

SCDOT Investigations at the Meekins Cemetery (38ML213), May-June 2018

In February 2018, Mr. Peter Meekins reached out to archaeologists with the SC Department of Transportation (SCDOT) to inquire about the Meekins Cemetery, a small family cemetery located on the west side of Hebron Dunbar Road in Marlboro County. The cemetery had been located by another member of the Meekins Family, Mr. James Meekins, in the early 1990s, and was recorded by the Chicora Foundation as archaeological site 38ML213 in 1992. Based on Chicora's work it appeared that a portion of the cemetery extended into the Hebron Dunbar Road right of way (ROW), and it was because of this that Peter Meekins contacted SCDOT. Chicora also documented considerable modern disturbance to the cemetery from the creation of fire lines, powerline maintenance, and other factors. However, no work took place on the cemetery after 1992.

Following an initial investigation by members of the Marlboro County SCDOT Maintenance Office SCDOT archaeologists visited the site on May 3, 2018 to assess the potential for graves to be present within the ROW (33 feet from centerline). During this initial visit the cemetery was found to be heavily overgrown with briars and vines, but portions of three stone grave markers and a scattering of brick fragments apparently associated with a collapsed brick burial vault were partially exposed on the ground surface. At least one of the stone markers was confirmed to be within the ROW **(Figure 1)**.

Based on the poor condition of the cemetery and the presence of at least one marked grave within the ROW it was deemed highly probable that additional, unmarked graves might be present that were in jeopardy of being damaged by roadway maintenance activities. In order to determine if any unmarked graves were present New South Associates was commissioned to conduct a ground penetrating radar (GPR) survey of the land fronting the cemetery within the right of way.

On June 6, 2018, SCDOT archaeologists and Marlboro County DOT employees met at the cemetery to clear vegetation prior to the GPR survey **(Figure 2)**. An area measuring approximately 16x120 feet was chosen for the survey. The SW to NE dimensions of the survey area were determined by the edge of the roadway cut bank on the NE and edge of the ROW on the SW, with the addition of an approximately two meter buffer to the SW. The NW and SE edges of the survey area were situated so as to extend beyond the estimated limits of the cemetery as determined based on local topography, vegetation, and the extent of brick rubble and fill surrounding the extant markers. Historical aerial photographs of the cemetery vicinity were also utilized to postulate the boundaries of the site by measuring the extent of the area around the cemetery that was left unplowed and forested from year to year **(Figure 3)**. Vegetation within the GPR survey grid was hand cut to less than 4 inches above ground surface. This was done in order to ensure that the accuracy of the GPR equipment would not be impeded by above-ground obstructions **(Figure 4)**.

New South Associates conducted the GPR survey on June 7, 2018 **(Figure 5)**. As documented in the New South survey report, after processing the data a total of 24 probable graves were identified within the GPR study area. Of those, 17 probable graves were determined to be partially or completely located within the Hebron Dunbar Road ROW. The GPR data indicate that the maximum amount of disturbance, and likely the greatest concentration of graves are located in the core portion of the cemetery

surrounding the extant markers, but show potential grave locations across the full extent of the study area, all the way up to the northwestern and southeastern edges of the area. Thus, a definitive boundary for the cemetery could not be drawn based on the GPR data.

Conclusions and Recommendations

The Meekins Cemetery was found to be in very poor condition. Although the heavy growth of vegetation and necessity to confine the current investigation to the SCDOT ROW prevented a thorough evaluation of the cemetery, it appears that it has degraded further from the already deteriorated condition documented by the Chicora Foundation in 1992.

At least three partially intact markers remain in the cemetery (**Figures 6-8**). These markers lie flush to the ground but appear to be flat slabs or grave covers, rather than toppled over tombstones. Based on the fact that they retain an E-W orientation the markers appear to be on or near their original locations. This being said, the results of the GPR survey suggested that the markers may have been displaced slightly from their original spots. At least one of the markers extends into the Hebron Dunbar Road ROW.

Other than a scatter of bricks no remains of the brick burial vaults documented in the 1992 Chicora investigation were found. Either the vaults were beyond the study area and obscured by thick vegetation or they have completely collapsed since the 1992 work. It is also possible that the theft of bricks by local collectors, as documented in the Chicora report, continued after 1992.

Although the extant markers and remnant vegetation associated with the cemetery are confined to a small area, the GPR survey suggests that unmarked graves may be present for some distance to the northwest and southeast. However, ground truthing would be necessary determine if the anomalies recorded outside the core area of the cemetery are graves or are associated with some other disturbance. Also, because work during the current study was confined to the Hebron-Dunbar Road ROW, no attempt was made define the limits of the cemetery to the west. An important next step in preserving and protecting the cemetery would be to fully define its extent. Pending this, in the absence of more definitive information a tentative boundary has been assigned to the cemetery as a result of this revisit consisting of a 100 foot buffer placed around the visible cemetery remnants. Additional investigations may result in the expansion or contraction of this boundary.

In addition to a portion of the cemetery being within the ROW of Hebron Dunbar Road, a part of the cemetery lies within a powerline easement for a powerline that runs parallel to the road. As part of the current project the owner of the powerline, Duke Energy, was notified of the presence of the cemetery so that they could avoid it during their maintenance activities.

Additional protective measures anticipated include the placement of signs within the roadway right of way denoting the presence of the cemetery, and developing a protocol to ensure that the cemetery isn't damaged during ditch clearing operations or other roadway maintenance actions.

Site 38ML213 has also been assigned Above Ground Resource # 2735.



Figure 1 - Condition of the Meekins Cemetery on May 3, 2018.



Figure 2 – SCDOT crew clearing the GPR study area at the Meekins Cemetery on June 6, 2018.



Figure 3 – Forested area surrounding the Meekins Cemetery (Indicated by Arrow) as shown on a 1937 aerial photograph. Source: University of South Carolina Map Library.



Figure 4 – GPR study area after clearing on June 6, 2018.



Figure 5 – Archaeologists with New South Associates conducting GPR Survey, June 7, 2018.



Figure 6 - Unidentified Grave Marker within the SCDOT Right of Way.



