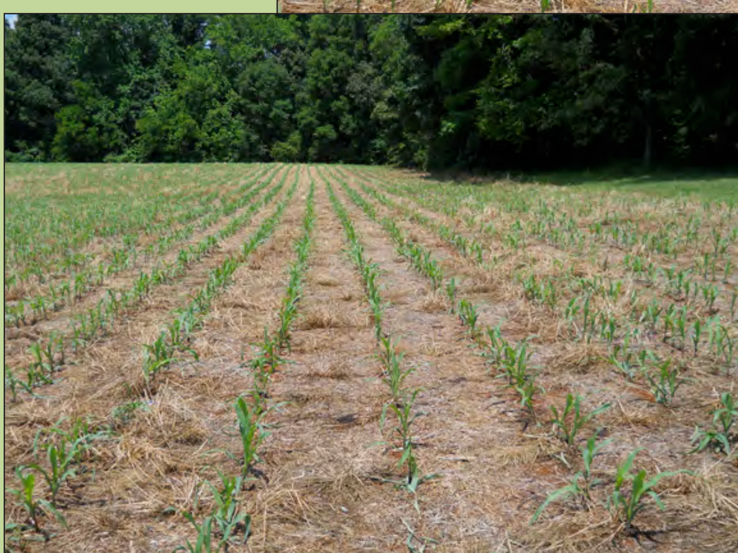
The project area is in a rural setting and is characterized by an agricultural field, a modern residence built circa 1991, manicured lawn, gravel driveway, and a large wooded area on the north side (Figure 2). Historically the area was primarily under cultivation.

Figure 2.
Photographs of the Current Setting



A.
Survey Area Showing Existing Markers, Looking Southeast

B.
Fowler Residence, Looking East From Agricultural Field



C.
Agricultural Field, Looking North

III. PREVIOUS WORK

The Hasty-Fowler-Secrest Cemetery is identified as site 31UN351** (Gregory et al. 2009). Initially, the site was recorded during the archaeological survey of the proposed highway improvements. Fieldstone grave markers were noted, and the landowners reported these as the Hasty-Fowler-Secrest Cemetery.

Subsequent work at the site included archival research (e.g., deeds, genealogy) and a penetrometer survey to identify possible unmarked graves. Conflicting accounts were noted regarding the number of grave markers and whether or not they had been moved from a previous location. Archival research yielded information that reported the cemetery was impacted from house construction and the grave markers were moved.

Initial identification efforts were based on the presence of broken grave markers and fieldstone scattered among a small stand of mature trees (Figure 2). Cemeteries in rural, upland environments typically exhibit at least a few of the following patterns or traits: human-sized rectangular/oval depressions or mounds, formal grave markers (wood, stone, or metal), fieldstone markers arranged as headstones and footstones, ornamental ground cover (vinca, narcissus, cedar, hemlock, and other flowers), enclosures to restrict land use (stone walls, iron fences, vegetation), materials placed on the ground to outline a grave (stone, glass, wood, metal, etc.), low oval or rectangular piles of stones, maintained areas with evidence of clearing or vegetation removal, and human-sized ground discolorations.

Field survey identified standing fieldstone markers arranged in rows and paired to represent the head and foot positions, as well as piles of loose fieldstone scattered on the surface. These were all clustered in the tree area south and west of the Fowler residence. Additional fieldstone was noted behind (north) the Fowler residence, but this area is densely wooded and there was no indication that these served as grave markers.

Additional field efforts involved the use of a soil penetrometer to measure compaction and identify potential unmarked graves. Transects were spaced at 50 centimeters and sampling occurred at 50 centimeter intervals. Results indicated 12 subsurface anomalies that were consistent with expectations for human graves. Recommendations included additional work such as GPR and/or machine-assisted stripping to expose potential grave features.

IV. METHODS

MAPPING

Field mapping was conducted with a Nikon DTM-32 total station and TDS Recon data collector. A primary map station was established in the northwest portion of the study area. Coordinates (540506E, 3877061N, UTM Zone 17, NAD83) for this point were then collected with a Trimble GeoXT global positioning system (GPS). These coordinates were entered into the data collector so the total station data could be incorporated into the GIS.

All grave markers, GPR grid corners, and other major surface features such as trees, the Fowler house and driveway, and obstructions were recorded. Grave markers were identified with four points, one on each corner, to provide the maximum degree of accuracy and each was assigned a unique number in the field. The associated number for each grave feature was then displayed on subsequent maps prepared for the inventory phase.

All total station data were imported in ArcGIS for map production. Individual shapefiles were then created for each feature class (e.g., grave marker, tree, house). These data were used in the production of a detailed map that was overlaid with other spatial data (e.g., aerial imagery, topography).

MARKER INVENTORY

Each marker within the project area was inventoried and examined. In all cases, the markers were of local fieldstone with little to no additional modification. This limited the number and types of attributes that could be recorded. Each marker was given a unique inventory number. The 12 markers are arranged in pairs with a headstone and footstone, which leaves the appearance of six graves. Two of the markers contained epitaphs that were largely illegible, although the name “Hasty” was identified in both cases. Epitaphs on these markers are on the western face. Complete dates could not be determined, although they appeared to be from the 1860s. Many of the markers have been broken or damaged and have missing fragments. In addition, several rocks were recorded piled at the bases of two trees. Because they were not in primary context it was impossible to determine whether or not they were displaced grave markers or naturally occurring stone.

GROUND PENETRATING RADAR (GPR)

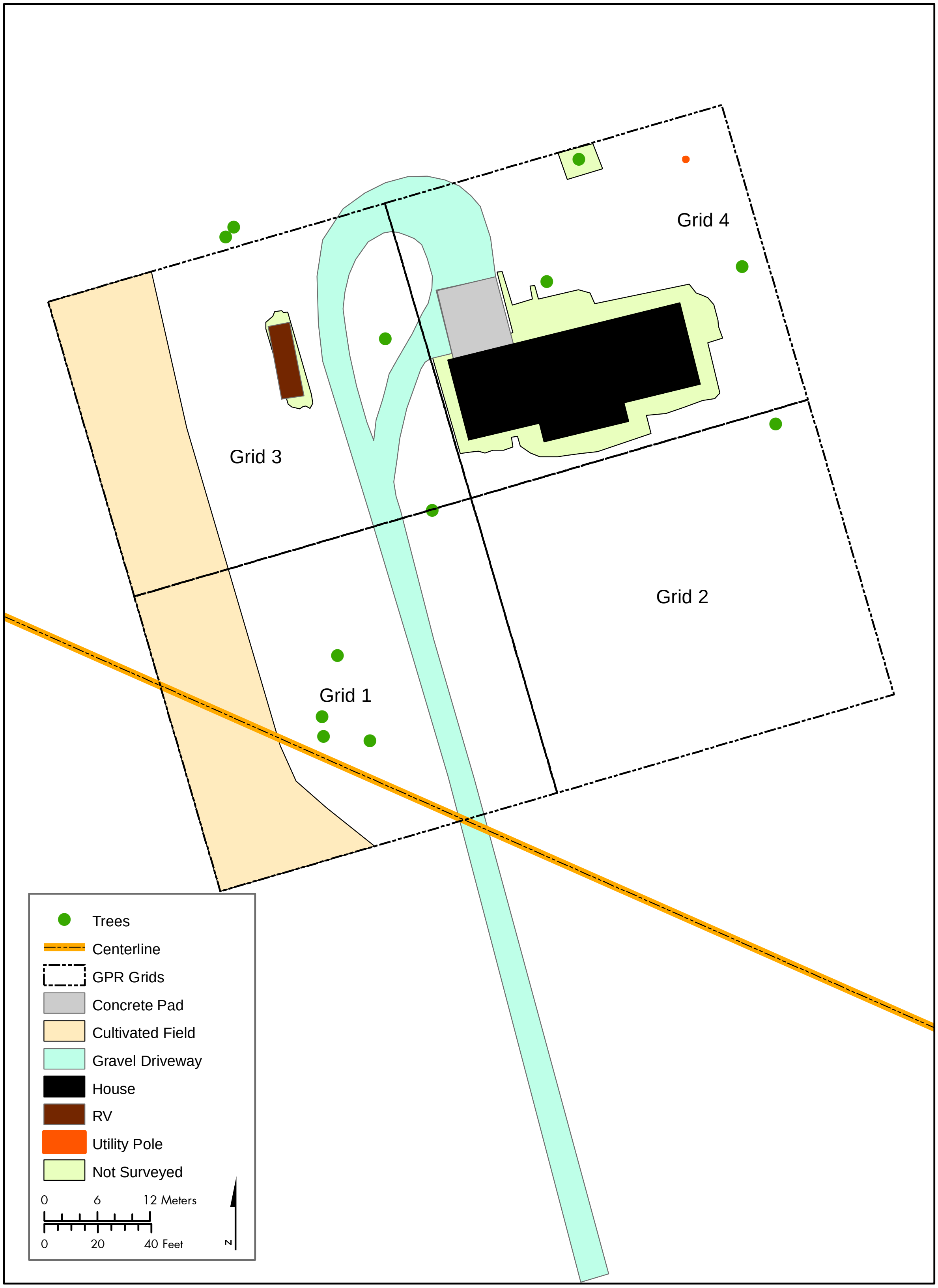
The GPR survey covered an area that measured approximately 1.4 acres in size (262 x 246 feet) (Figure 3). As proposed in our Work Plan, the survey area was defined to capture the potential cemetery as identified by Gregory et al. (2009). This included the small stand of trees with existing markers, all areas around the Fowler residence, portions of an agricultural field, and as much ground as possible up to the heavily wooded area on the north side. Archival research reported by Gregory et al. (2009) indicated up to 51 markers on the landform now occupied by the Fowler residence.

GPR is a remote sensing technique frequently used by archaeologists to investigate a wide range of research questions. In archaeological applications, GPR is used to prospect for potential subsurface features. Because GPR is a remote sensing technique, it is non-invasive, non-destructive, relatively quick and efficient, and highly accurate when used in appropriate situations. In cemeteries, GPR is commonly used to identify anomalies consistent with the expectations for human graves, without ground disturbance (Jones 2008; King et al. 1993).

The use of GPR for identifying potential historic graves is based on the concept of contrast, which may include differences in physical, electrical, or chemical properties between an object or feature and its surrounding matrix (Conyers 2006). For graves, the body itself is generally not detected; it is typically the coffin or casket, burial shaft, or bottom of the grave that causes the reflection (Jones 2008; King et al. 1993). Not surprisingly, greater contrast generally equates to better detection and resolution. For example, a metal casket in a concrete vault is much easier to see with GPR than a body buried in a wooden coffin only. In certain cases, it is also possible to detect buried markers or other associated grave features that were once present on the surface (Patch 2007).

GPR data are acquired by transmitting pulses of radar energy into the ground from a surface antenna, reflecting the energy off buried objects, features, or bedding contacts, and then detecting the reflected waves back at the ground surface with a receiving antenna (Conyers 2004a:1). When collecting radar reflection data, surface radar antennas are moved along the ground in transects, typically within a surveyed grid, and a large number of subsurface reflections are collected along each line. As radar energy moves through various materials, the velocity of the waves will change depending on the physical and chemical properties of the material through which they are traveling (Conyers and Lucius 1996). The greater the contrast in electrical and magnetic properties between two materials at an interface, the stronger the reflected signal, and, therefore, the greater the amplitude of reflected waves (Conyers 2004a).

Figure 3.
Map Showing Locations of GPR Survey Grids and Other Surface Features



When travel times of energy pulses are measured, and their velocity through the ground is known, distance (or depth in the ground) can be accurately measured (Conyers and Lucius 1996). Each time a radar pulse traverses a material with a different composition or water saturation, the velocity will change and a portion of the radar energy will reflect back to the surface and be recorded. The remaining energy will continue to pass into the ground to be further reflected, until it finally dissipates with depth.

The depths to which radar energy can penetrate, and the amount of resolution that can be expected in the subsurface, are partially controlled by the frequency (and therefore the wavelength) of the radar energy transmitted (Conyers 2004a). Standard GPR antennas propagate radar energy that varies in frequency from about 10 megahertz (MHz) to 1000 MHz. Low frequency antennas (10-120 MHz) generate long wavelength radar energy that can penetrate up to 50 meters in certain conditions but are capable of resolving only very large buried features. In contrast, the maximum depth of penetration of a 900 MHz antenna is about one meter or less in typical materials, but its generated reflections can resolve features with a maximum dimension of a few centimeters. A trade-off therefore exists between depth of penetration and subsurface resolution.

The success of GPR surveys in archaeology is largely dependent on soil and sediment mineralogy, clay content, ground moisture, depth of buried features, and surface topography and vegetation. Electrically conductive or highly magnetic materials will quickly attenuate radar energy and prevent its transmission to depth. Depth penetration varies considerably depending on local conditions. Clay can be challenging for GPR because it has a low relative dielectric permittivity (RDP). In practical applications, this generally results in shallower than normal depth penetration because the radar signal is absorbed (attenuated) by the clay regardless of antenna frequency (Conyers 2004a).

The basic configuration for a GPR survey consists of an antenna (with both a transmitter and receiver), a harness or cart, and a wheel for calibrating distance. The operator then pulls or pushes the antenna across the ground surface systematically (a grid) collecting data along a transect. These data are then stored by the receiver and available for later processing.

The “time window” within which data were gathered was 30 nanoseconds (ns). This is the time during which the system is “listening” for returning reflections from within the ground. The greater the time window, the deeper the system can potentially record reflections. To convert time in nanoseconds to depth, it is necessary to determine the elapsed time it takes the radar energy to be transmitted, reflected, and recorded back at the surface by doing a velocity test. Hyperbolas were found on reflection profiles and measured to yield a relative dielectric permittivity (RDP), which is a way to calculate velocity. The shape of hyperbolas generated in programs is a function of the speed at which energy moves in the ground, and can therefore be used to calculate velocity (Conyers and Lucius 1996). The RDP for soils in the survey area was approximately eight, which, when converted to one-way travel time, (the time it takes the energy to reach a reflection source), is approximately 10 centimeters/nanosecond. All profiles and processed maps were converted from time in nanoseconds (ns) to depth in centimeters using this average velocity.

FIELD METHODS

The first step was to calibrate the antenna to local conditions by walking the survey area and adjusting the instrument's gain settings. This method allows the user to get an average set of readings based on subtle changes in the RDP (Conyers 2004a). Field calibration was repeated as necessary to account for changes in soil and/or moisture conditions (Conyers 2004b). Effective depth penetration was approximately 1.2 meters. Slight signal attenuation (degradation) was noted in the field, which was due to the presence of clay soils. However, signal attenuation was not severe enough to limit detection of graves.

The field survey was conducted using a GSSI SIR-3000 using two antennae of different frequencies over the entire area. Transect spacing with the 400MHz antenna was 50 centimeters and with the 900MHz was 25 centimeters. The closer transect spacing with the 900MHz antenna provided a very dense and high resolution dataset. All transects were oriented north-south to intercept the presumed long axis of potential graves at right angles. Signal attenuation was observed with both antennae at approximately 25 nanoseconds (+/- 3 feet). This was likely caused by shallow bedrock and dense clay soils. However, overall data quality and resolution are good. The purpose of both antennae and increased sampling density was to provide the maximum amount of data on the distribution and extent of potential burials. In short, this approach ensured that every possible advantage of GPR was used to its fullest extent.

In order to effectively collect and process GPR data, it is necessary to establish a formal grid. For this project, grid layout was accomplished with a total station, metric tapes, and surveyor's chaining pins. The survey area was subdivided into smaller grids to facilitate data collection and limit file sizes from becoming too large (Table 1). Total survey area was approximately 1.4 acres, but because it was covered twice it was the equivalent of 2.8 acres.

