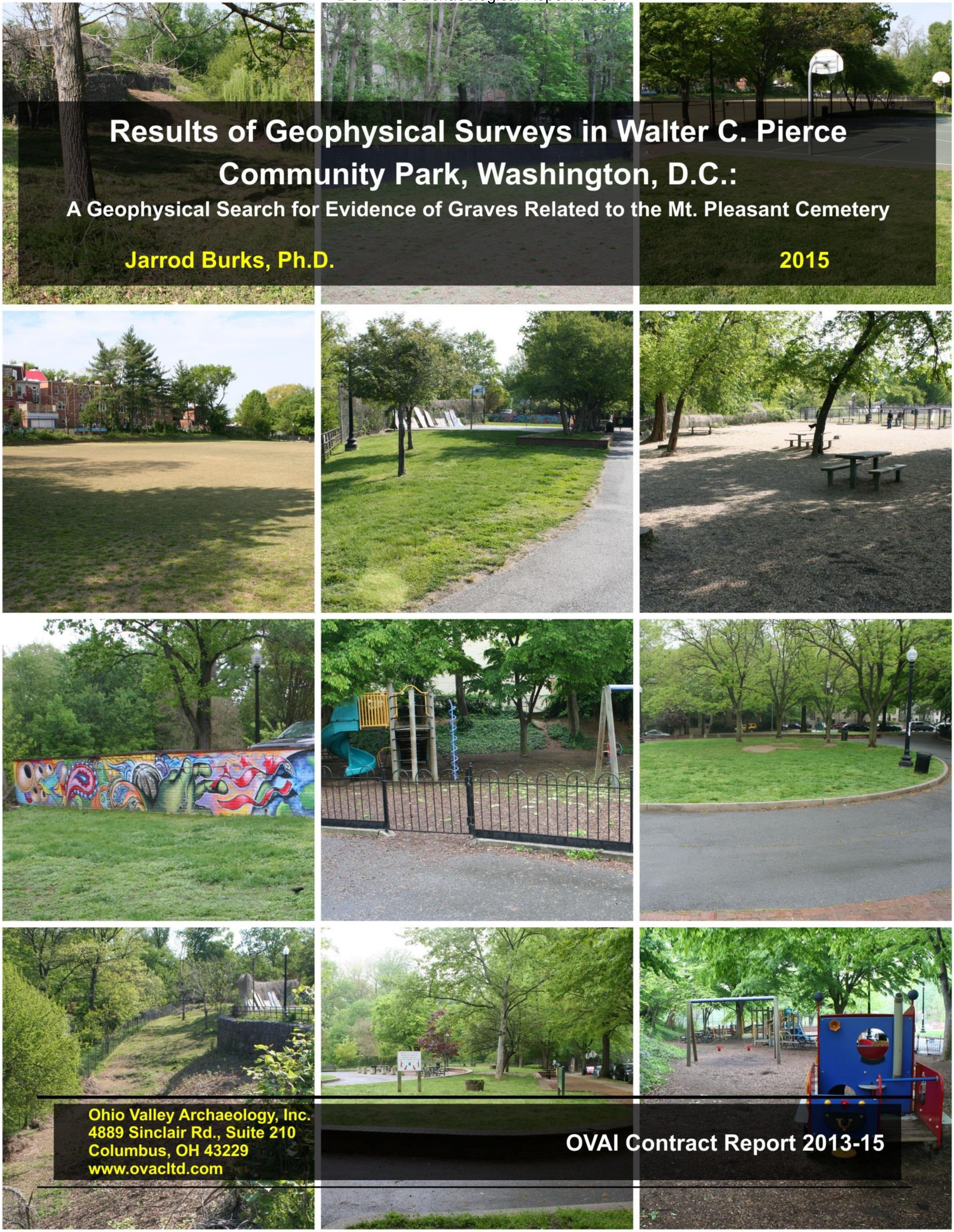
DC SHPO Archaeological Report # 651



Results of Geophysical Surveys in Walter C. Pierce Community Park, Washington, D.C.:

A Geophysical Search for Evidence of Graves Related to the Mt. Pleasant Cemetery

Jarrod Burks, Ph.D.