Figure 7 - Grave Marker of Thomas Meekins Outside of the SCDOT Right of Way



Figure 8 - Unidentified Grave Marker Outside of the SCDOT Right of Way



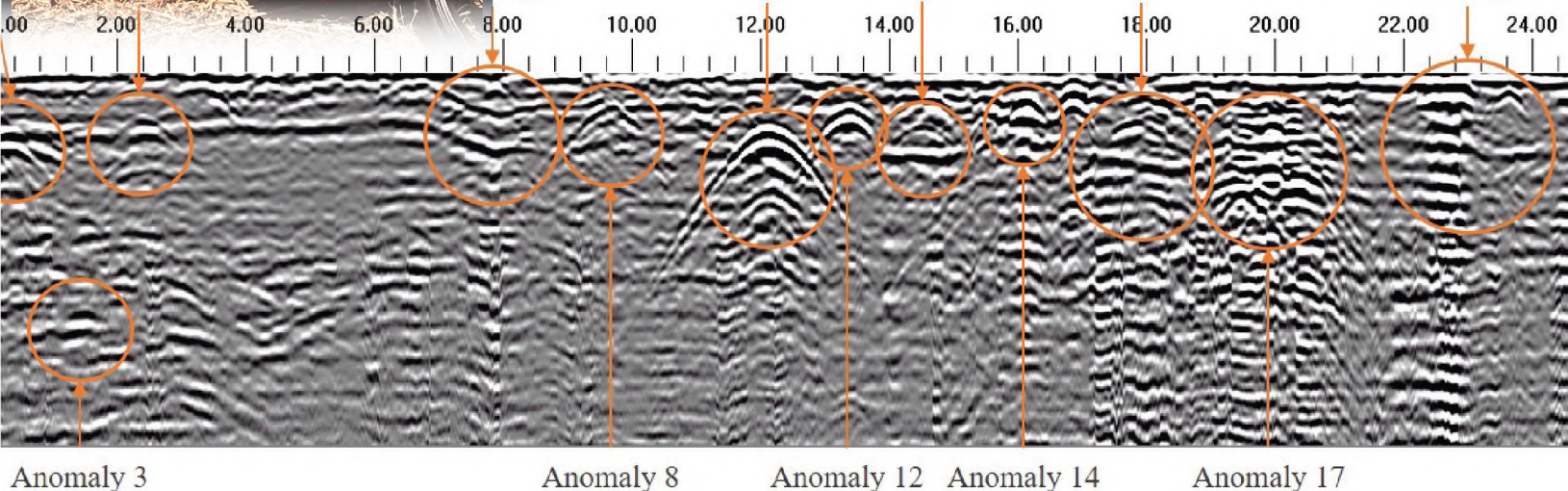
Figure 9 – Location of Grave Marker within the SCDOT Right of Way. Mr. Peter Meekins is shown examining the marker.

GROUND-PENETRATING RADAR SURVEY OF THE **MEEKINS CEMETERY** **(38ML213)**

at the Right of Way of
Hebron Dunbar Road

MARLBORO COUNTY, SOUTH CAROLINA

New South Associates, Inc.



Ground-Penetrating Radar Survey of the Meekins Cemetery (38ML213) at the Right of Way of Hebron Dunbar Road

Marlboro County, South Carolina

Report submitted to:

South Carolina Department of Transportation • Environmental Services
955 Park Street • Columbia, SC 29201-3959

Report prepared by:

New South Associates • 6150 East Ponce de Leon Avenue • Stone Mountain, Georgia 30083



Shawn Patch, M.A., RPA – Principal Investigator

Maeve Herrick, RPA – Archaeologist and Author

July 9, 2018 • **Draft Report**
New South Associates Technical Report 2856

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ABSTRACT

New South Associates, Inc. (New South) conducted a ground-penetrating radar (GPR) survey of a 0.05-acre section of the Meekins Cemetery (38ML213) in Marlboro County, South Carolina. The survey area comprises a portion of the cemetery where it intersects the right-of-way (ROW) of Hebron Dunbar Road (S-35-23) along with a two-meter buffer. The survey located 24 probable individual graves. Seventeen of the probable graves are partially or completely within the ROW. New South recommends that the 24 GPR anomalies identified as probable graves should be treated as such and protected from further damage. Extreme care should be taken if ground disturbance is planned along the shoulder of Hebron Dunbar Road (S-35-23), as there are probable graves within approximately five meters of the road. If avoidance is not possible, then additional steps should be taken to relocate the graves in compliance with South Carolina statutes.

ACKNOWLEDGEMENTS

New South Associates thanks Bill Jurgelski and Tracy Martin of SCDOT for their assistance, and the Marlboro County Maintenance Office, who cleared the dense vegetation from the cemetery prior to our survey. The support of Peter Meekins during data collection was appreciated.

TABLE OF CONTENTS

ABSTRACT	i
ACKNOWLEDGEMENTS.....	ii
TABLE OF CONTENTS	iii
LIST OF FIGURES AND TABLE.....	iv
 I. INTRODUCTION	 1
 II. METHODS	 7
SURVEY GRID AND MAPPING.....	7
GROUND-PENETRATING RADAR (GPR).....	7
FIELD METHODS.....	9
DATA PROCESSING	9
GPR IN CEMETERIES	11
 III. RESULTS AND RECOMMENDATIONS.....	 13
 REFERENCES CITED	 25

LIST OF FIGURES AND TABLE

Figure 1.	Location of GPR Survey.....	2
Figure 2.	GPR Data Collection	3
Figure 3.	Chicora Foundation Map of Cemetery (1992).....	4
Figure 4.	Map of Survey Area and Approximate Cemetery Boundary	5
Figure 5.	GPR Survey Grid	10
Figure 6.	Map of the Surveyed Area Showing Identified Probable Graves and Right-of-Way	14
Figure 7.	Amplitude Slice Map from 0-30 Centimeters Below Surface (cmbs)	15
Figure 8.	Amplitude Slice Map from 30-60 cmbs	16
Figure 9.	Amplitude Slice Map from 60-90 cmbs	17
Figure 10.	Amplitude Slice Map from 90-120 cmbs	18
Figure 11.	Amplitude Slice Map from 120-150 cmbs	19
Figure 12.	Amplitude Slice Map from 150-180 cmbs	20
Figure 13.	Amplitude Slice Map from 180-210 cmbs	21
Figure 14.	Example of Probable Graves in Profile	22
Table 1.	GPR Anomalies.....	13

I. INTRODUCTION

New South Associates, Inc., (New South) conducted a ground-penetrating radar (GPR) survey of a section of the Meekins Cemetery (38ML213) in Marlboro County, South Carolina (Figure 1). The purpose of the survey was to identify unmarked graves within the right-of-way (ROW) of Hebron Dunbar Road (S-35-23). The area covered by the GPR survey consisted a 0.05-acre section of the eastern portion of the cemetery where it overlaps the ROW and a two-meter buffer (Figure 2).

The Meekins Cemetery (38ML213) is a family burial ground with graves dating to the eighteenth and nineteenth centuries (Adams and Trinkley 1992:4, 7). The cemetery's condition was assessed in 1992 by the Chicora Foundation at the request of James Meekins, who had observed that the cemetery had been damaged by construction equipment. The map of the cemetery produced by Chicora Foundation indicates that considerable damage has occurred to the cemetery since that assessment (Figure 3). Currently, there are markers and brick fragments scattered in the center part of the survey area. The brick fragments are the remnants of brick vaults that are no longer discernible (Adams and Trinkley 1992:2). One broken marker was recorded within the ROW (Figure 4). The present GPR survey was intended to identify and document any graves within the ROW to assist in planning for their protection from further damage.

The USDA mapped one soil within the cemetery: Noboco loamy sand, 2- 6 percent slopes, which consists of well-drained silty loamy sand (Morton 2006:101). Maeve Herrick and Colin Bean conducted fieldwork for this GPR survey on June 7, 2018. The interpreted results included the identification of 24 probable graves. Seventeen of the probable graves are partially or completely within the ROW. New South recommends that the 24 GPR anomalies identified as probable graves should be treated as such.

The report is divided into three chapters. Chapter I introduces the investigation and describes the project setting. Chapter II outlines the methods employed during the field investigations and Chapter III discusses the field investigation results and recommendations.