Table 1. Summary Data for GPR Survey Grids

Grid	Antenna	Origin	Method	Interval	X-Length (feet)	Y-Length (feet)	Square Feet	Acres
1	400	Southwest	Alternating	50cm	131	115	15,065	0.35
2	400	Southwest	Alternating	50cm	131	115	15,065	0.35
3	400	Southwest	Alternating	50cm	131	115	15,065	0.35
4	400	Northwest	Alternating and Baseline	50cm	131	115	15,065	0.35
1	900	Southwest	Alternating	25cm	131	115	15,065	0.35
2	900	Northwest	Alternating	25cm	131	115	15,065	0.35
3	900	Southwest	Alternating	25cm	131	115	15,065	0.35
4	900	Northwest	Alternating and Baseline	25cm	131	115	15,065	0.35

It is generally standard practice to orient transects perpendicular to the long axis of suspected features. Transect spacing was 50 centimeters for the 400MHz and 25 centimeters for the 900MHz. These intervals were designed to maximize each antenna's potential while generating the best resolution possible (Pomfret 2006). Transects were collected in two ways depending on surface conditions (e.g., alternating or baseline). Alternating transects are faster because the antenna collects data in two directions, but it requires an even grid. Baseline transects require the antenna to be returned to the same starting position for each pass and data collection is slower. However, the advantage of this method is that it does not require a square grid, and it is particularly useful when working around surface obstacles.

DATA PROCESSING

All data were downloaded from the control unit to a laptop computer for post-processing. Radar returns are initially recorded by their strength and the elapsed time between their transmission and receipt by the antenna. Therefore, the first task in the data processing was to set "time zero", which tells the software where in the profile the true ground surface was. This is critical to getting accurate results when elapsed time is converted to target depth. A background filter was applied to the data, which removes the horizontal banding that can result from antenna energy "ringing" and outside frequencies such as cell phones and radio towers. Background noise can make it difficult to visually interpret reflections. Hyperbolic reflections are generated from the way the radar energy reflects off point targets. In cemeteries, graves are often visible as hyperbolic reflections.

The next data processing step involved the generation of amplitude slice-maps (Conyers 2004a). Amplitude slice-maps are a three-dimensional tool for viewing differences in reflected amplitudes across a given surface at various depths (see Appendix A). Reflected radar amplitudes are of interest because they measure the degree of physical and chemical differences in the buried materials. Strong, or high amplitude reflections often indicate denser (or different) buried materials. Such reflections can be generated at pockets of air, such as within collapsed graves, or from slumping sediments. Amplitude slice-maps are generated through comparison of reflected amplitudes between the reflections recorded in vertical profiles. In this method, amplitude variations, recorded as digital values, are analyzed at each location in a grid of many profiles where there is a reflection recorded. The amplitudes of all reflection traces are compared to the amplitudes of all nearby traces along each profile. This database can then be "sliced" horizontally and displayed to show the variation in reflection amplitudes at a sequence of depths in the ground. The result is a map that shows amplitudes in plan view, but also with depth.

Slicing of the data was done using the mapping program *Surfer 8*. Slice maps are a series of x,y,z values, with x (east) and y (north) representing the horizontal location on the surface within each grid and z representing the amplitude of the reflected waves. All data were interpolated using the Inverse Distance Weighted method and then image maps were generated from the resulting files.

From the original .dzt files (raw reflection data), a series of image files was created for cross-referencing to the amplitude slice maps that were produced. Two-dimensional reflection profiles were also analyzed to determine the nature of the features identified on the amplitude slice maps. The reflection profiles show the geometry of the reflections, which can lend insight into whether the radar energy is reflecting from a flat layer (seen as a distinct band on profile) or a single object (seen as a hyperbola in profile). Individual profile analysis was used in conjunction with amplitude slice maps to provide stronger interpretations about possible graves.

The final step in the data processing is to integrate the depth slices with other spatial data. This was done using ArcGIS 9.3, which can display and manipulate all forms of spatial data created for this project, including GPR results, GPS data, and base graphics such as aerial photography and topographic maps. The resulting anomalies were digitized as individual features and referenced to the UTM Zone 17, NAD83 coordinate system.

GPR IN CEMETERIES

Several factors influence the overall effectiveness of GPR for detecting human graves. Soil conditions are the most important, with clay being the most difficult to penetrate. Its high conductivity causes the radar signal to attenuate much quicker, which in turn limits its overall depth and strength.

Age of the graves is also critical, with older graves being more difficult to detect because they have had more time to decompose and are less likely to have intact coffins or caskets (if they were present to begin with).

Burial "container," or what the physical remains may have been placed in, is also important, and includes simple linen or cloth shrouds, pine boxes or wooden coffins, lead or other metal caskets, and burial vaults (Trinkley and Hacker 2009). In certain cases, hardware such as nails, hinges, and handles may be present, but not necessarily all the time. Although there is a high degree of variation in specific types among different geographical regions, each of these tends to have been used at certain times throughout history and correlates with the presumed age of the grave. For example, burial shrouds were common throughout the seventeenth and early eighteenth centuries before being replaced by wooden coffins. It must also be noted that cultural trends and patterns tended to persist longer in rural and/or economically depressed areas much longer than urban centers.

V. RESULTS AND RECOMMENDATIONS

EXISTING GRAVE MARKERS

Twelve grave markers of local fieldstone are present in a cluster of trees in the southwest corner of the survey area (Figure 4). These are the same markers discussed by Gregory et al. (2009). The markers are arranged in two rows with three graves each (Figures 5-7). Each set of stones forms one pair, with a corresponding headstone and footstone (Figure 5). They are oriented approximately east-west, which is consistent with patterns noted in most Judeo-Christian cemeteries.

Markers 1, 2, and 4 have inscriptions on their west sides that vary considerably in terms of legibility (Figure 8). For example, the inscription on marker 1 was completely illegible except for the fragment of a date. Only the “18” could be discerned. Marker 2 had an inscription that was arranged with text on three lines:

> C HAST(illegible)
> NOV
> 1867

Marker 4 had an inscription with text on two lines:

> J HASTY
> 18(illegible)

Conditions for all extant markers were overwhelmingly poor. Almost all show at least minimal evidence of weathering (e.g., flaking surfaces, nicked corners). Headstone markers 2 and 4, both of which are inscribed, were also broken in multiple pieces. Several of the markers are loosely buried in the ground and as a result are leaning or in danger or falling (Figure 9). In these cases very little of the marker is actually buried in the ground and it suggests that they may have been moved or reset.

Several additional fragments of fieldstone were noted at the bases of two of the mature trees (Figure 10). It is unclear what their original context might have been and whether or not they served as actual grave markers or simply represent fieldstone that was collected opportunistically. Inspection of these did not identify any pieces or fragments that could be refit

Figure 4.
Map Showing Location and Detail of Existing Grave Markers

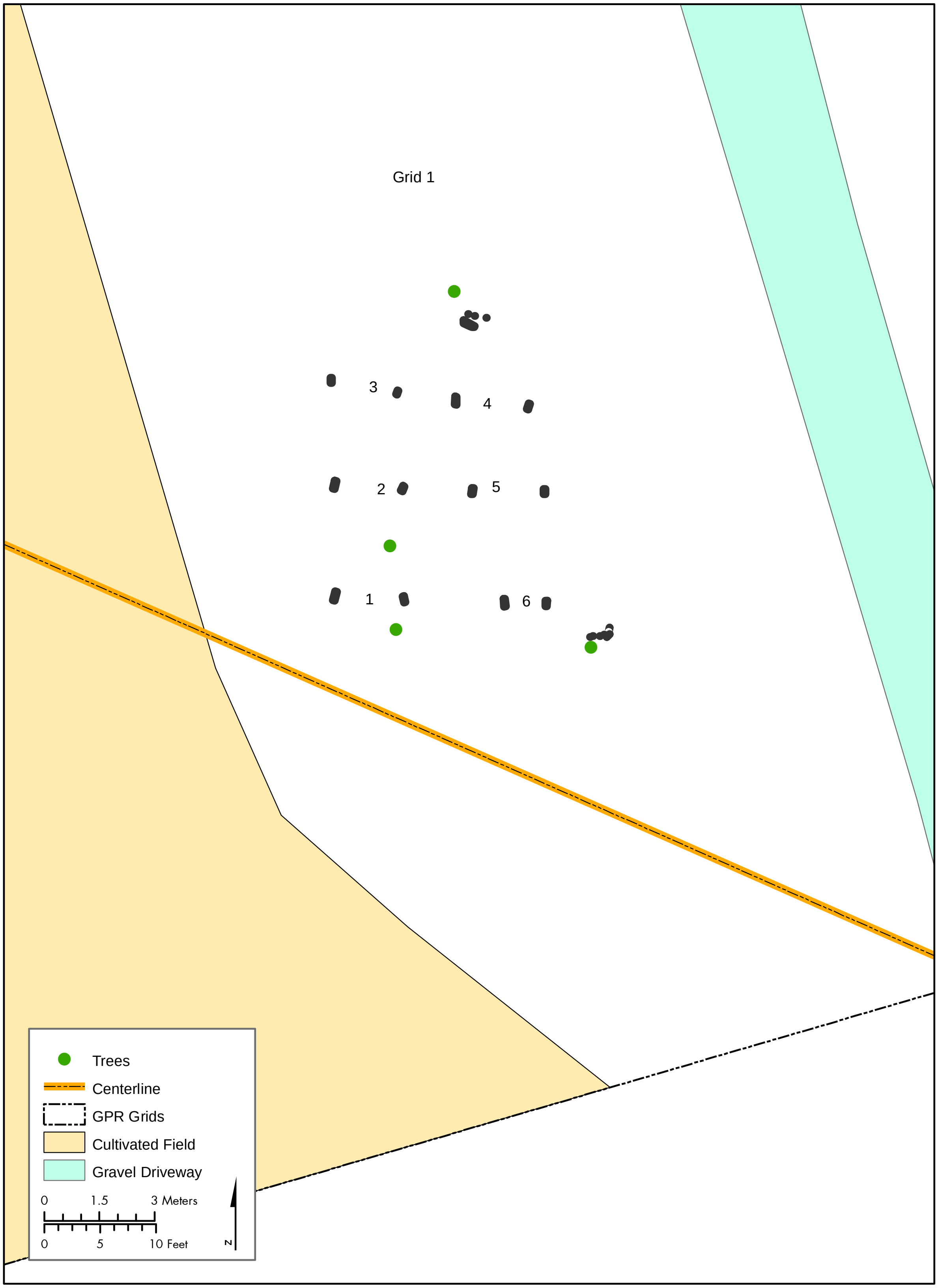


Figure 5.
Photograph Showing Arrangement of Existing Grave Markers, Looking West

Figure 6.
Photographs of Graves 1-3

A.
Markers for Grave 1

B.
Markers for Grave 2

C.
Markers for Grave 3

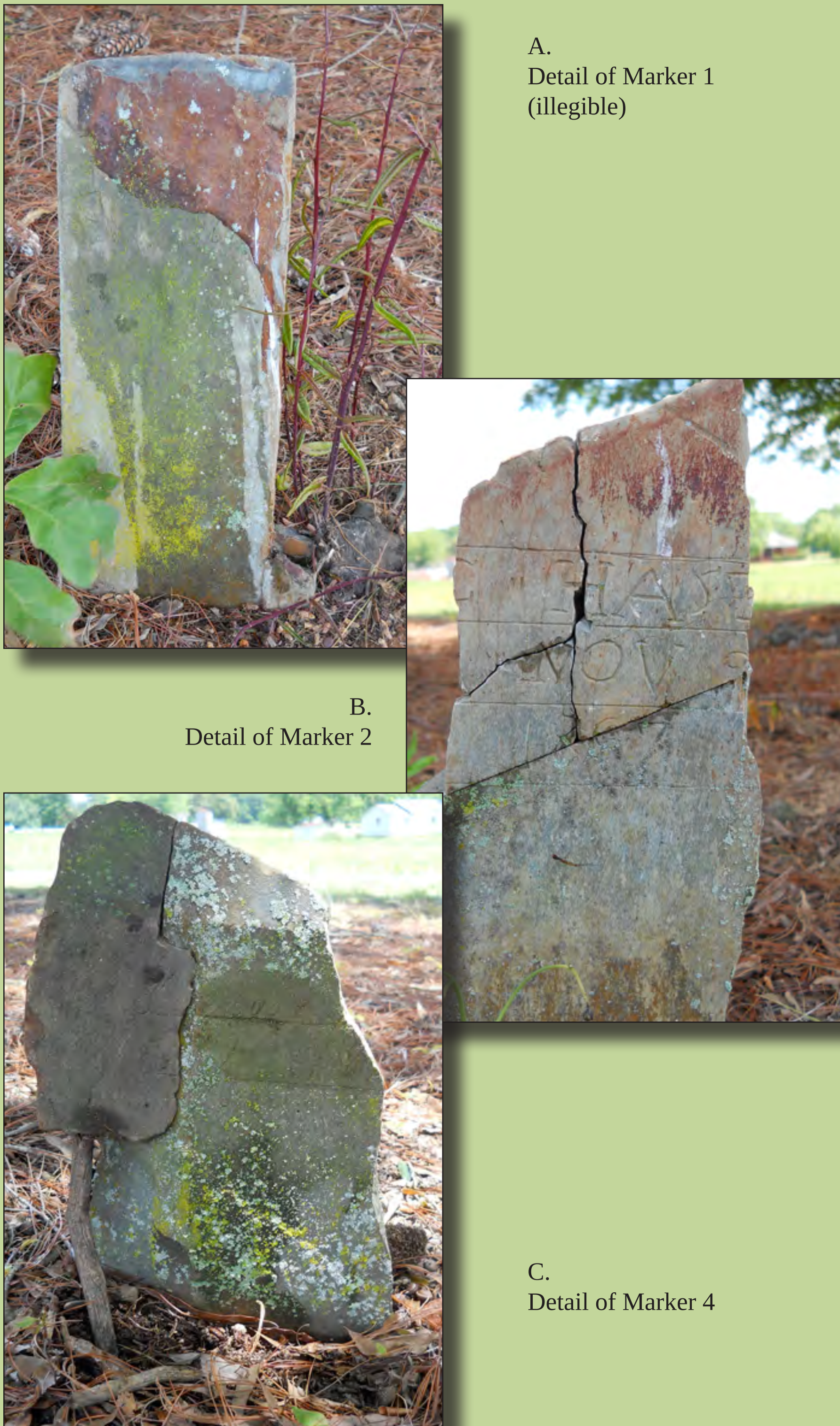
Figure 7.
Photographs of Graves 4-6

A.
Markers for Grave 4

B.
Markers for Grave 5

C.
Markers for Grave 6

Figure 8.
Photographs of Three Markers with Inscriptions



A.
Detail of Marker 1
(illegible)

B.
Detail of Marker 2

C.
Detail of Marker 4

Figure 9.
Photograph of Marker Number 3, Loose and Leaning

Figure 10.
Photographs Showing Piles of Fieldstone at Bases of Trees

with the extant markers. These show a huge size range from very small pebbles to large cobbles, yet none had any evidence of having served as a grave marker. Several had edge damage consistent with plowing, suggesting they were collected from agricultural fields and deposited in this area at an unknown time.

Archival research included review of North Carolina cemetery records for Union County collected during the WPA years. This particular cemetery was not listed, although numerous references were located in other cemeteries for the names Hasty, Fowler, and Secrest. It is unclear whether or not these surveys were comprehensive or selective and opportunistic. A full range of cemetery types is represented, including rural locations with only a handful of graves to urban settings with hundreds of marked graves.

GROUND PENETRATING RADAR

The primary purpose of the GPR survey was to identify geophysical anomalies consistent with the expected signature for historic-era graves. GPR results were based on analysis of both the 400MHz and 900MHz datasets, including individual reflection profiles and amplitude slice maps. Analysis of the 400MHz data indicated a very clean landscape with no obvious anomalies beyond those that were associated with trees, the driveway, and Fowler residence. However, analysis of the 900MHz data indicated a much different situation with far better resolution of subtle features. The results presented below were derived primarily from this dataset, although there was a certain degree of overlap between the two. The finer resolution generated in the 900MHz dataset made it possible to better distinguish subtle features that appeared as general background noise in the 400MHz dataset. Results indicate the presence of 46 unique anomalies (Tables 2 and 3, and Figure 11).