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Due to the sensitive nature of the results of this survey some of the maps have been redacted. Please help us preserve this important site and prevent looting.
Ruth Trocolli, District Archaeologist 8/18/2017

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Project Summary

In 2013 geophysical surveys using ground-penetrating radar and two types of magnetometers were conducted in Walter C. Pierce Community Park (Washington, D.C.) in the search for graves related to two cemeteries once located there: the Mt. Pleasant Plains Cemetery, a large African American cemetery in use from 1870-1890 (also known as CUBA), and the Friends (Quaker) Burying Ground that was actively used from 1807-1890. Extensive modifications to the land in the 1950s radically altered the site's topographic contours and disturbed hundreds, if not thousands of graves. Additional land modifications related to the creation of Walter C. Pierce Park have further altered the landscape. Today the bulk of the property that was once part of the cemetery is owned by Washington, D.C. (Walter C. Pierce Park), but small portions of the cemetery to the north and west are also owned by the National Zoo and the National Park Service, respectively.

The geophysical surveys reported here focused on those portions of the cemeteries that are now within Walter C. Pierce Park. Eight areas within the park were subjected to survey, and geophysical evidence of possible graves was found in four of the eight surveyed areas. These results agree well with a topographic cut-fill analysis showing that some portions of Walter C. Pierce Park are still relatively close to the original land surface of the cemetery.

The cut-fill topographic analysis, coupled with previous archaeological investigations conducted by Howard University, also show that large areas of the former cemetery are now buried under fill—fill that includes human bone, head- and footstones, coffin hardware, and other remains from the cemetery that were disturbed during the land modifications of the 1950s.

Together, the geophysical surveys, the cut-fill topographic analysis, and the work completed by Howard University all suggest that the Friends Burying Ground has been destroyed, but portions of the Mt. Pleasant Plains Cemetery remain intact near the surface and buried beneath up to 12 meters of fill—most of which was cut away from other areas of the cemetery and thus also contains human remains.

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Acknowledgements

This project was conducted on behalf of Washington Parks & People (WP&P) with a grant from the District of Columbia. Stephen Coleman, WP&P executive director and president, graciously welcomed us to D.C. and the WP&P offices at the Josephine Butler Parks Center. Jeff Catts of WP&P was the primary project coordinator. In the field, Behnam Mehrabkhani of WP&P did the lion's share of the brush clearing in Area 5 and was assisted on several days by Kenny Barbour (WP&P Staff), Jeff Catts, RonDell Pooler (WP&P Staff), Clayton Baltimore (DC Green Corps Trainee), Yamile Talero (DC Green Corps Trainee), Turrell Smith (DC Green Corps Trainee), and Travis Freeman (DC Green Corps Trainee). Dr. Jarrod Burks (Ohio Valley Archaeology, Inc.) conducted all of the geophysical surveys and was assisted on several occasions by Behnam Mehrabkhani, Kenny Barbour, and Yamile Talero. Dr. Ruth Trocolli, City Archaeologist in the D.C. Historic Preservation Office provided much guidance to the project, as well as many historic maps related to Washington, D.C. Jamie Davis (Ohio Valley Archaeology, Inc.) digitized the 1888 D.C. topographic map, rasterized the digitized data, and subtracted it from a modern topographic dataset. Mary Belcher was kind enough to provide a draft copy of the Walter C. Pierce Park Archaeology Project report for review while Dr. Burks was in the field collecting geophysical data. She also showed the team around the site, pointing out features and objects located and recorded by the archaeology survey crews from 2006-2012.

Introduction

Cemeteries from the nineteenth century and earlier abound in cities in the United States, especially in the eastern half of the country. Some of these cemeteries are still actively receiving burials, others have become static and are maintained as park-like settings. Many more have been lost and forgotten, only to be rediscovered when new development inadvertently encounters the graves during excavation work.