Figure 1.
Location of GPR Survey

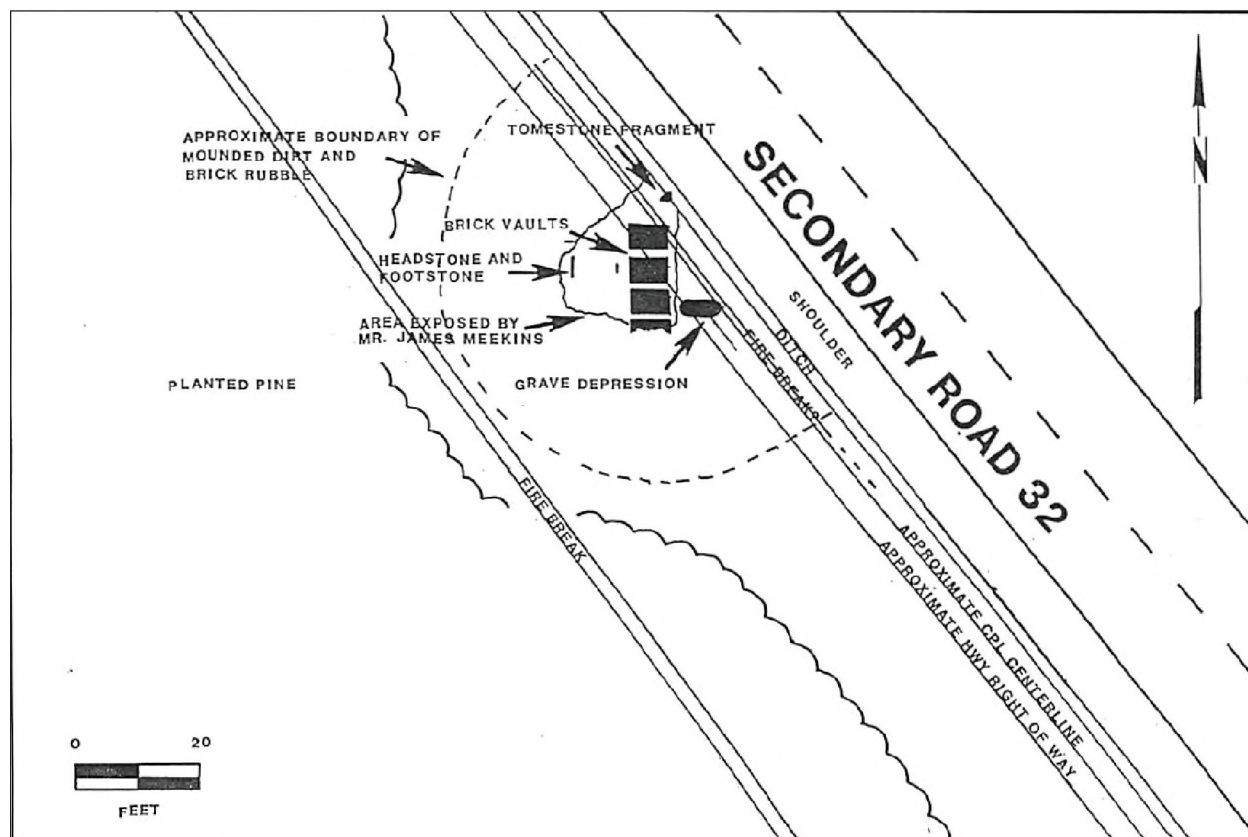


Source: ESRI World Imagery (2018)

Figure 2.
GPR Data Collection



Figure 3.
Chicora Foundation Map of Cemetery (1992)



(Approximate Boundary from Adams and Trinkley 1992:3)

Figure 4.
Map of Survey Area and Approximate Cemetery Boundary



Source: Adams and Trinkley (1992:3); ESRI world Imagery (2018)

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II. METHODS

SURVEY GRID AND MAPPING

Prior to data collection, a survey grid was established to cover the portion of the cemetery within the ROW along with a two-meter buffer. This was accomplished using metric measuring tapes and marking each grid corner with survey flags. Grid corners and visible grave markers were mapped using a Trimble handheld GPS unit with sub-meter accuracy.

All spatial data were downloaded from the Trimble handheld GPS unit and then imported into ArcMap 10, ESRI's geographic information system (GIS) program. Separate shapefiles were then created for the geophysical interpretations, markers, the right of way, and grids.

GROUND-PENETRATING RADAR (GPR)

GPR is a remote sensing technique frequently used by archaeologists to prospect for potential subsurface features and address a variety of research questions. This technique is non-invasive, nondestructive, relatively quick, 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 (Jones 2008; King et al. 1993).

The basis of GPR for identifying potential historic features or graves is based on differences in physical, electrical, or chemical properties between an object or feature and its surrounding matrix (Conyers 2004a). For graves, the body itself is generally not detected. Instead, it is typically the coffin or casket, burial shaft, or bottom of the grave that causes the reflection (Jones 2008; King et al. 1993). Greater contrast equates to better detection and resolution. For example, a metal casket in a concrete vault is easier to see with GPR than a body in only a wooden coffin.

GPR data are acquired by transmitting pulses of radar energy into the ground from the surface and detecting the energy waves reflecting off buried objects, features, or bedding contacts (Conyers 2004a:1). When collecting radar reflection data, surface radar antennas are moved along the ground in transects within a grid, acquiring large numbers of subsurface reflections along each line. As radar energy moves through various materials, the velocity of the waves changes 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 2004b).

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. 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 largely depends on soil and mineralogy, ground moisture, subsurface material moisture retention, the depth of buried features, and surface topography and vegetation. Depth penetration varies considerably depending on local conditions. Electrically conductive or highly magnetic materials quickly attenuate radar energy and prevent its transmission to depth. Subsurface materials that absorb and retain large amounts of water can affect GPR depth penetration because of their low relative dielectric permittivity (RDP). In practical applications, this generally results in shallower than normal penetration because the radar signal is absorbed (attenuated) by the materials regardless of antenna frequency (Conyers 2004a, 2012; Conyers and Lucius 1996). Differential water retention can also enhance data collection when a material of interest, such as a burial, retains more water than the surrounding soils and creates greater contrast.

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 pulls or pushes the antenna across the ground surface systematically (i.e., within a grid) collecting data along transects. These data are then stored by the receiver for later processing. The “time window” within which data were gathered was 70 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 found on reflection profiles are 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 electromagnetic 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 13.1, which, when converted to one-way travel time (the time it takes the energy to reach a reflection source), is approximately 8.3 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 allows the user to obtain an average set of readings based on subtle changes in the RDP (Conyers 2004b). Field calibration was repeated as necessary to account for changes in soil and/or moisture conditions (Conyers 2004a). Effective depth penetration was approximately 230 centimeters (7.5 feet), with very slight signal attenuation occurring at the bottom of the profile. This is good depth penetration for a 350 MHz HyperStacking (HS) antenna.

The field survey was conducted using a GSSI SIR-4000 using a 350 MHz HS antenna over the entire project area. The survey area was defined to cover an approximately 0.05-acre section of the cemetery that intersects the right of way (Figure 5). It is generally standard practice to orient transects perpendicular to the long axis of suspected features. In this case, data were collected roughly north to south, as Christian burials are generally oriented east to west. Transect spacing was 50 centimeters, an interval that has been demonstrated to generate the best resolution while maintaining fieldwork efficiency (Pomfret 2005). Transects were collected in a zig-zag pattern, alternating starting direction, along the y-axis (north-south).