Table 2. Summary of GPR Anomalies by Depth with Interpretation

ID	Antenna	Depth (nanoseconds)	Depth (cmbs)	Interpretation
1	900	4	10-30	Concrete
2	900	4	10-30	Driveway
3	900	4	10-30	Driveway
4	900	4	10-30	Driveway
5	900	4	10-30	Foundation
6	900	4	10-30	Foundation
7	900	4	10-30	Foundation
8	900	4	10-30	Foundation
9	900	4	10-30	Foundation
10	900	4	10-30	Foundation
11	900	16	70-90	Pipe

Table 2. Summary of GPR Anomalies by Depth with Interpretation

ID	Antenna	Depth (nanoseconds)	Depth (cmbs)	Interpretation
12	900	12	50-70	Possible Grave
13	900	12	50-70	Possible Grave
14	900	12	50-70	Possible Grave
15	900	8	30-50	Possible Grave
16	900	8	30-50	Possible Grave
17	900	8	30-50	Possible Grave
18	900	8	30-50	Possible Grave
19	900	16	70-90	Possible Grave
20	900	8	30-50	Possible Grave
21	900	8	30-50	Possible Grave
22	900	8	30-50	Possible Grave
23	900	16	70-90	Possible Grave
24	900	16	70-90	Possible Grave
25	900	16	70-90	Possible Grave
26	900	16	70-90	Possible Grave
27	900	16	70-90	Possible Grave
28	900	16	70-90	Possible Grave
29	900	16	70-90	Possible Grave
30	900	16	70-90	Possible Grave
31	900	4	10-30	Root System
32	900	4	10-30	Root System
33	900	8	30-50	Root System
34	900	4	10-30	Root System
35	900	4	10-30	Root System
36	900	8	30-50	Septic Drain
37	900	8	30-50	Septic Drain
38	900	8	30-50	Septic Drain
39	900	8	30-50	Septic Drain
40	900	8	30-50	Septic Drain
41	900	4	10-30	Unknown
42	900	4	10-30	Unknown
43	900	8	30-50	Unknown
44	900	8	30-50	Unknown
45	900	8	30-50	Utility
46	900	16	70-90	Utility

Figure 11.
Map Showing Distribution of All GPR Anomalies

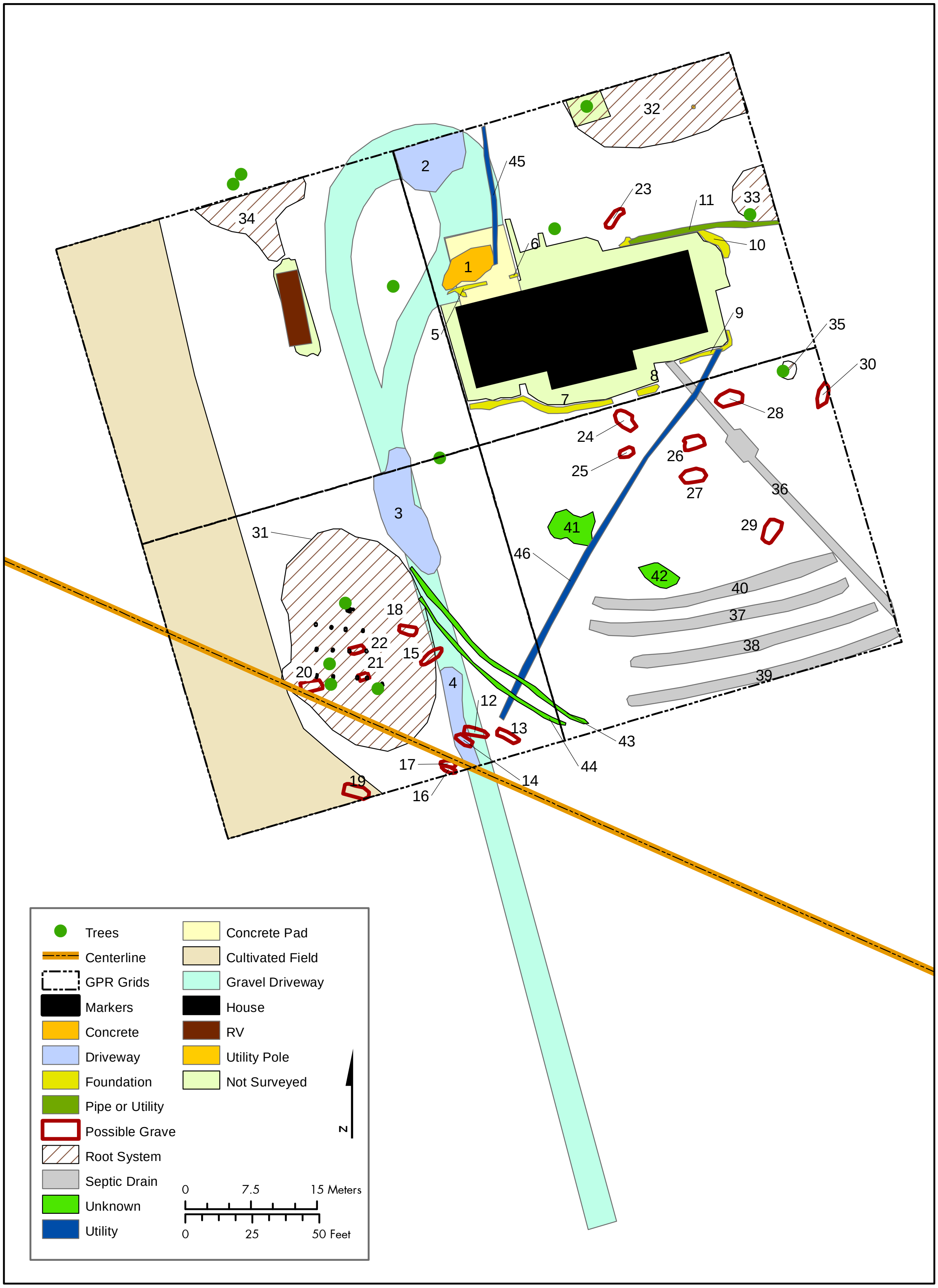


Table 3. GPR Interpretations by Depth Below Surface

Interpretation	Depth (cmbs)				Grand Total
	10-30	30-50	50-70	70-90	
Concrete	1				1
Driveway	3				3
Foundation	6				6
Pipe				1	1
Possible Grave		7	3	9	19
Root System	4	1			5
Septic Drain		5			5
Unknown	2	2			4
Utility		1		1	2
Grand Total	16	16	3	11	46

New South Associates takes a conservative approach to the identification of possible historic graves based on GPR data. Several factors influence the overall effectiveness of GPR for detecting anomalies consistent with graves including soil type and acidity, moisture and precipitation, age of probable graves, likely burial depth, burial container (e.g., shroud, wood coffin, metal casket, concrete vault), and social/cultural/economic practices of a particular group. Possible graves in GPR data are identified based on their size, shape, depth, orientation, and overall reflective characteristics in both plan and profile.

Evaluation of GPR results needs to consider the following points, particularly with respect to estimating the number of potential unmarked graves. First, it is highly unlikely that all graves were detected and imaged (Buck 2003; Jones 2008; King et al. 1993). Because of the environmental variables noted above, at least a certain number of graves likely exist that could not be defined. Second, at least a small percentage of the identified anomalies will be false positives; that is, they appear to be consistent with human graves yet are likely not actual graves. However, the GPR data provides a reasonable estimate of the total number of probable graves in the study area.

POSSIBLE GRAVES (N=19)

GPR results indicate 19 anomalies that are interpreted as possible graves based on their size, shape, orientation, and reflection characteristics (Figure 11). They are loosely arranged in two clusters of varying size, and a single outlier. One cluster is located around the existing markers and the other is located in the front yard. The outlier is located in the rear yard.

CLUSTER 1 (EXTANT MARKERS)

This cluster contains 11 GPR features (Numbers 12-22) around existing markers in a small stand of trees (Figure 12). Orientations for these anomalies vary, but they tend to follow a general pattern of east-west. Identifying and interpreting these particular anomalies was complicated by the extensive tree roots.

Two of these anomalies correlate with existing grave markers. Anomaly 21 is associated with Grave Marker Number 5 and Anomaly 22 is associated with Grave Marker Number 6. Anomaly 20 appears close to Grave Marker Number 1, although it is less obvious than the other two. All three of these are relatively shallow, located between 30 and 50 centimeters. In profile, Anomaly 20 appears as a strong hyperbolic reflection (Figure 13A). Anomalies 21 and 22 appear as weak hyperbolic reflections at the bottom of apparent voids (Figure 13B). In certain cases, this type of reflection may indicate a grave shaft.

Anomalies 15 and 18 are located on the eastern edge of this cluster and have no associated surface markers (Figure 12). They are both located between 30 and 50 centimeters. In plan view, they have rectangular or oblong shapes. In profile, they have strong hyperbolic reflections (Figure 14).

Anomaly 19 is located to the south and west of the main cluster at the edge of the agricultural field (Figure 12). Vertically, it is located between 70 and 90 centimeters, placing it well below the suspected plow zone. In profile, it appears as a strong reflection in consecutive profiles (Figure 15).

Anomalies 12, 13, and 14 are located under the driveway on the southeast side of Cluster 1 (Figure 12). In profile they are clearly visible as strong point reflections in multiple, consecutive profiles (Figure 16). The driveway is clearly visible at the surface. There are no obvious tree roots in this particular area that might generate a false positive.

Anomalies 16 and 17 are located along the southern edge of the survey area west of the driveway (Figure 12). Vertically, they are distributed between 30 and 50 centimeters. In plan view, they are oblong or rectangular in shape and appear adjacent to one another. In profile, they appear as a series of strong hyperbolic reflections in consecutive transects (Figure 17).

CLUSTER 2

This cluster consists of seven possible graves located in the front yard of the Fowler residence (anomalies 24-30) (Figure 18). Topographically they are situated on slightly elevated ground. Orientations vary considerably, but generally follow an east-west pattern. Morphologically, they are slightly larger than expected, less well defined, and have weaker reflective values than those observed in cluster 1. However, as a cluster they are relatively

Figure 12.
Plan View Detail of GPR Anomalies in the Southwest Portion of the Survey Area