Walter C. Pierce Community Park in Washington, D.C. is a prime example of two nineteenth-century cemeteries that, though not completely lost and forgotten, have been through several transformations since their days as active burial grounds (Figure 1). The park is located just north of the line of buildings in the northwest corner of Calvert Street, NW and Adams Mill Road, NW. It hugs the edge of a ravine marking the southern boundary of the National Zoo. The Friends Burying Ground and Mt. Pleasant Plains Cemetery once defined the land now inhabited by Walter C. Pierce Park. Row upon row of marked graves, interior paths and walkways, and even an aboveground vault all were present. However, much has happened since the last burials were officially interred in these cemeteries. The grounds have been so thoroughly modified that it is hard to know what, if anything, still remains of the thousands of graves that were once there. Are intact graves still present within the park? If not, how is it that fragments of coffins and human skeletal material continue to be found on the surface in some areas of the park (see Mack and Belcher 2013), and how do they relate to the cemeteries?

This report presents the results of a two-tiered effort, using topographic analysis and geophysical survey, to determine what, if anything remains of the two cemeteries. The detailed topographic study is performed using cut-fill analysis and it provides clear boundaries on where we might expect to find possible intact graves and where the land has been so thoroughly modified that all signs of the cemeteries have been removed. The geophysical survey work allows us to look into the ground without digging and identify possible indications of intact graves. Eight areas within the park were covered during the geophysical surveys (Figure 2). Possible indications of graves were detected in two of the eight areas, and the topographic analysis indicates that at least two more of the survey areas likely contain graves that are too deep to detect with the geophysical instruments.

What follows is presented in several main sections. A brief history of the cemetery sets the stage. Then an examination of the site’s topography, before and after the massive land modifications of the 1950s, shows us what areas of the cemeteries could be reasonably intact, where the cemeteries have been completely removed by excavation, and where fill has covered over the original surface of the cemeteries. A methods section examines the instruments used during the geophysical survey and their effectiveness at detecting graves. Then the results of the surveys are presented by area. These results are summarized in a final section that highlights which areas are most likely to contain intact graves.