DATA PROCESSING

All data were downloaded from the control unit to a laptop computer for post-processing. Radar signals 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. Range gains were also applied to the data to make reflections from later in the time window more visible.

Figure 5.
GPR Survey Grid



Image Source: ESRI World Topographic Map (2018)

The next data processing step involved the generation of amplitude slice-maps (Conyers 2004b), which illustrate differences in reflected radar amplitudes across a given surface at various depths. Reflected amplitudes measure the degree of physical and chemical differences in the buried materials. Strong or high amplitude reflections often indicate denser (or different) buried materials. They can be generated from pockets of air, such as within collapsed graves, or from slumping sediments. The slice-maps are developed through comparison of reflected amplitudes recorded in vertical profiles. Variations in amplitude, recorded as digital values, are analyzed at each location in a grid containing many profiles where reflections were 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 showing amplitudes in plan view at varying depths.

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 Kriging 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. Two-dimensional reflection profiles were also analyzed to determine the nature of the features identified on the amplitude slice maps. The reflection profiles may comprise flat layers (seen as distinct bands in profile) or single objects (appearing as hyperbolas in profile). Hyperbolic reflections are generated from the way the radar energy reflects off point targets and, in cemeteries, often represent graves. Individual profile analysis was used in conjunction with amplitude slice maps to provide stronger interpretations about probable graves.

The final step in the data processing is to integrate the depth slices with other spatial data. This was done using ArcGIS 10, which can display and manipulate all spatial data created for this project, including GPR results, GPS data, marker inventory data, and base graphics such as aerial photographs and maps. The resulting interpretations were digitized as individual features.

GPR IN CEMETERIES

Most Judeo-Christian cemeteries share common characteristics with respect to burial of the dead. In general, bodies are oriented east-west, with the head to the west. Depths vary, but are typically between two and six feet, depending on local conditions and customs. Shapes are usually oblong and rectangular. Sizes can vary considerably, particularly between adults and infants, with most adults in the range of approximately six feet long and two feet wide (Patch 2009).

Several factors influence the overall effectiveness of GPR for detecting anomalies consistent with individual graves. Contrast between the remains, grave shaft, coffin, or casket and the surrounding soils is the most important variable. Remains that have a chemical or physical contrast from the subsurface materials surrounding them will cause reflections of electromagnetic energy. Age of the graves will affect the results. Older graves typically have less contrast because they have had more time to decompose and are less likely to have intact coffins or caskets (if these were present to begin with). As a consequence, they are more difficult to detect.

The burial “container” that the physical remains may have been placed in may also influence the results. Container types include simple linen or cloth shrouds, wooden boxes or coffins, lead or other metal caskets, and burial vaults. In certain cases, hardware such as nails, hinges, and handles may be present. Although there is a high degree of variation in specific container 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 much longer in rural and/or economically depressed areas than in urban centers.

III. RESULTS AND RECOMMENDATIONS

The purpose of this survey was to identify geophysical anomalies consistent with the expected signature for graves. GPR results were based on analysis of the 350 MHz HS data, including individual reflection profiles and amplitude slice maps (Figures 6-13). The anomalies represented distinct contrasts with the adjacent soils and were visible in both plan and profile (Figure 14).

Of 24 probable individual graves identified, 17 were partially or completely within the ROW (Table 1, see Figure 6). Two markers and a scattering of brick were also recorded on the surface. It is likely that the markers correlate with anomalies 17 and 18, but as they have been damaged they may not be in situ (Figure 6).

Table 1. GPR Anomalies

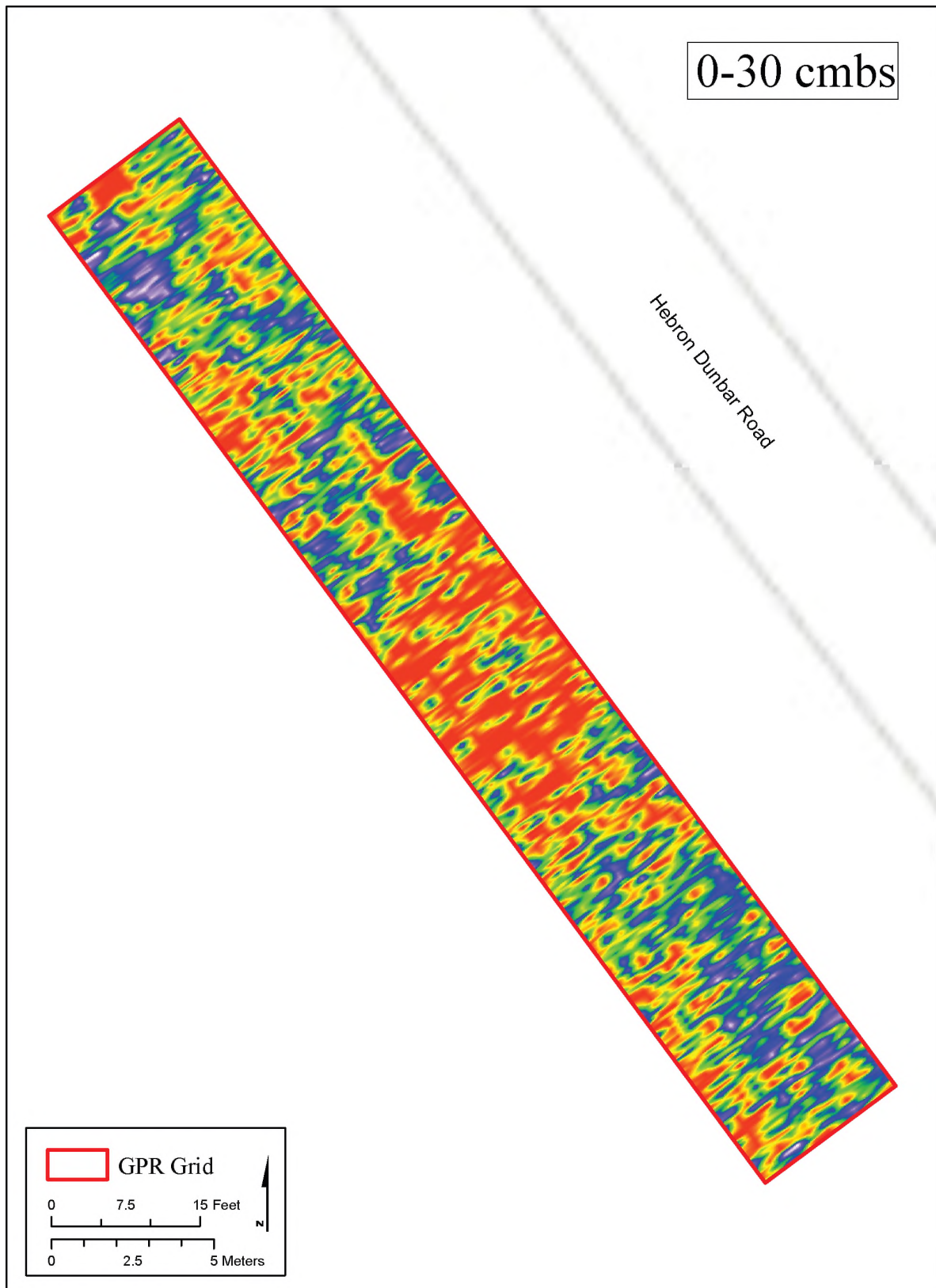
Anomaly	Label	Depth (cm)	UTM Northing	UTM Easting	Within ROW?
1	Probable grave	15-185	3823808.05264	630940.04942	Yes
2	Probable grave	15-120	3823809.46097	630937.43375	No
3	Probable grave	15-190	3823808.95684	630939.11309	Yes
4	Probable grave	110-170	3823812.11348	630936.46629	Yes
5	Probable grave	35-135	3823814.48339	630931.98833	No
6	Probable grave	15-75	3823814.60079	630935.83457	Yes
7	Probable grave	10-145	3823814.89052	630934.18264	Yes
8	Probable grave	15-95	3823816.17628	630934.46470	Yes
9	Probable grave	15-140	3823817.36590	630930.69028	No
10	Probable grave	20-135	3823818.07227	630933.16944	Yes
11	Probable grave	15-165	3823819.26815	630930.40837	Yes
12	Probable grave	15-65	3823819.20398	630932.29869	Yes
13	Probable grave	25-125	3823819.88193	630928.23823	No
14	Probable grave	15-90	3823821.11002	630930.62518	Yes
15	Probable grave	20-90	3823822.06205	630928.89390	Yes
16	Probable grave	10-160	3823822.22654	630926.88986	No
17	Probable grave	15-165	3823824.18527	630927.65693	Yes
18	Probable grave	10-95	3823826.32143	630926.15165	Yes
19	Probable grave	10-150	3823829.01187	630922.14372	No
20	Probable grave	10-80	3823830.78780	630924.20460	Yes
21	Probable grave	10-60	3823835.81483	630916.82223	No
22	Probable grave	20-115	3823836.92639	630919.61449	Yes
23	Probable grave	40-180	3823813.22059	630937.95175	Yes
24	Probable grave	15-155	3823811.51930	630939.25754	Yes