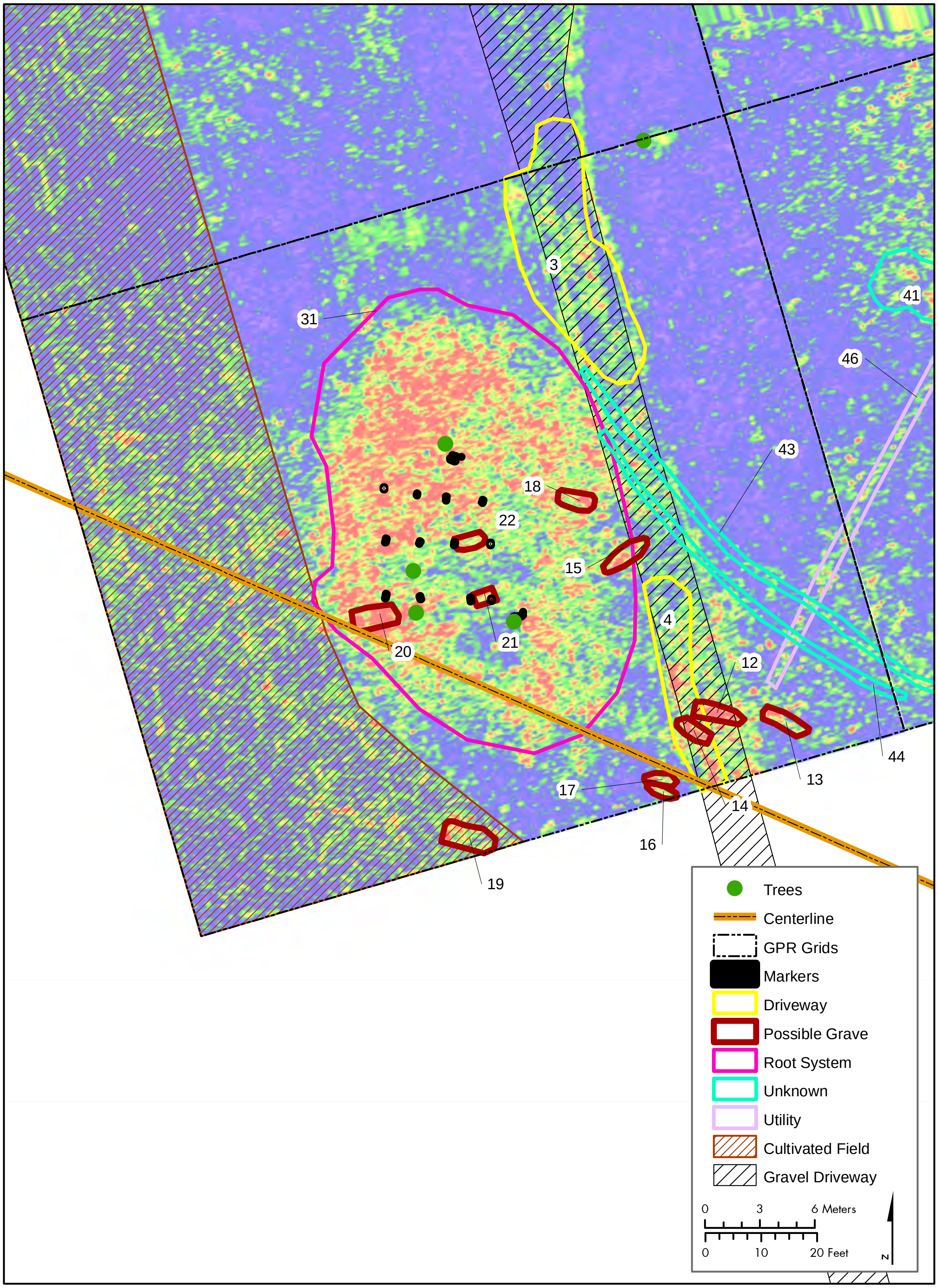


Figure 13.
GPR Profiles for Anomalies 20-22

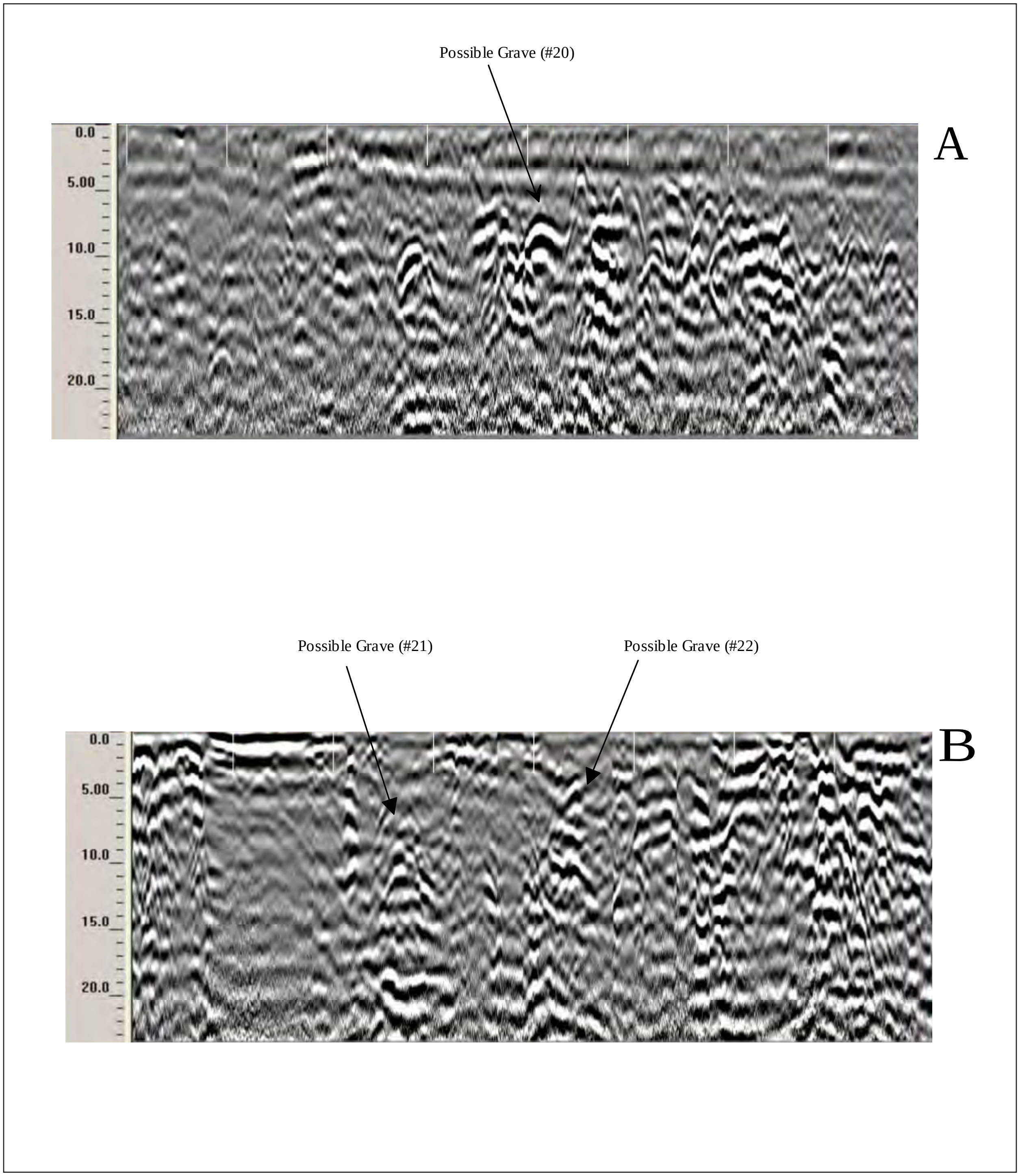


Figure 14.
GPR Profile for Anomalies 15 and 18

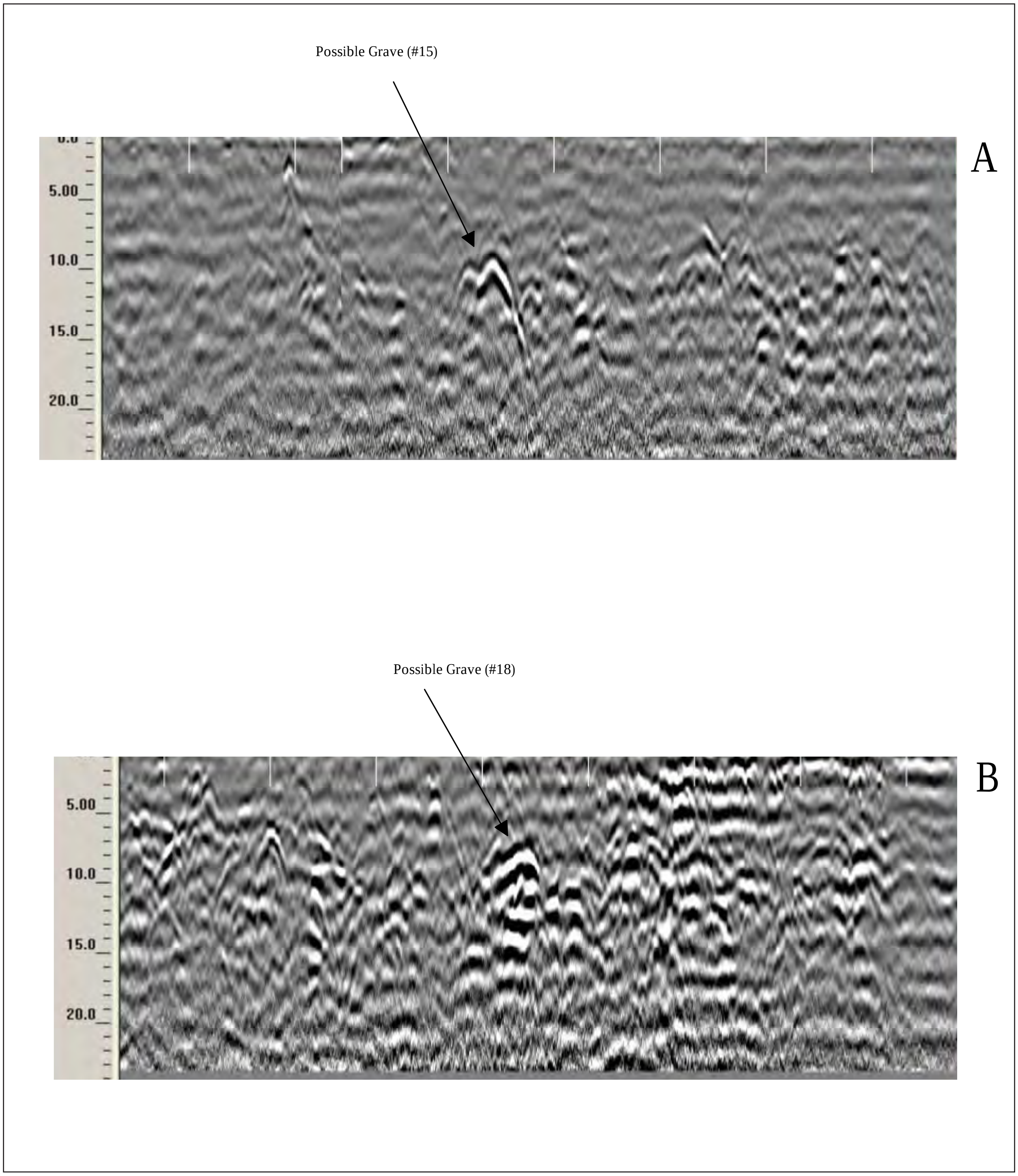


Figure 15.
GPR Profile for Anomaly 19

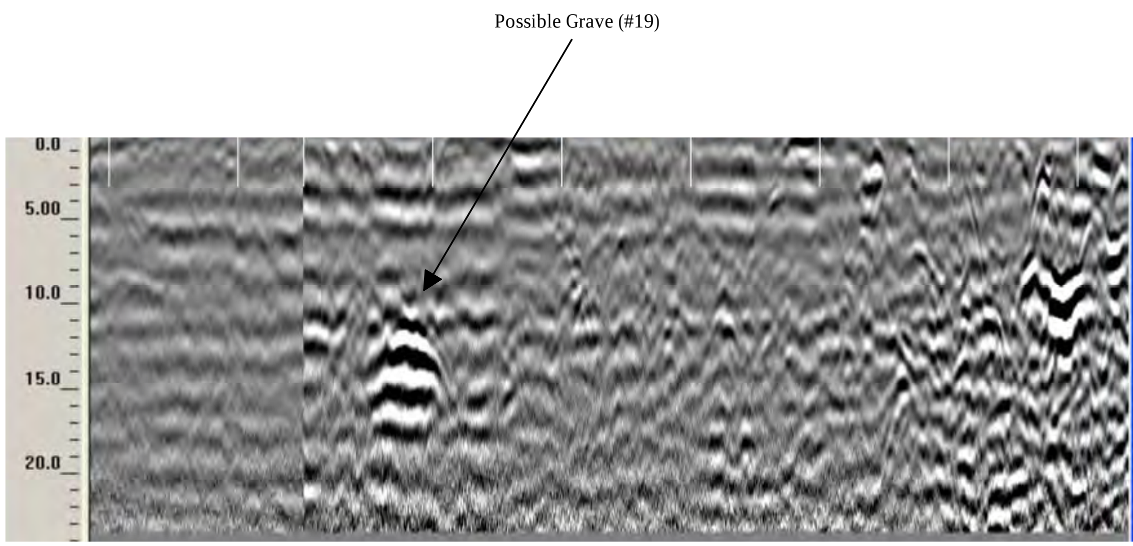
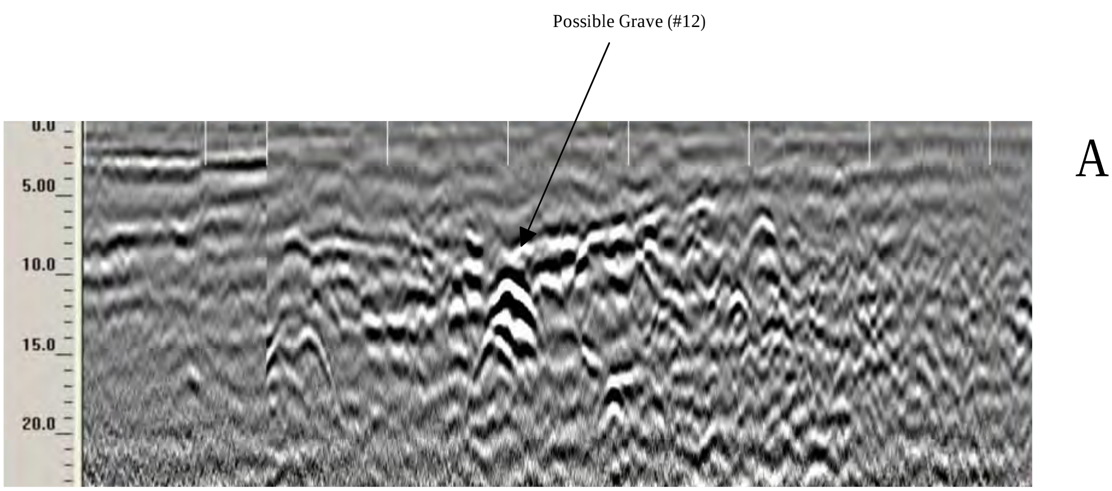


Figure 16.
GPR Profiles for Anomalies 12 and 13



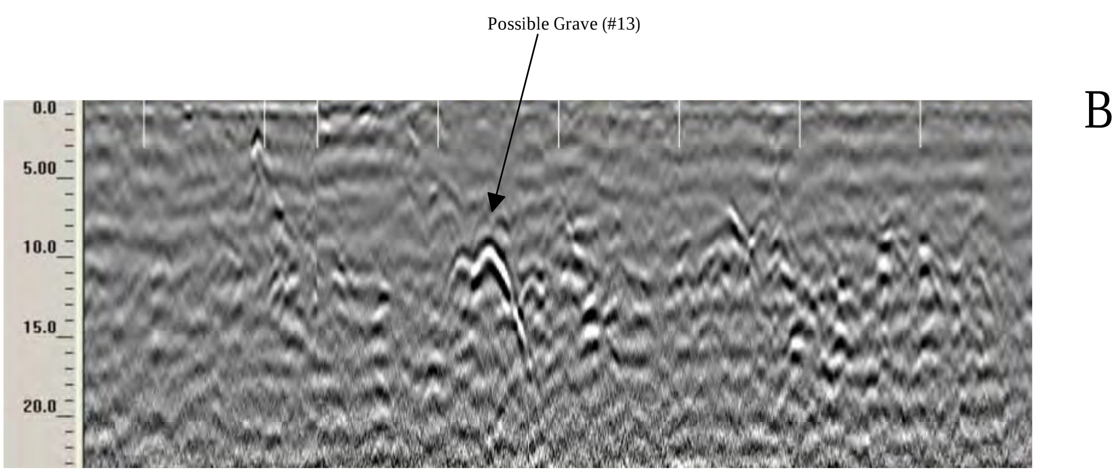


Figure 17.
GPR Profile for Anomalies 16 and 17

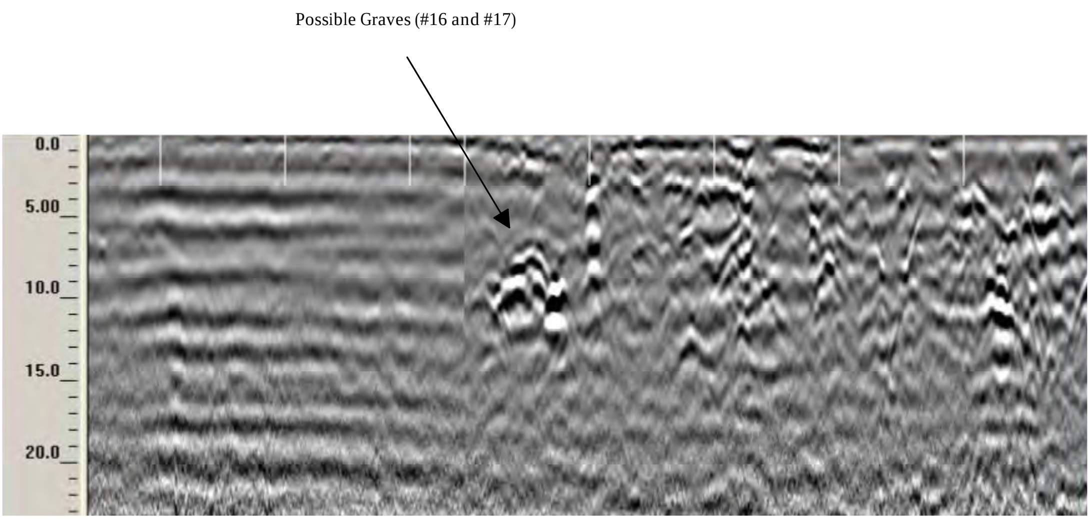
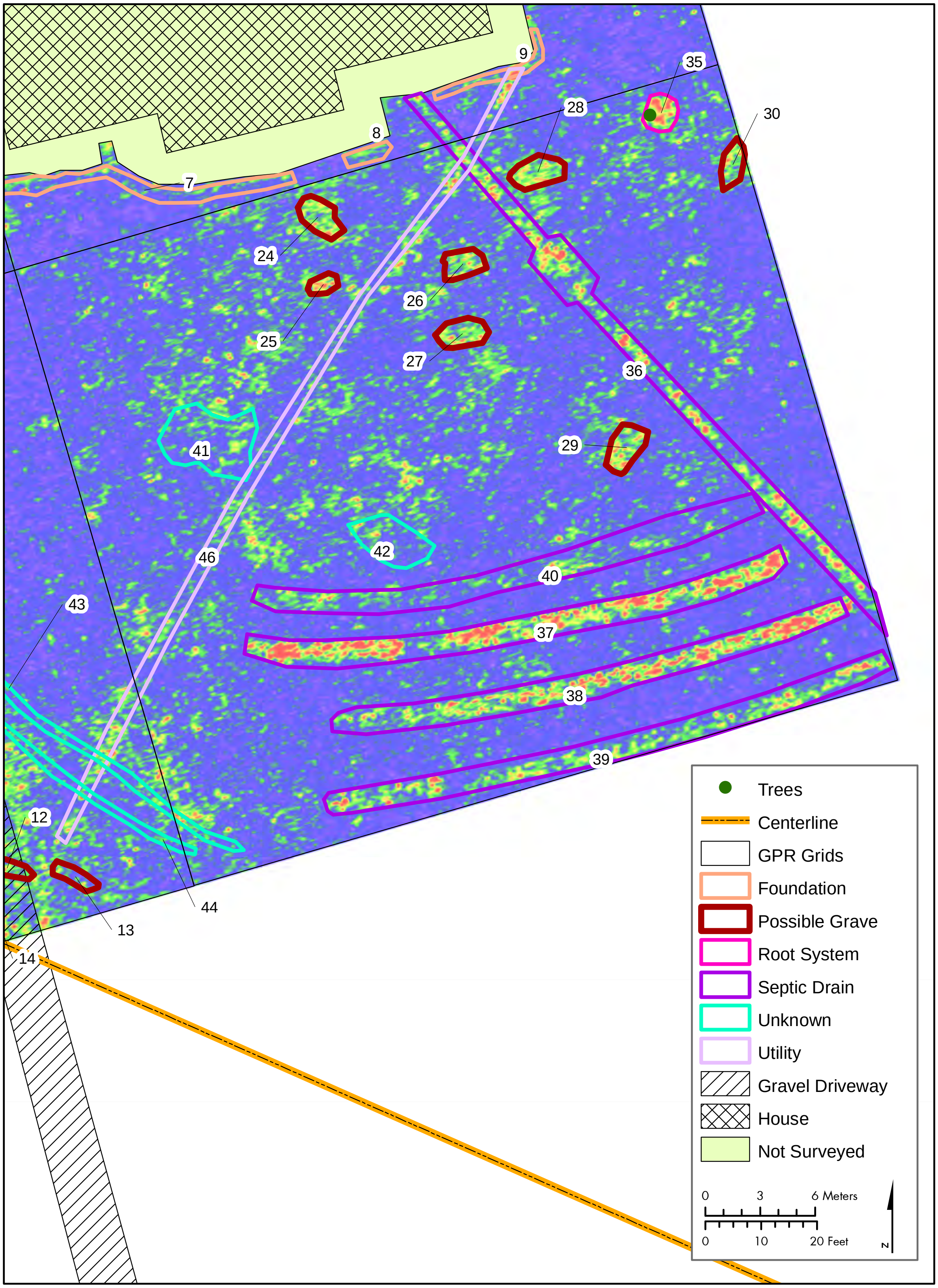


Figure 18.
Map Showing Possible GPR Graves in Cluster 2



consistent. Vertically, they appear strongest between 70 and 90 centimeters. In profile, these anomalies tend to be fainter and more difficult to see than those identified in Cluster 1 (Figure 19). The point reflections are slightly weaker and more diffuse. False positives cannot be ruled out, although it is difficult to speculate about what other types of features might cause these reflections.