Figure 6.
Map of Surveyed Area Showing Identified Probable Graves and Right-of-Way



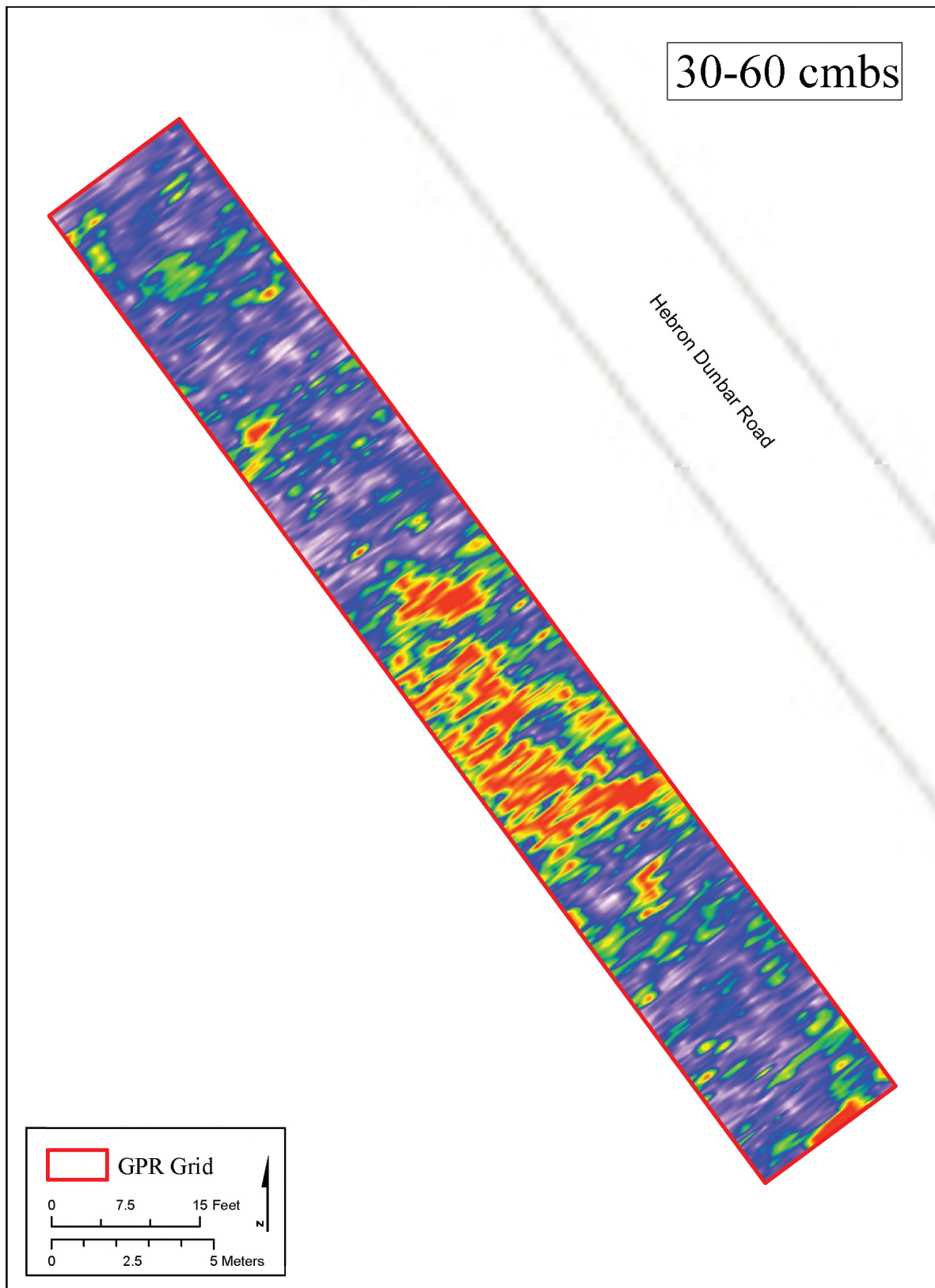
Source: ESRI World Topographic Map (2018)

Figure 7.
Amplitude Slice Map from 0-30 Centimeters Below Surface (cmbs)



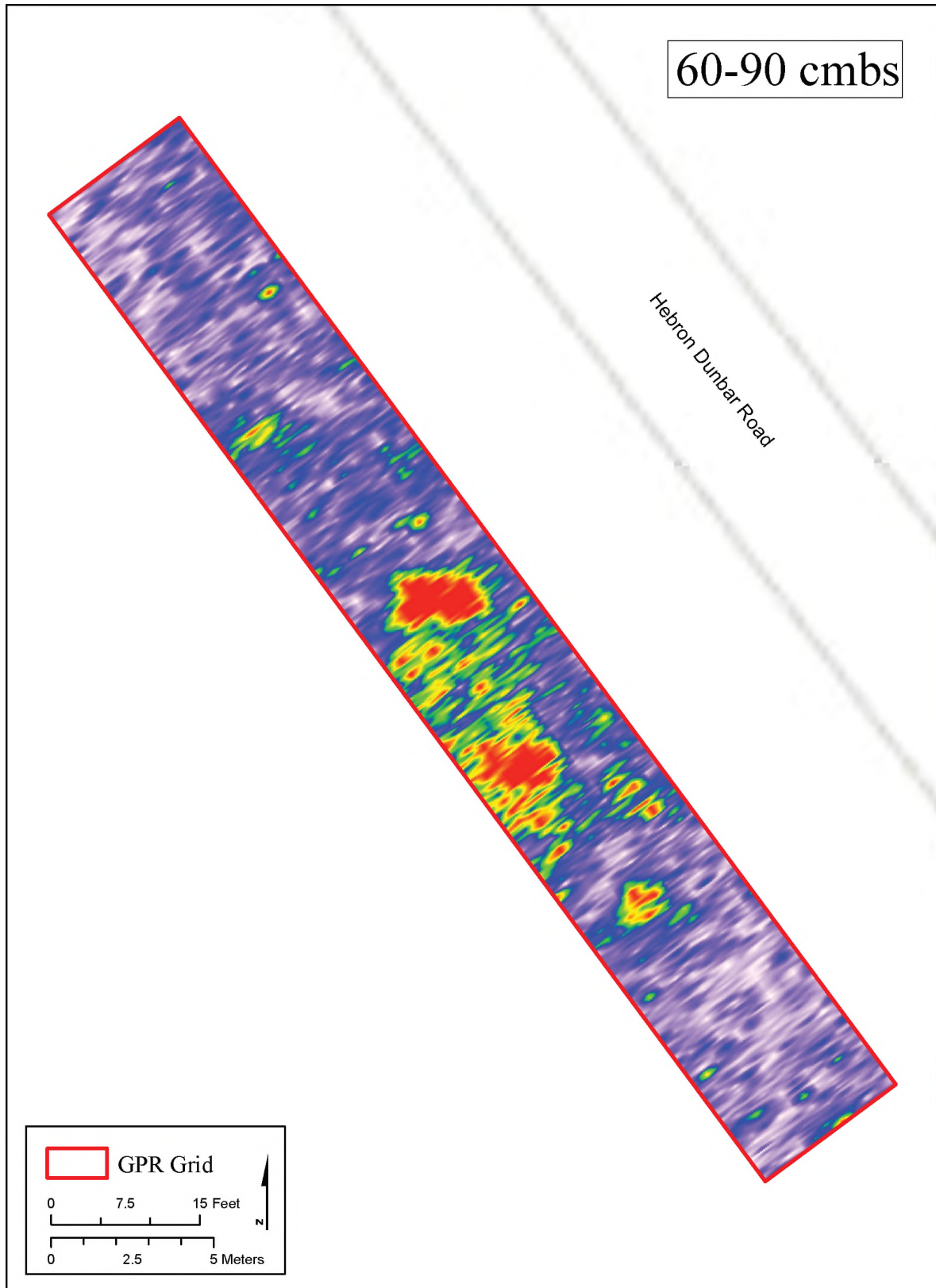
Source: ESRI World Topographic Map (2018)

Figure 8.
Amplitude Slice Map from 30-60 cmbs



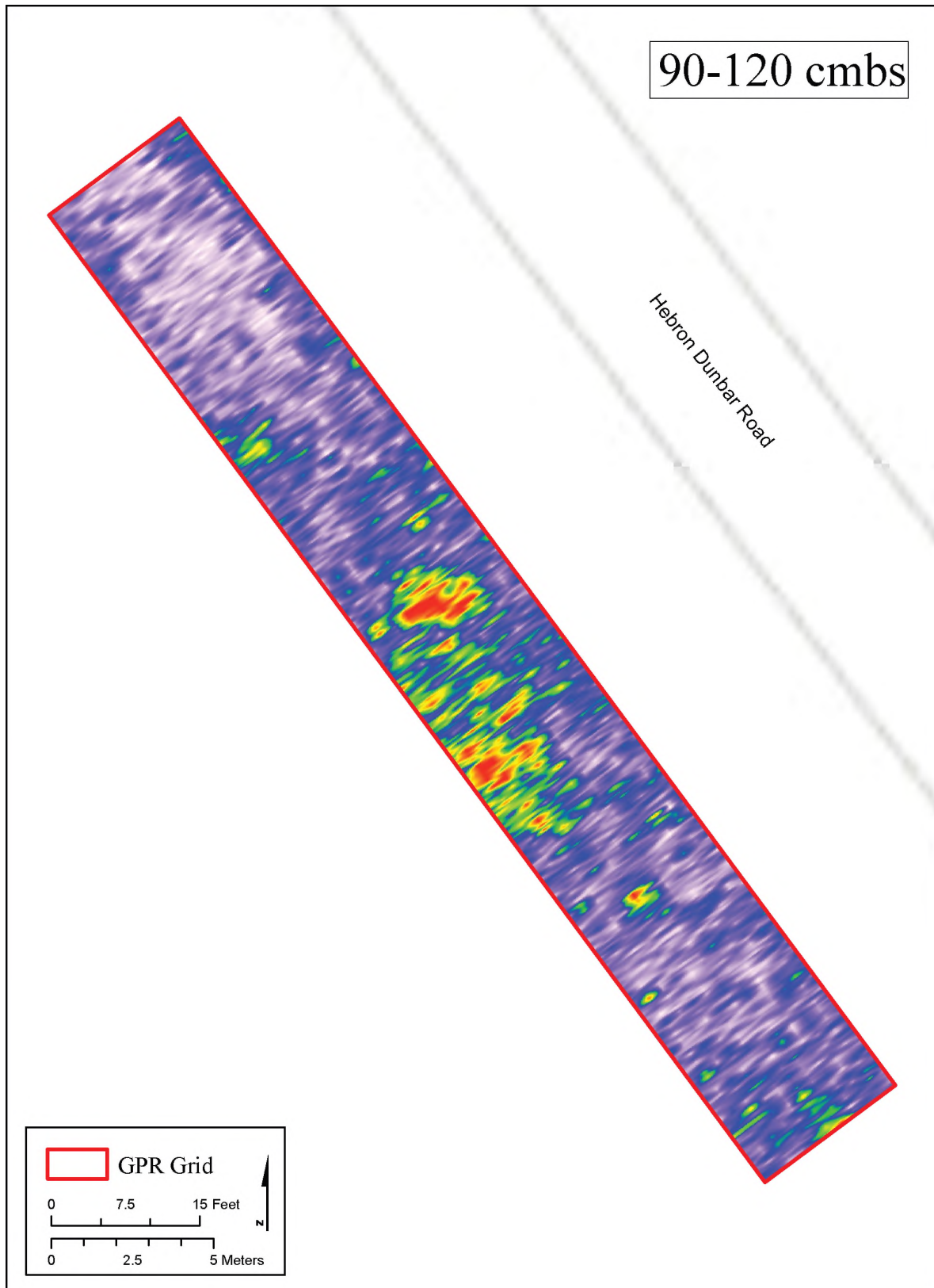
Source: ESRI World Topographic Map (2018)