SINGLE OUTLIER

This outlier consists of a single possible grave located in the rear yard of the Fowler residence (Anomaly 23) (Figure 20). Topographically it is situated on level, elevated ground. There are no trees or other surface obstructions that might have caused signal interference. Vertically, it is located between 70 and 90 centimeters. In plan view, it is rectangular or oblong and oriented northeast-southwest. In profile, it appears as a strong hyperbolic reflection in consecutive transects (Figure 21). These characteristics are all consistent with expectations for historic graves.

NON-MORTUARY FEATURES

UTILITIES (N=8)

Several utility lines are present in the survey area, all of which clearly lead to/from the Fowler residence (Figure 11). The front yard has an extensive sewer system, with an outlet pipe, septic tank, and associated drain lines (Anomalies 36-40). The outlet (Anomaly 36) leads from the southeast corner of the house to the drain lines (Anomalies 37-40), which are downslope from and roughly parallel to the house. In plan view, these are clearly visible in both datasets as high amplitude linear features. In profile, they appear as very strong hyperbolic reflections (Figure 22). Vertically, these are located between 30 and 50 centimeters.

Anomaly 46 is another likely utility that is oriented southwest through the front yard. It is narrower and of lower reflection and is associated with an unknown function. At 70-90 centimeters below surface, it is relatively deep compared to other utilities. In plan view, it is faint but discernable and in profile it appears as a series of low amplitude hyperbolas in consecutive transects.

Anomaly 45 is another utility located in the rear yard area that connects the house to a small pump house near the edge of the treeline. This likely serves to provide water from the well. It is buried between 30 and 50 centimeters. In plan view, it is clearly visible as a linear feature of low to moderate reflective strength. In profile, it appears as a hyperbolic reflection in consecutive transects.

Figure 19.
GPR Profiles for Anomalies 24, 25, and 29 in Cluster 2

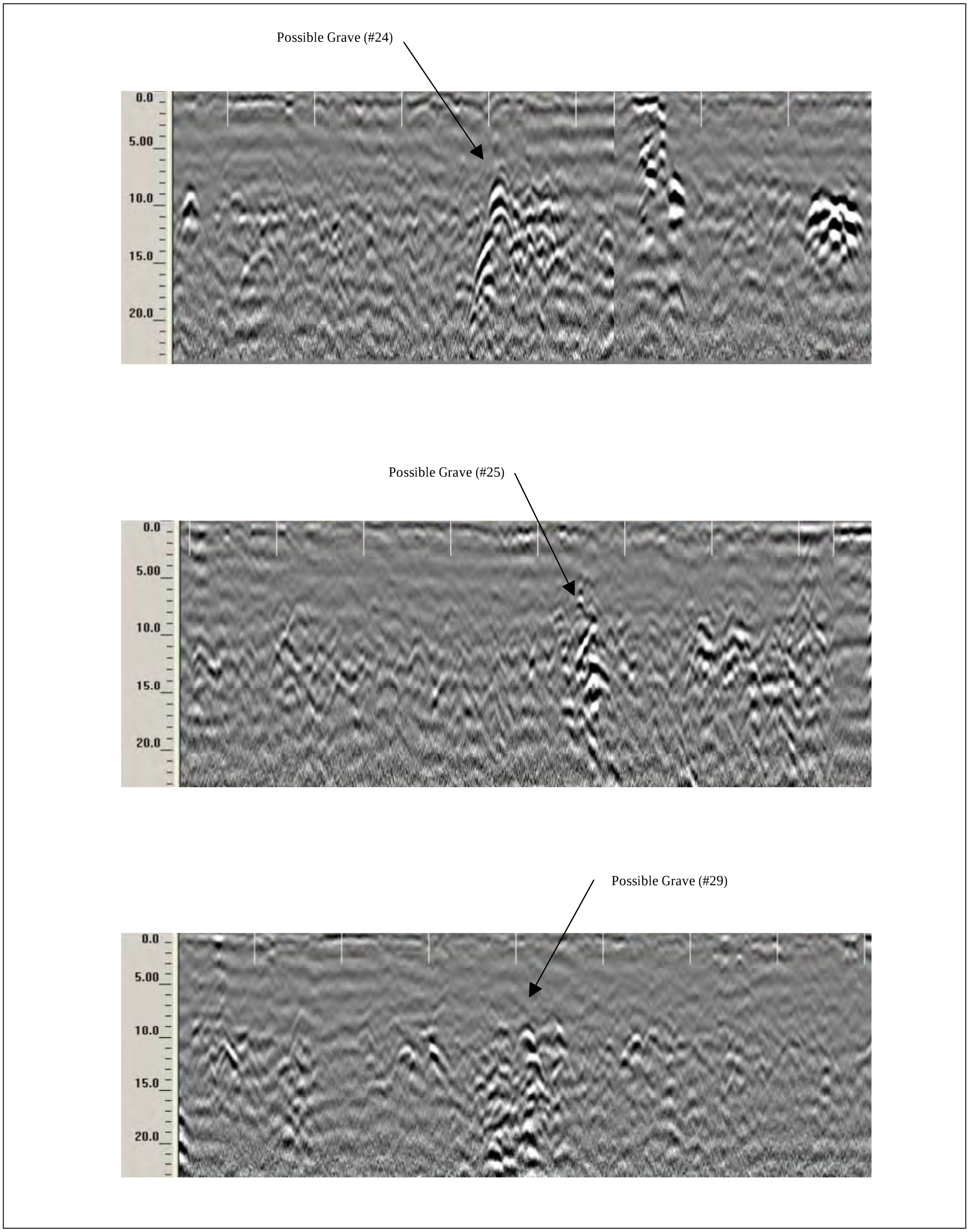


Figure 20.
Map Showing Possible Grave in Cluster 3

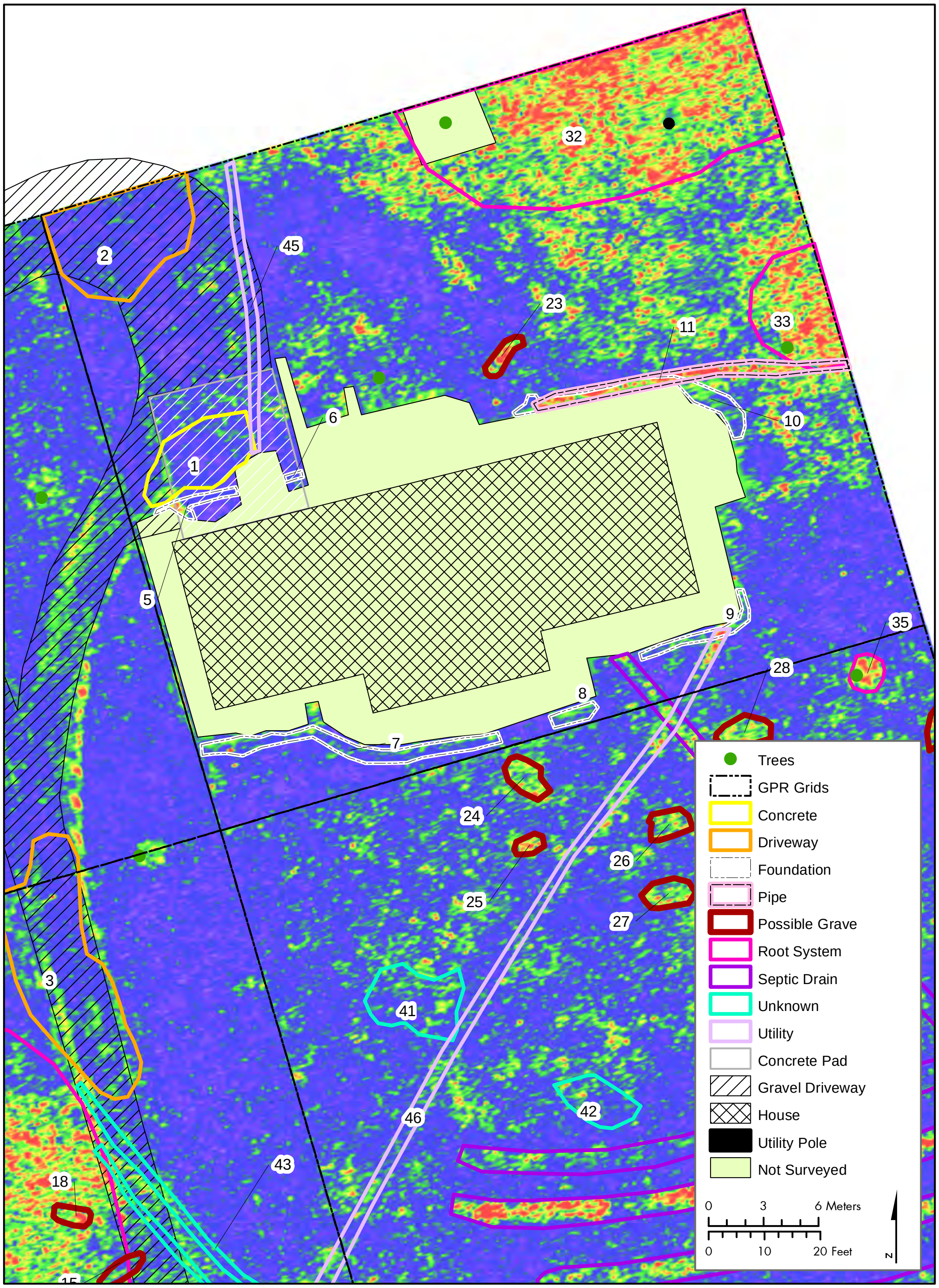


Figure 21.
GPR Profile for Anomaly 23

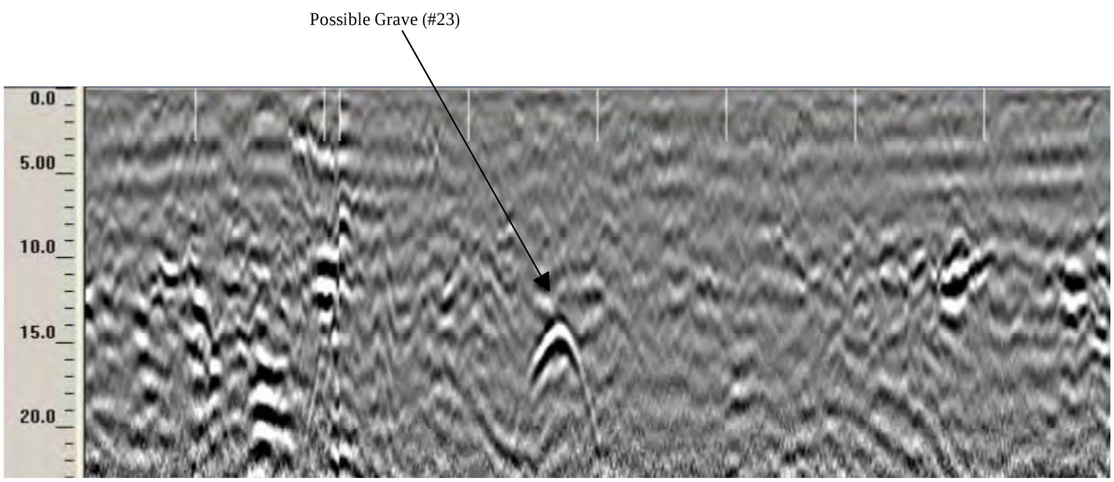
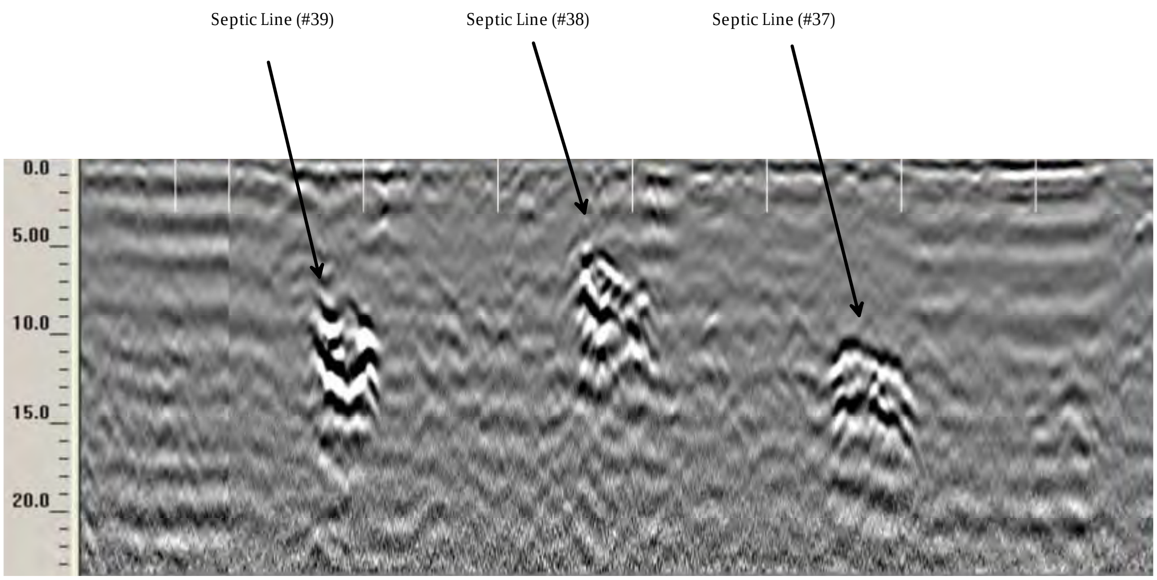


Figure 22.
GPR Profile Showing Septic System Features



Anomaly 11 is a probable fourth utility that leads eastward from the northeast corner of the house. It is buried between 70 and 90 centimeters. In profile, the hyperbolic reflection is consistent with a pipe. This could serve a drainage function.

DRIVEWAY (N=3)

The driveway is clearly visible as a near-surface feature in both GPR datasets because of its physical differences from the surrounding soil (Figure 11). GPR Anomalies 2-4 were identified as driveway related reflections, but below surface. Based on their size, shape, and reflective characteristics, these likely represent areas of pooled water or localized soil differences.

BUILDING ELEMENTS (N=7)

GPR results indicate a series of consistent anomalies located around the perimeter of the house and its associated landscaping beds (Anomalies 5-10) (Figure 11). These appear as different segments depending on their reflective strengths. In certain cases (e.g., near the concrete pad and garage), they appear to represent portions of the foundation or possibly construction zones. In other cases (e.g., front of house) where the landscaping beds are wide, the reflections may represent soil or moisture changes. Either way, these are clearly associated with the house. GPR Anomaly 1 is a concrete pad associated with the garage.

AGRICULTURAL FIELD

The agricultural field on the western side of the survey area is clearly visible in the GPR data. Plowing has resulted in changes in the sub-surface setting that appears as a series of streaks.

ROOT SYSTEMS (N=5)

Several areas were identified representing prominent and extensive root systems (Anomalies 31-35) (Figure 11). The most obvious are located around the extant markers in the southwest quadrant and along the northern survey boundary adjacent to the tree line. Two additional areas were also recorded along the eastern edge of the survey area that are associated with specific trees. These tend to be relatively shallow vertically (10-30 centimeters) and extensive horizontally (i.e., they cover a broad area). In profile, tree roots tend to appear as very sharp hyperbolic reflections with very long tails.

In certain cases, it was also possible to identify specific networks of individual tree roots. Although these were not recorded as distinct GPR anomalies, they were included on maps of the project area.