Figure 9.
Amplitude Slice Map from 60-90 cmbs



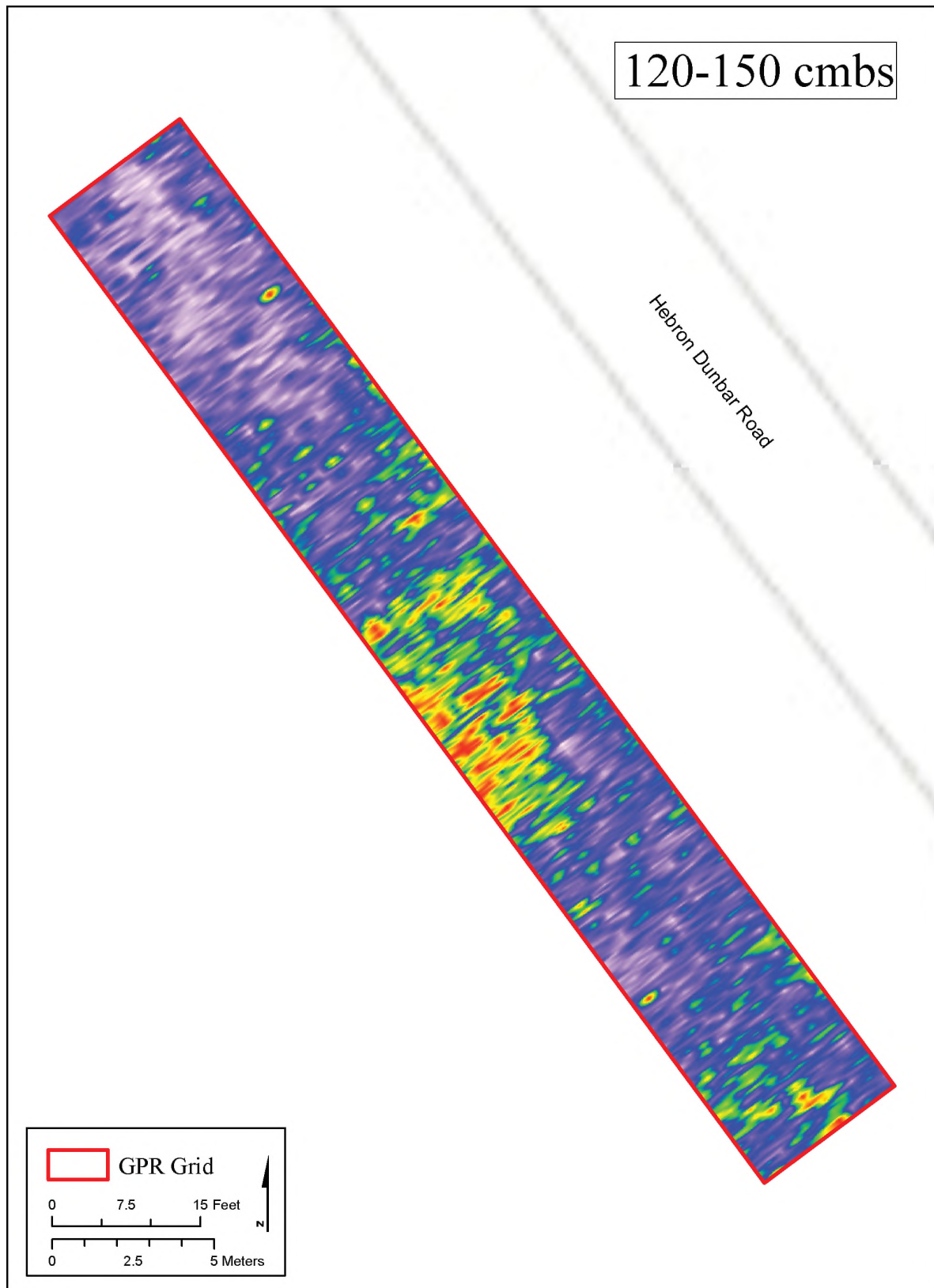
Source: ESRI World Topographic Map (2018)

Figure 10.
Amplitude Slice Map from 90-120 cmbs



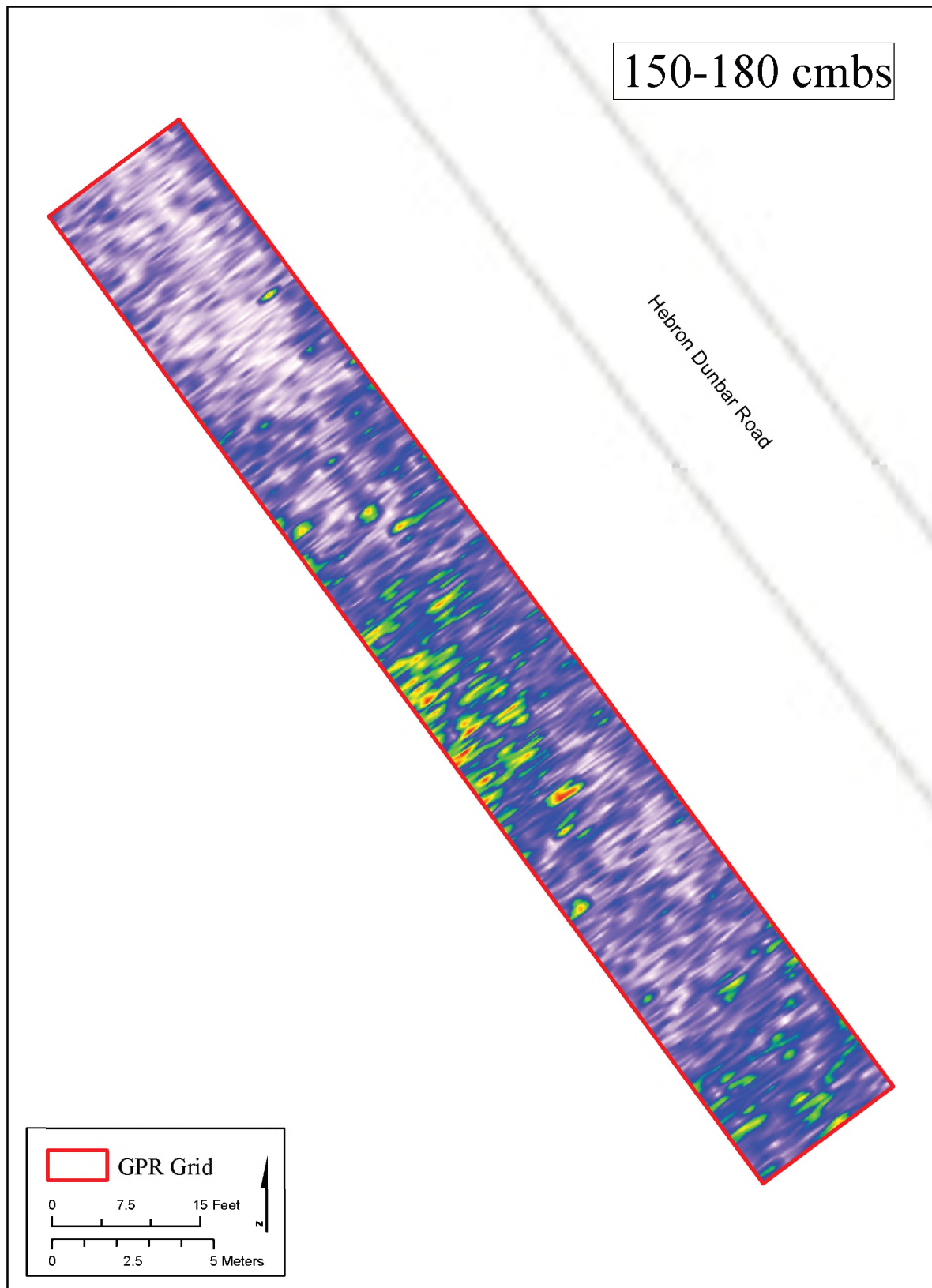
Source: ESRI World Topographic Map (2018)