UNKNOWN (N=4)

Several GPR anomalies were identified that could not be clearly associated with a specific function or event. Anomalies 41 and 42 are both located in the front yard area at a depth of 30-50 centimeters. In plan view, they are approximately rectangular in shape and have clear boundaries. Anomaly 41 has a strong hyperbolic reflection at the bottom and more subtle reflections along its sides (Figure 23A). It is larger and better defined than a typical grave. The sides, or walls, are sloped, which gives the appearance of a depression or pit from an unknown origin.

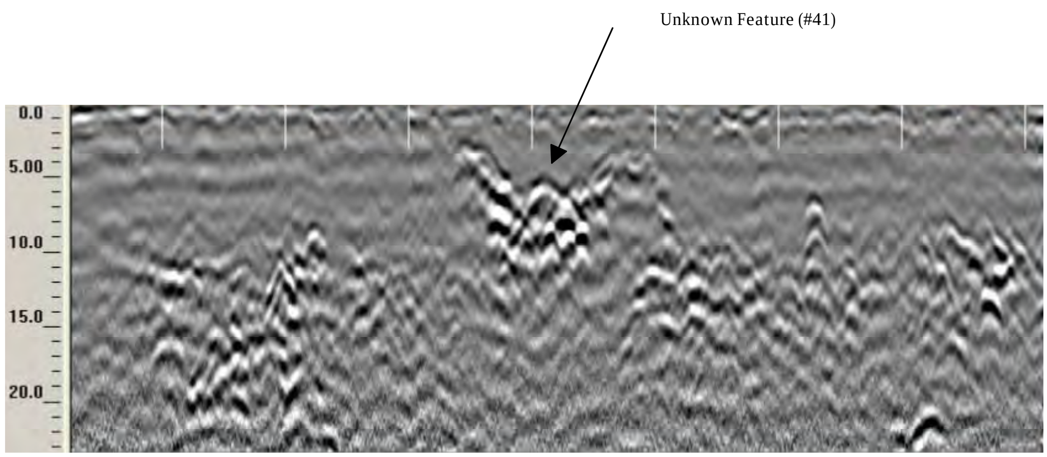
Anomaly 42 is slightly different in profile (Figure 23B). It appears more like a buried surface rather than a depression. There is a series of small, repeating hyperbolic reflections that are not as clearly defined. It is larger than a typical grave and has a different signature. This anomaly is less distinct and more diffuse, but still clear in the slice maps.

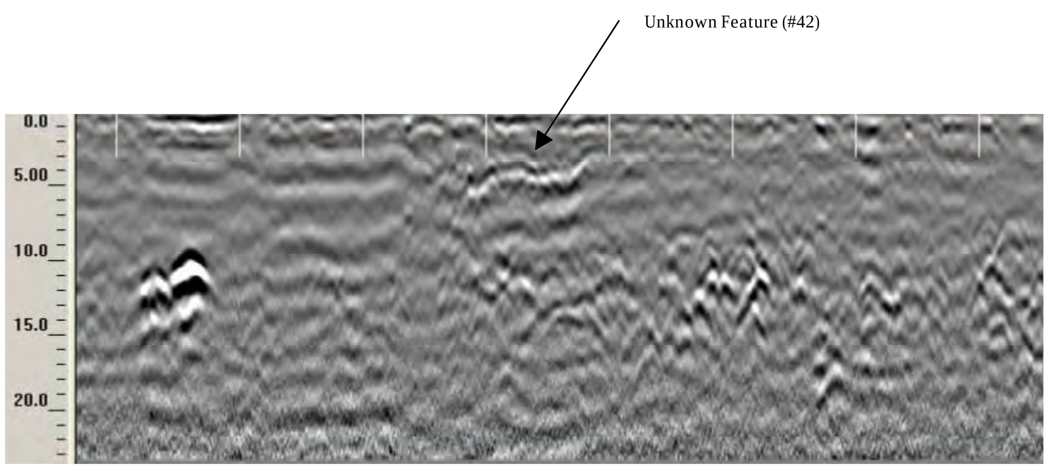
Anomalies 43 and 44 are located in the southern portion of the survey area (Figure 11). They are long, linear, parallel, and very faint in the GPR data. Vertically, they are located between 30 and 50 centimeters. They do not appear to be utilities because of their low reflective values and lack of association with any structures or buildings. Although there is no evidence to support this possibility, they are reminiscent of what might be expected from a former road.

DISCUSSION

Analysis of the 400MHz dataset did not yield evidence for possible graves. However, the 900MHz dataset produced 19 possible graves. In most cemetery applications, a 400MHz antenna is sufficient for identifying graves and it is better suited for greater depths. The circumstances at the Hasty-Fowler-Secrest Cemetery indicate a relatively shallow profile with heavily eroded soils and bedrock close to the surface. For this reason, the 900MHz antenna with its better resolution and higher density sampling interval, produced better imagery of the subsurface conditions. Comparison of both datasets clearly indicates the 900MHz dataset was more useful for this particular setting. Evaluation of these results suggests that future cemetery GPR surveys should consider using a 900MHz antenna at least in addition to a 400MHz antenna.

Figure 23.
GPR Profiles of Selected Unknown Features





The high resolution GPR data clearly show buried anomalies, which indicates the instrument worked as expected. Despite the clay soils and shallow bedrock, there is virtually no background or environmental noise to interfere with identification and interpretation of potential features beyond those already noted. Therefore, it is not easy to reconcile the relatively low number of possible graves (n=19) against the 51 graves suggested by the archival record. Two possibilities are that additional graves were/are present beneath the 1991 house, or the archival record is mistaken.

RECOMMENDATIONS

The Hasty-Fowler-Secrest Cemetery contains six marked graves arranged in two rows of three graves each. Analysis of the GPR data indicates at least 19 features consistent with expectations for historic graves, two of which correlate with extant markers. The remaining 17 possible graves have no surface expression. The GPR features are clustered around extant markers, in the front yard of the Fowler residence, and a single anomaly in the rear yard.

New South Associates recommends that all possible burials identified through GPR, as well as though indicated by markers in the absence of an anomaly, be treated as burials for management purposes. All such anomalies should be considered potential human remains, and treated appropriately under North Carolina burial removal laws. It is also possible that additional graves are present that were not imaged with GPR. Field investigations to test the possible grave features should include mechanical scraping of the topsoil to expose grave shafts and outlines. In addition, if excavation verifies that the near-house anomalies are human graves, the area beneath the house should be examined for possible graves after the structure has been carefully removed.