Figure 11.
Amplitude Slice Map from 120-150 cmbs



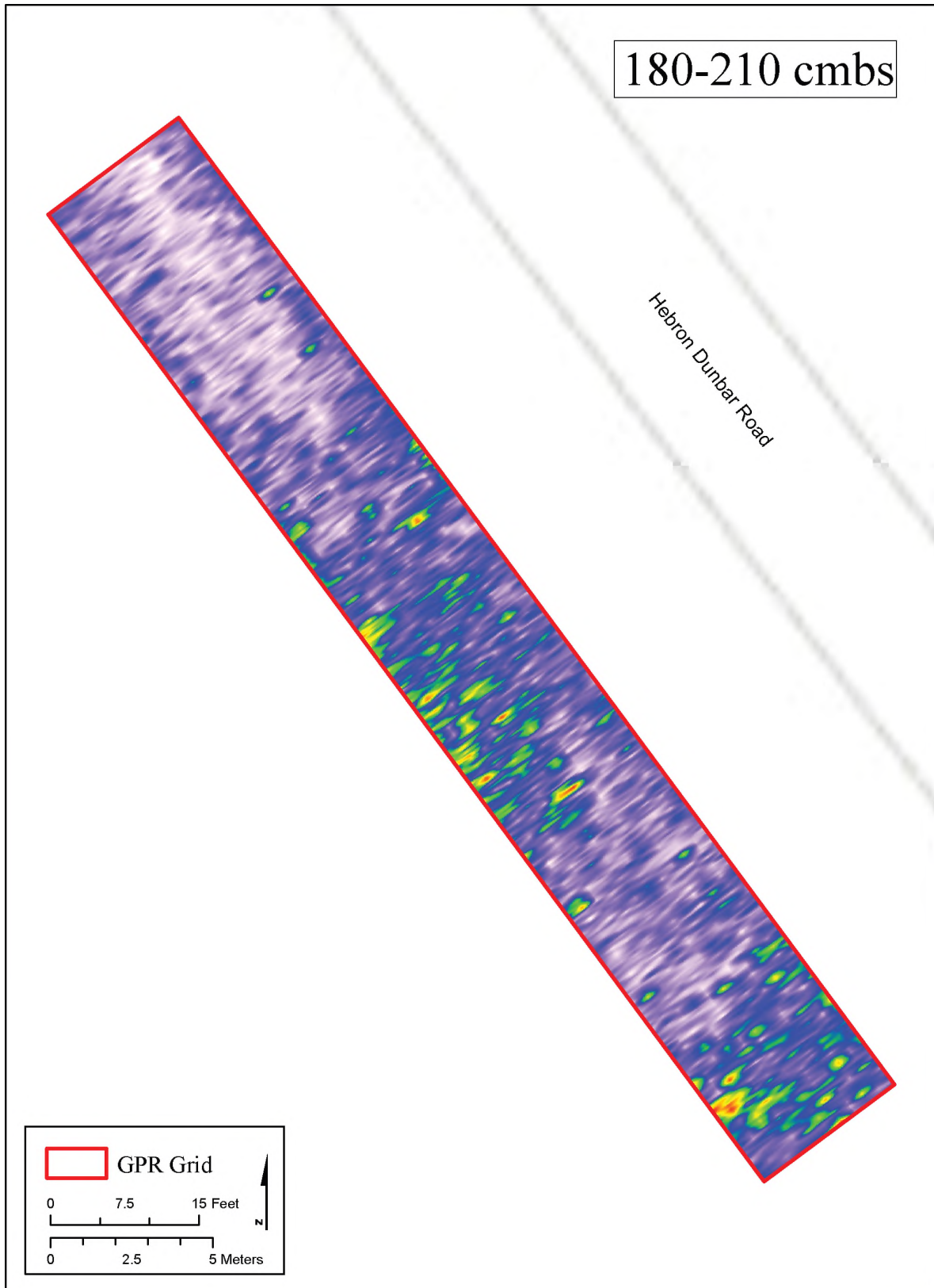
Source: ESRI World Topographic Map (2018)

Figure 12.
Amplitude Slice Map from 150-180 cmbs



Source: ESRI World Topographic Map (2018)

Figure 13.
Amplitude Slice Map from 180-210 cmbs



Source: ESRI World Topographic Map (2018)

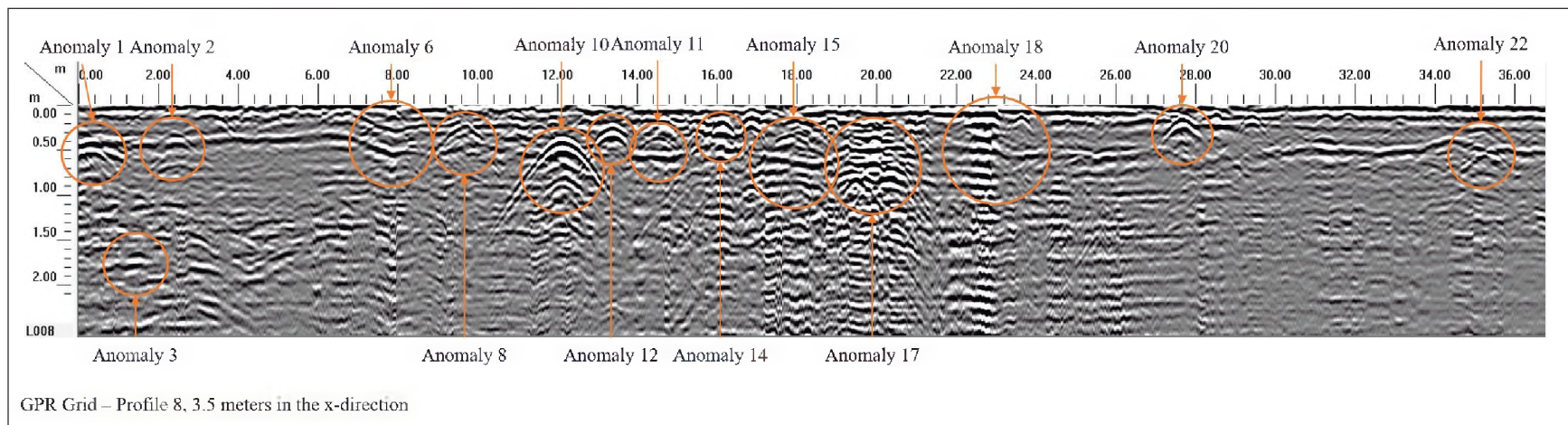


Figure 14.
Example of Probable Graves in Profile

Many 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 grave depth, and burial container (e.g., shroud, wood coffin, metal casket, concrete vault). New South takes a conservative approach to the identification of graves based on GPR data. The probable graves in the survey area were identified on the basis of size, shape, depth, orientation, and overall reflective characteristics in both plan and profile. In general, if the anomaly has any of the characteristics of a grave it is marked as a potential grave.

New South recommends that the 24 GPR anomalies identified as probable graves should be treated as such. Additionally, care should be taken if any ground is to be disturbed within the cemetery to avoid damaging any graves that might be present but that were not detected because of poor preservation. If avoidance of graves is not possible, then additional steps should be taken to relocate the graves in compliance with the relevant South Carolina statutes. It is New South's understanding that no disturbances are currently planned within the cemetery, but that the cemetery has been damaged. The anomalies identified as probable graves should be protected from further damage.

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