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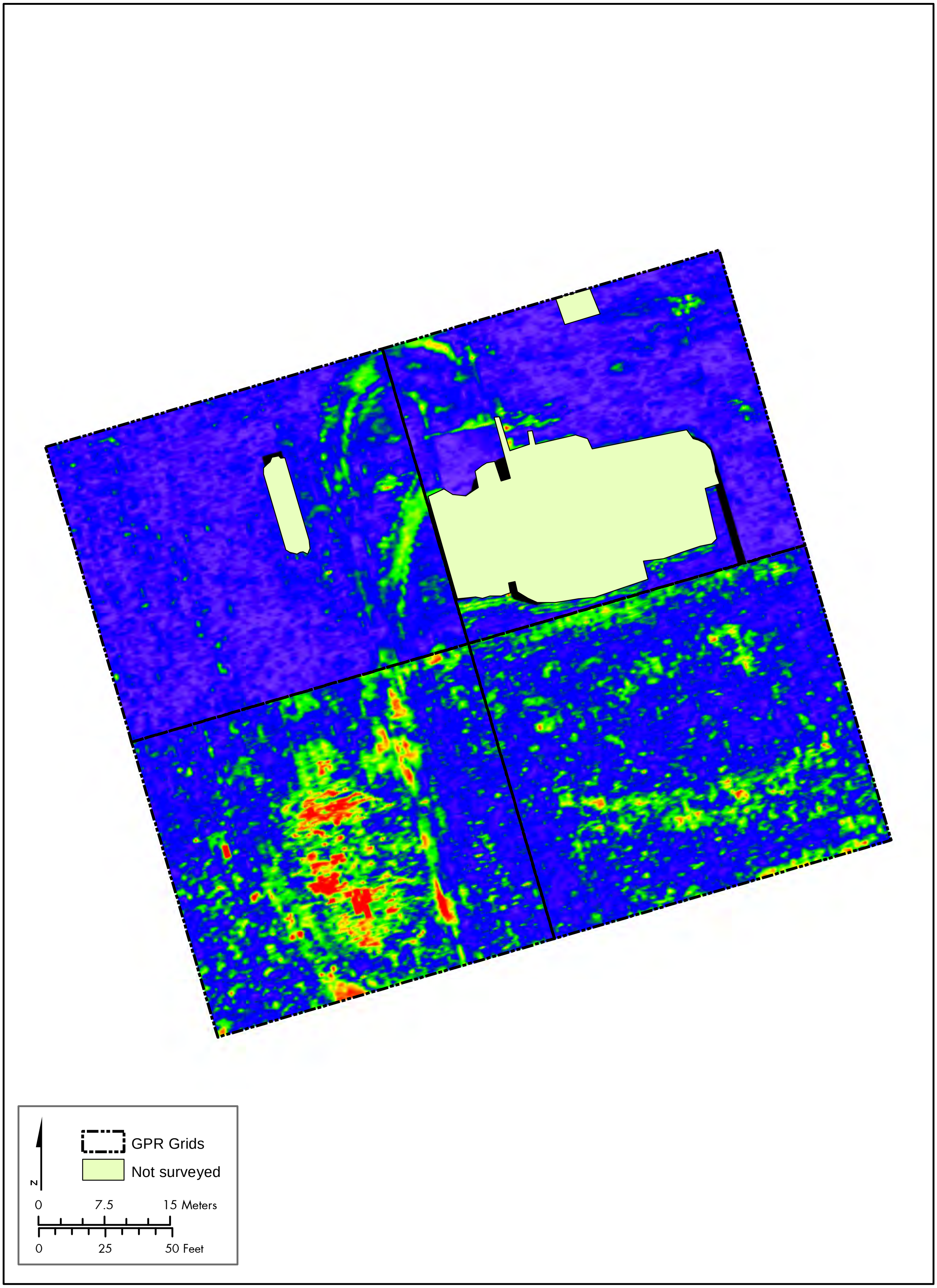
APPENDIX A: GPR AMPLITUDE SLICE MAPS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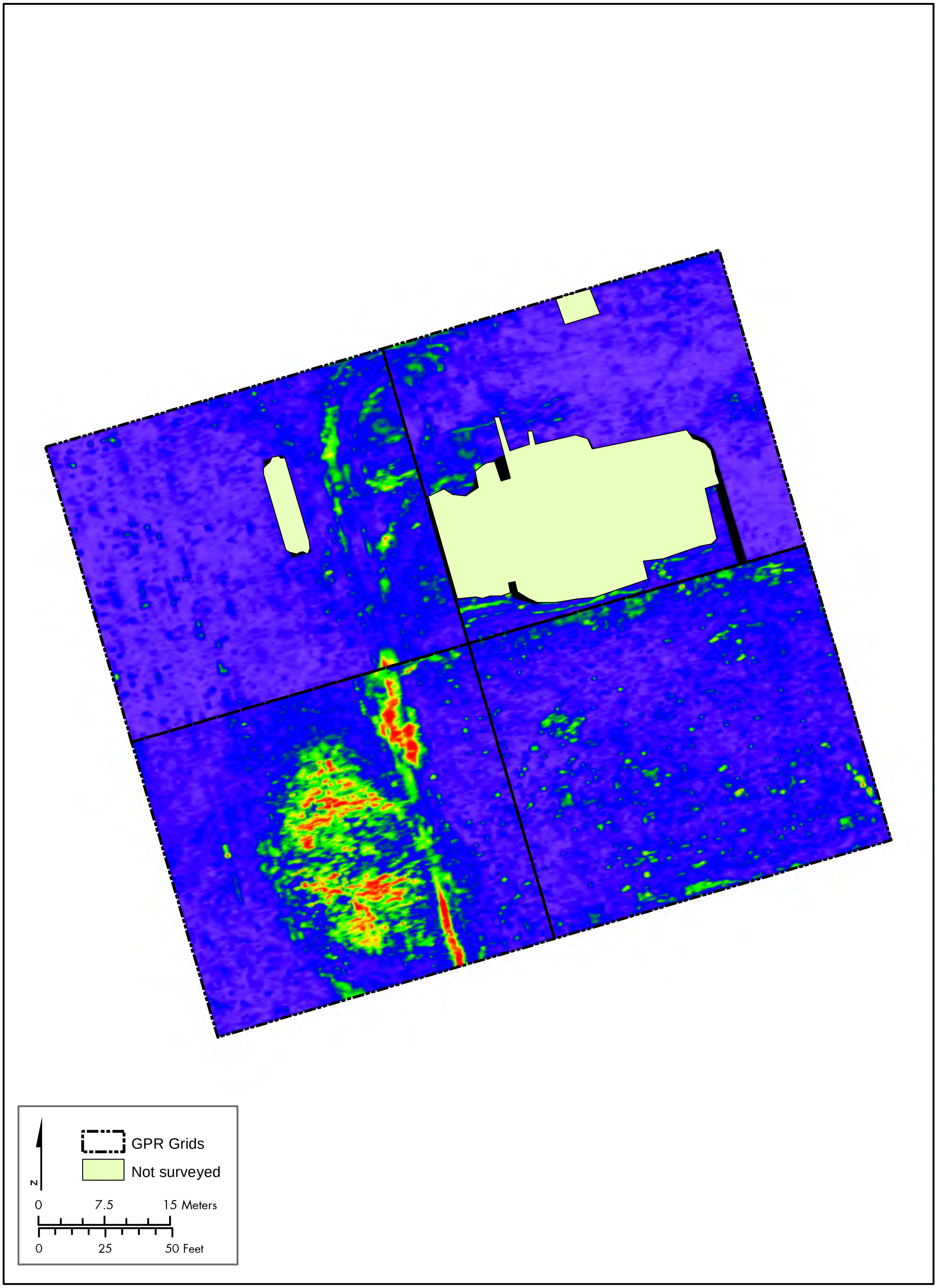
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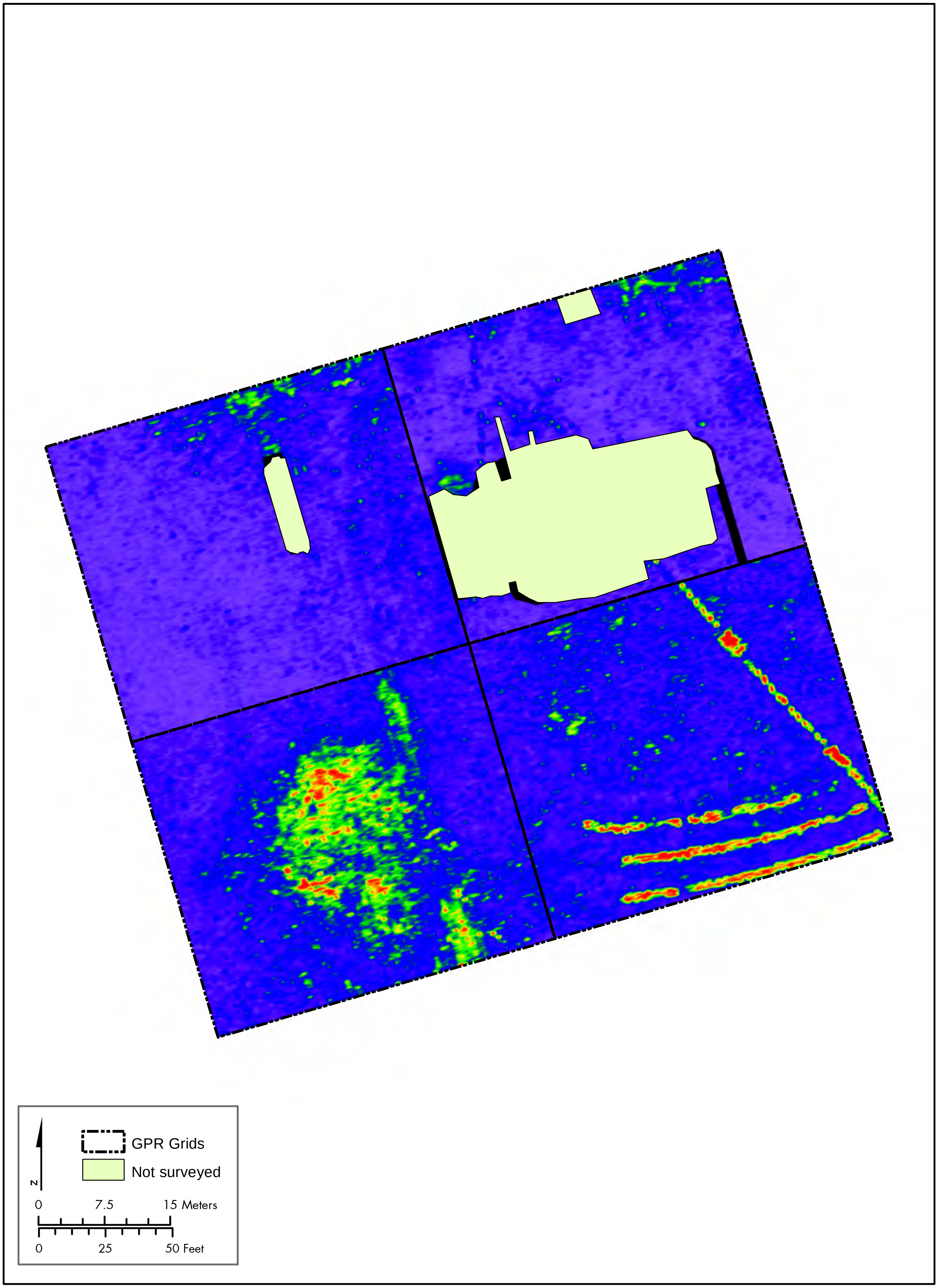
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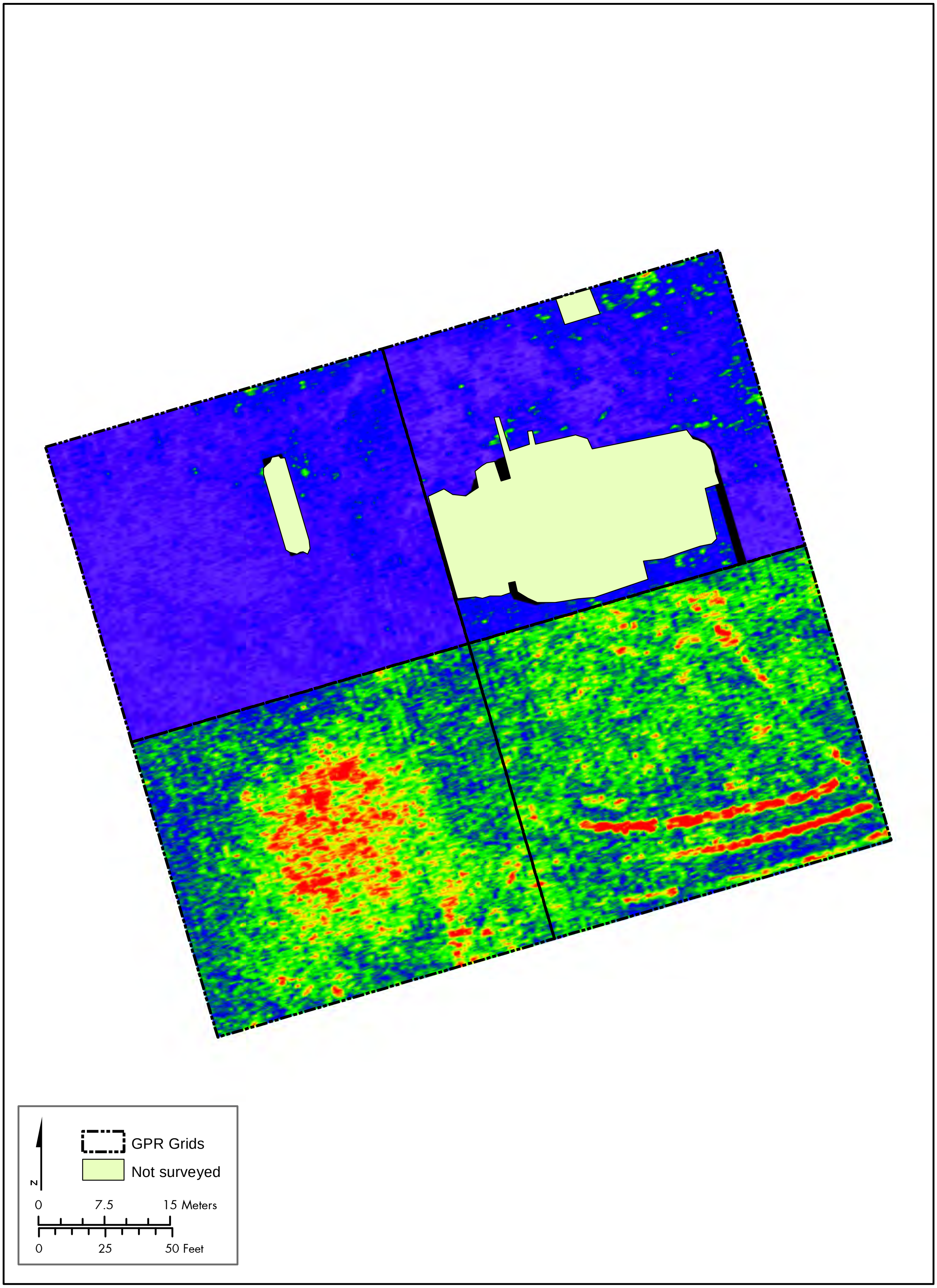
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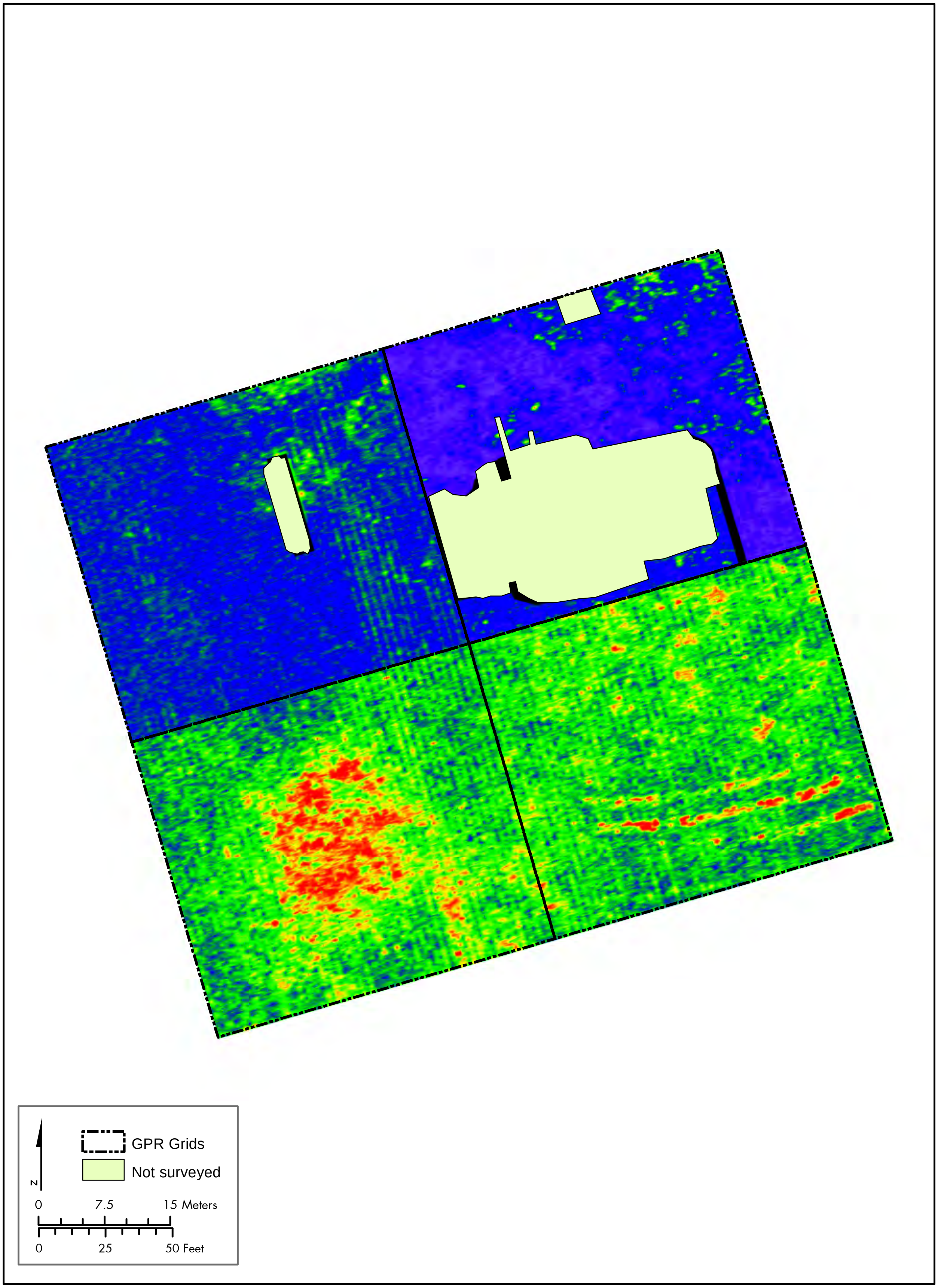
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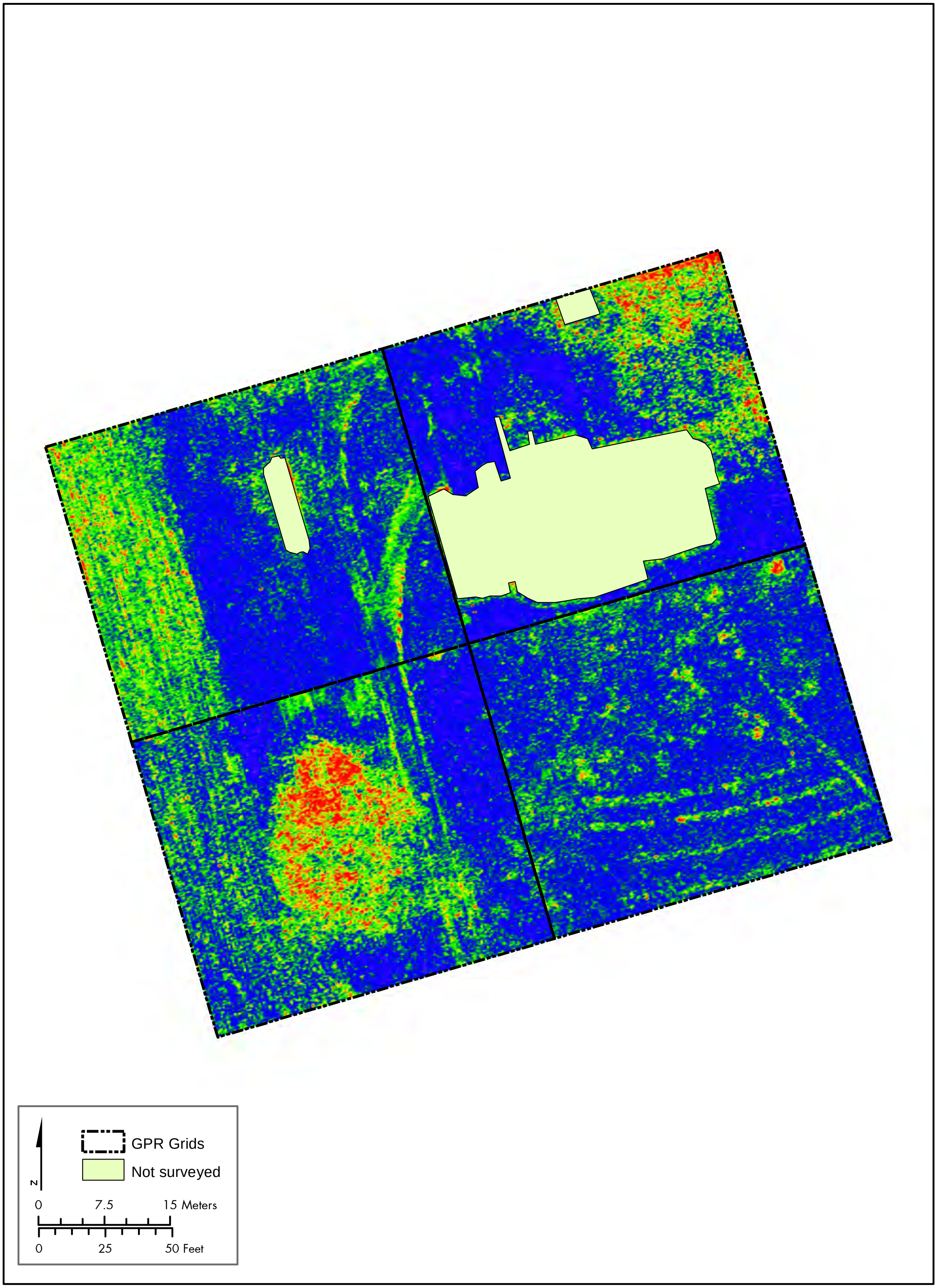
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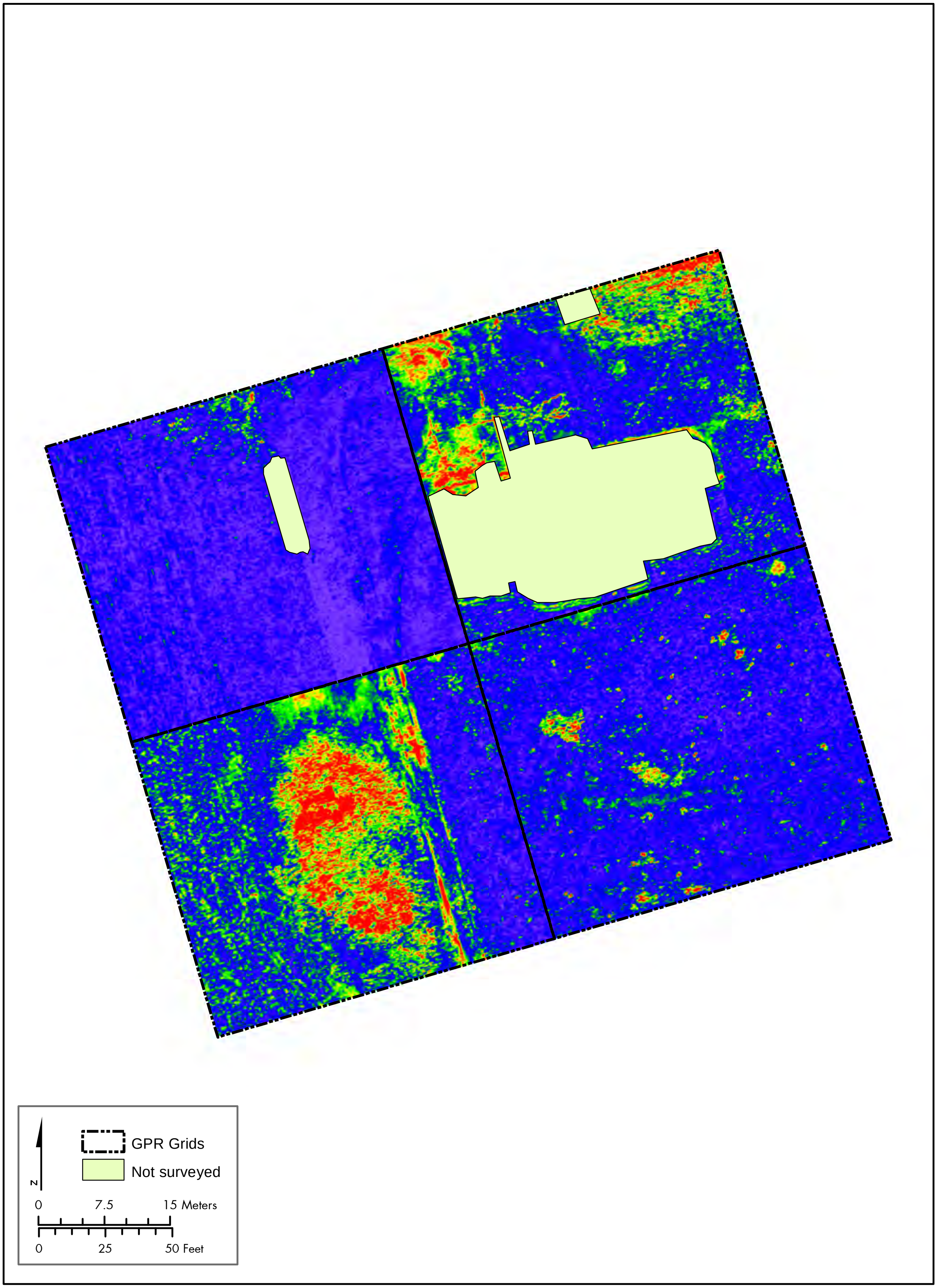
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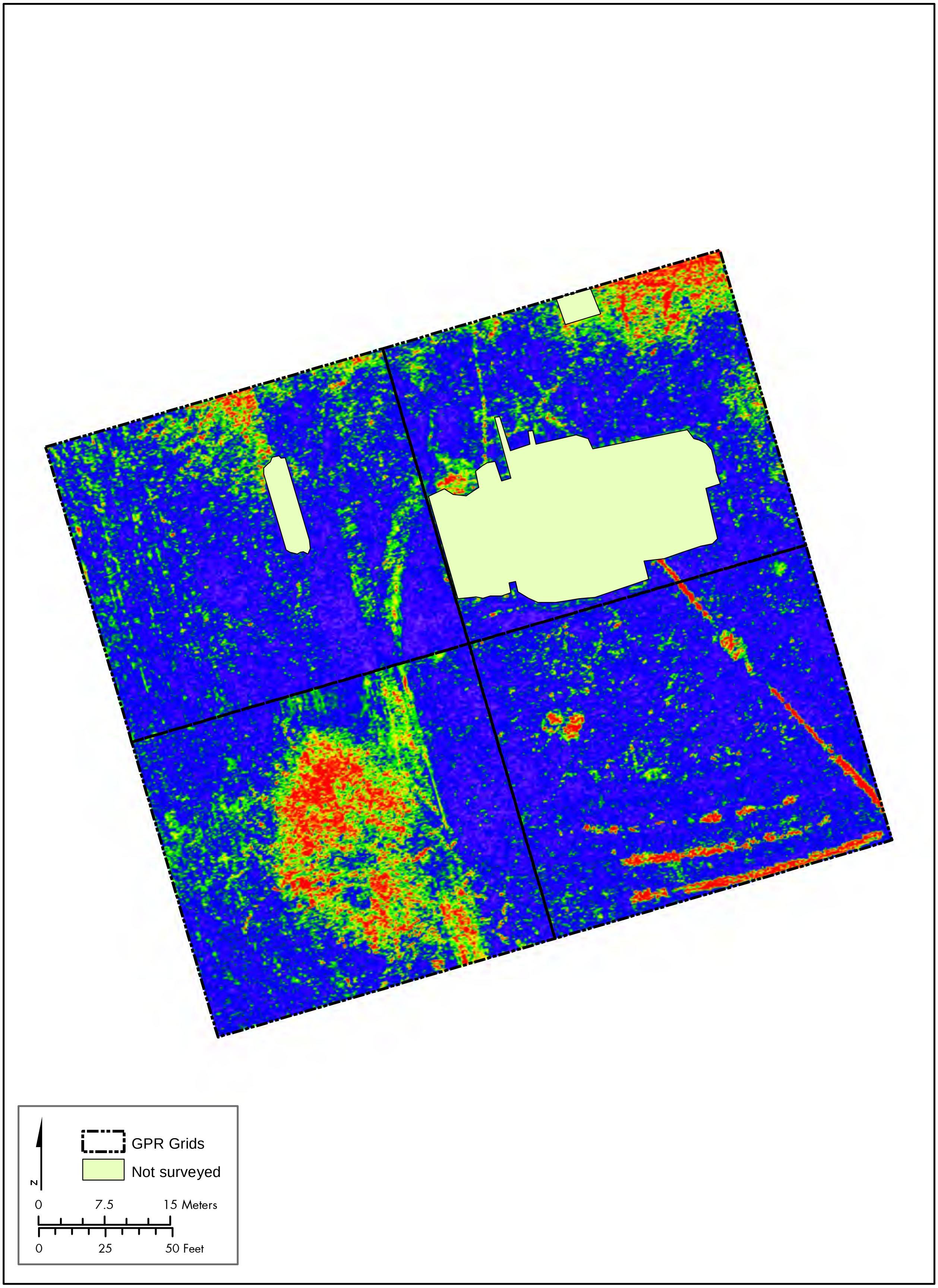

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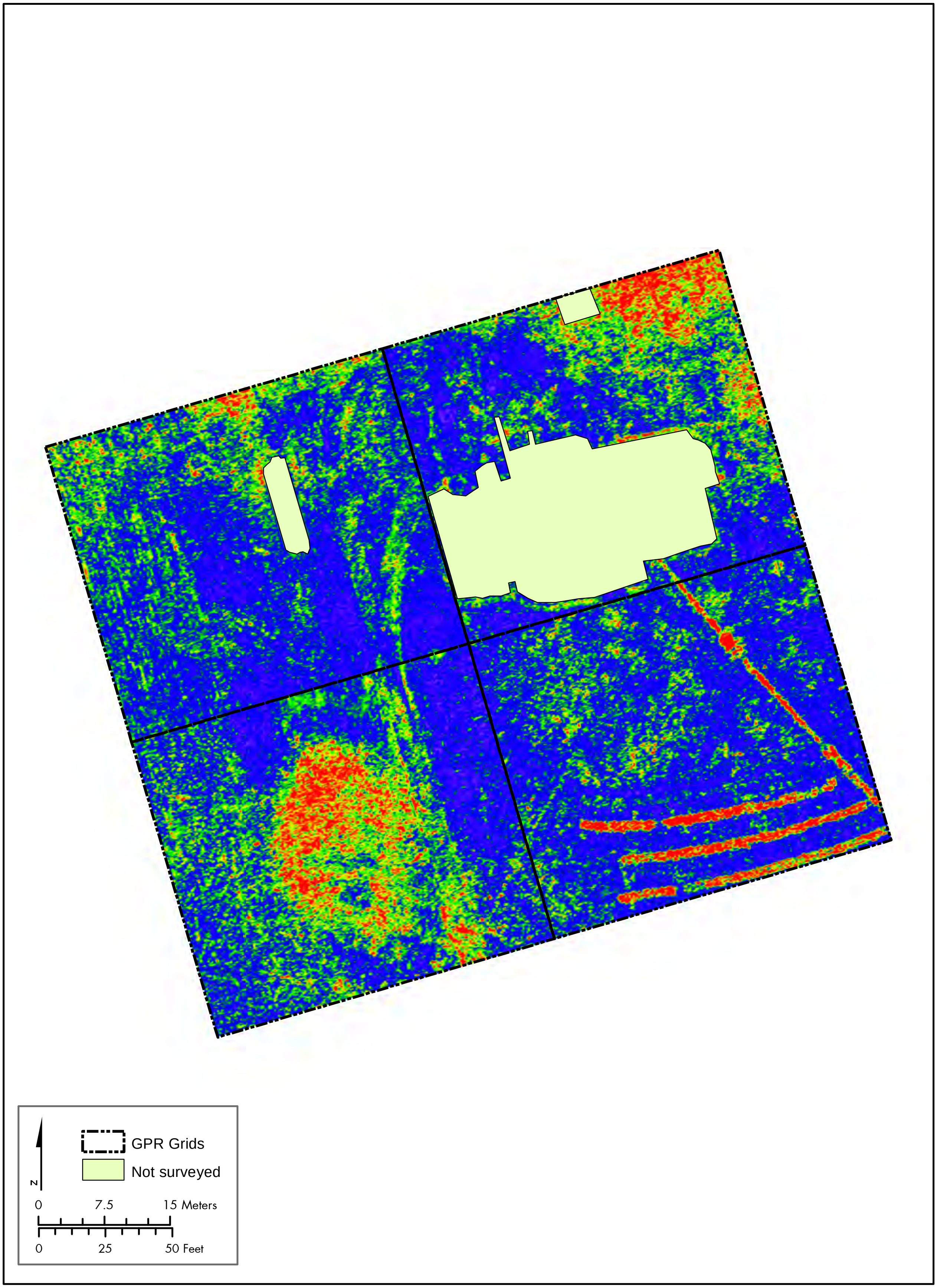
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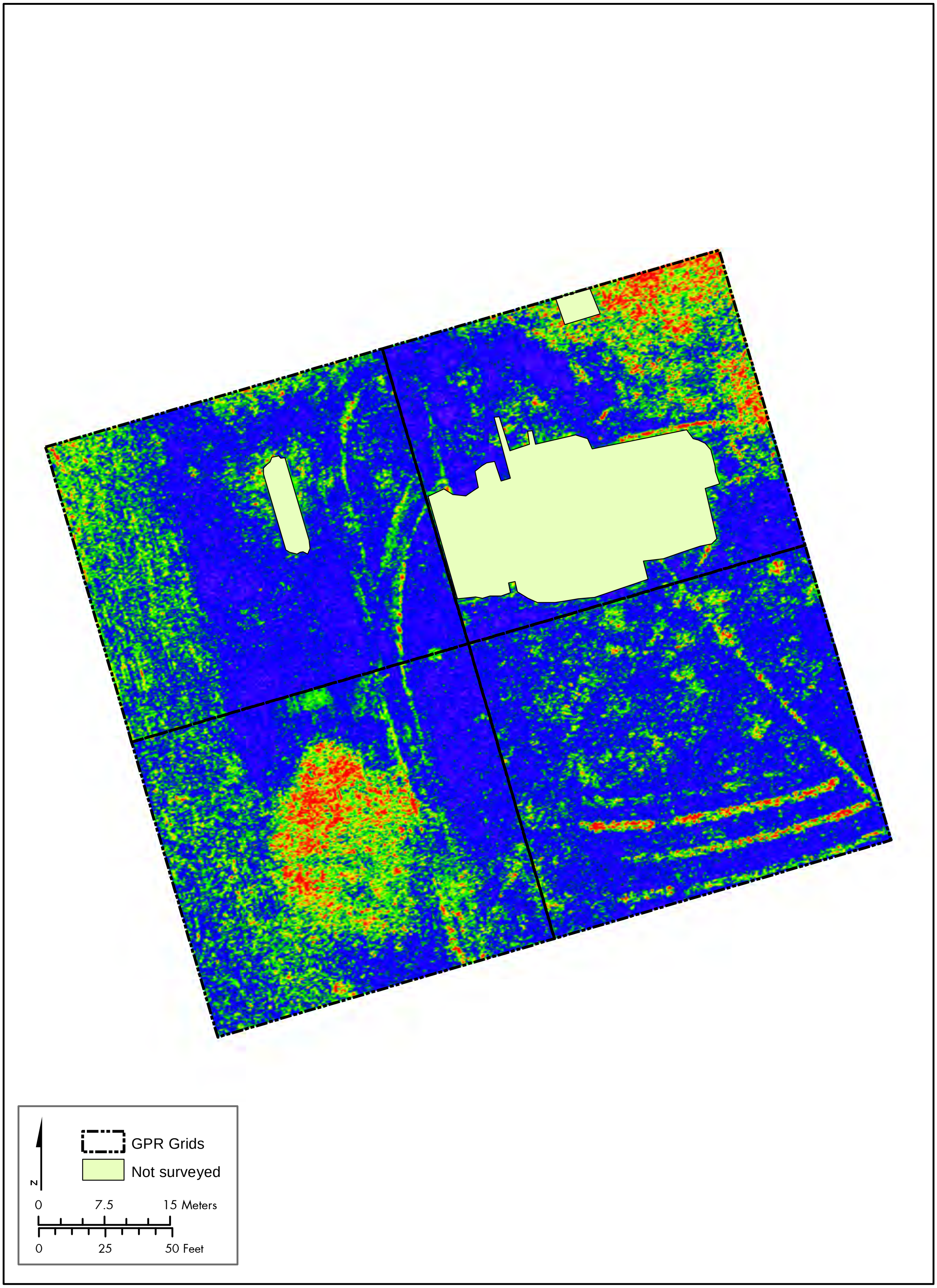
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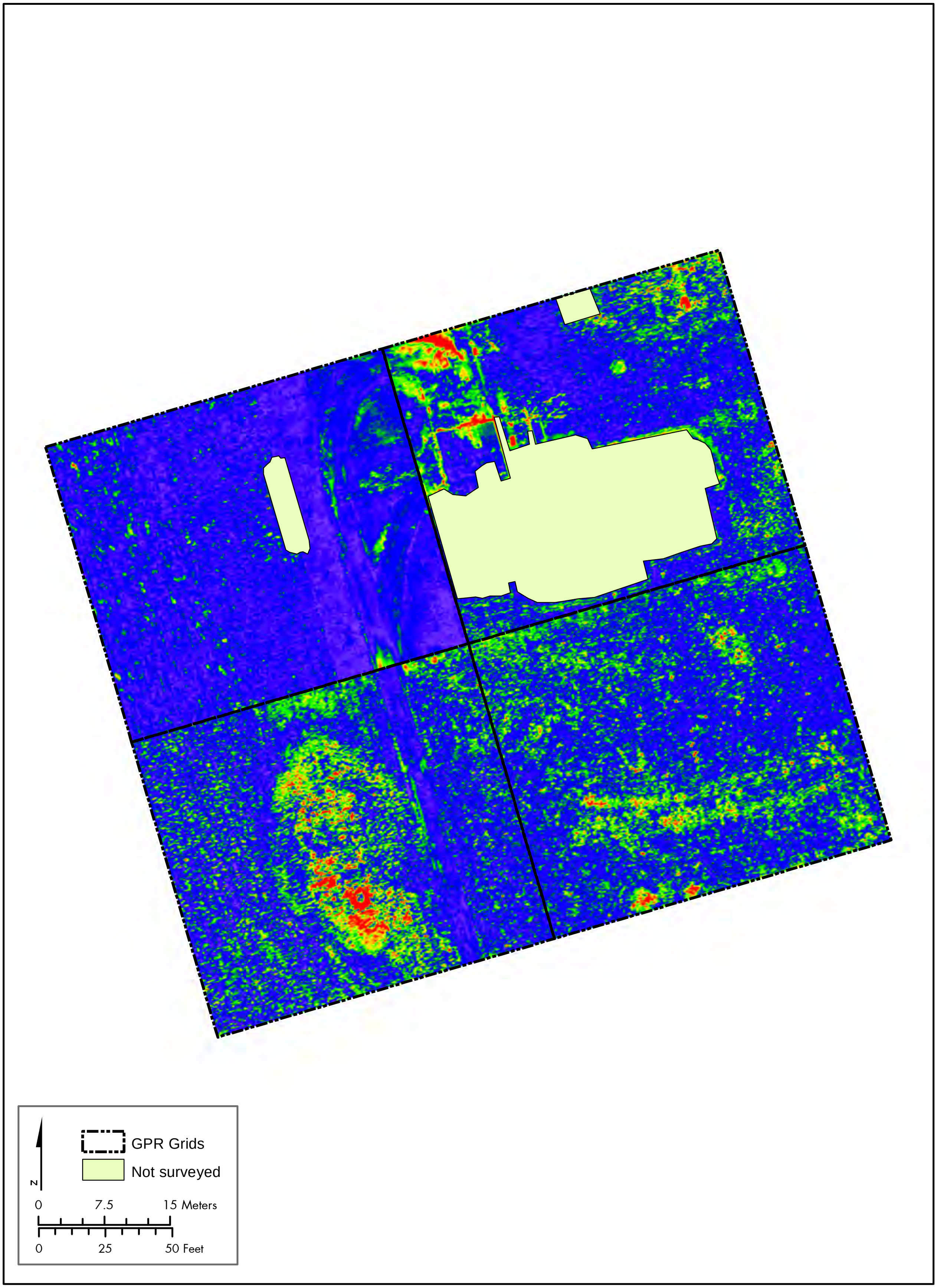
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