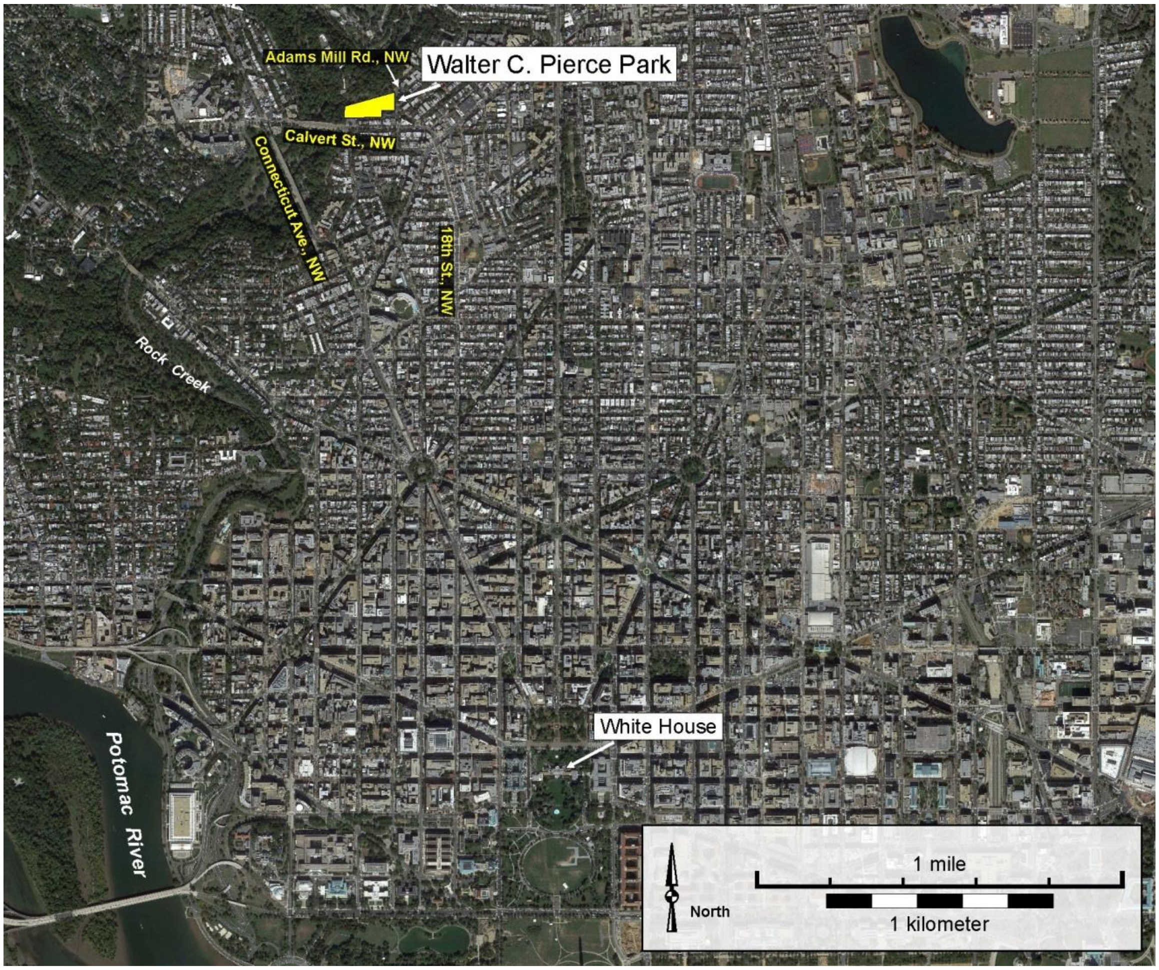

Figure 1. Location of Walter C. Pierce Community Park in Washington, D.C.

Historical Background: The Cemeteries and Walter C. Pierce Park

The Washington, D.C. area has some remarkably good maps from the late nineteenth and early twentieth centuries. These maps very clearly show the presence of two cemeteries near the intersection of Adams Mill Road and Calvert Street, NW. Accurately overlaying Walter C. Pierce Park and the geophysical survey areas on these early maps is an important first step in determining how today's park relates to these nineteenth-century cemeteries.

A combination of the 1888 Coast and Geodetic Survey map plus the 1919 *Baist's Real Estate Surveys of Washington, District of Columbia* allows us to determine how the cemetery boundaries of old relate to current park boundaries. In Figure 3 the geophysical survey areas and the cemetery boundaries (from Baist's 1919 map) are overlaid on the two historic maps. The location of Adams Mill Road to the north and east of the cemetery is largely unchanged since the late nineteenth century, though to the north the road is now part of the National Zoo property. This road can be used to anchor the 1888 map to the 1919 real estate map, the latter of which shows the configuration of roads that we basically have in this area today. Many of the buildings along Calvert Street from the

Figure 2. Survey area and grid datum locations on a 2012 aerial photograph. (Google Earth)

1919 map are also still standing. Thus, between the roads and the buildings from these two maps, it was fairly simple to determine the approximate boundary of the two cemeteries on a modern aerial photo (see Figure 2).

A recent report by Mack and Belcher (2013) provides many details about the origin, extent, and history of the cemeteries that once were located in the area now covered by Walter C. Pierce Park. Their report is based on original research and the work of Louana Lackey, who in 1981 did some of the first detailed research regarding the history of the Mt. Pleasant Plains and Friends Burying Ground cemeteries. It is worth summarizing some of the detail presented in those two reports as they are important to understanding the results of the topographic analysis and the geophysical surveys. The Friends Burying Ground was the first cemetery to appear in the area. It was created in 1807 when Jonathan Shoemaker deeded one quarter of an acre to the Society for Friends (Mack and Belcher 2013:9). This small cemetery appears on an 1861 map of the area published by A. Boschke (*Topographical Map, District of Columbia surveyed in the years 1856, '57, 58.'* Published by D. McClelland, Blanchard & Mohun, Washington, D.C.), and it remained this size and at the same location until its use terminated in 1890 (see Baist map in Figure 3 for its 1919 location). We can see the location of this one-quarter-acre parcel on a modern aerial photograph in Figure 2—it is the small parallelogram outlined in red at the east end of geophysical survey Area 4.

The Mt. Pleasant Plains Cemetery came into existence in 1870, when heirs of John Quincy Adams sold 6.75 acres, located north and west of the Friends Burying Ground, to the Colored Union Benevolent Association (Mack and Belcher 2013:15). The outline of a portion of this 6.75 acres is shown on the 1919 Baist real estate map in Figure 3, with the one-quarter-acre Quaker Burying Ground clearly indicated, as well. In 1873,

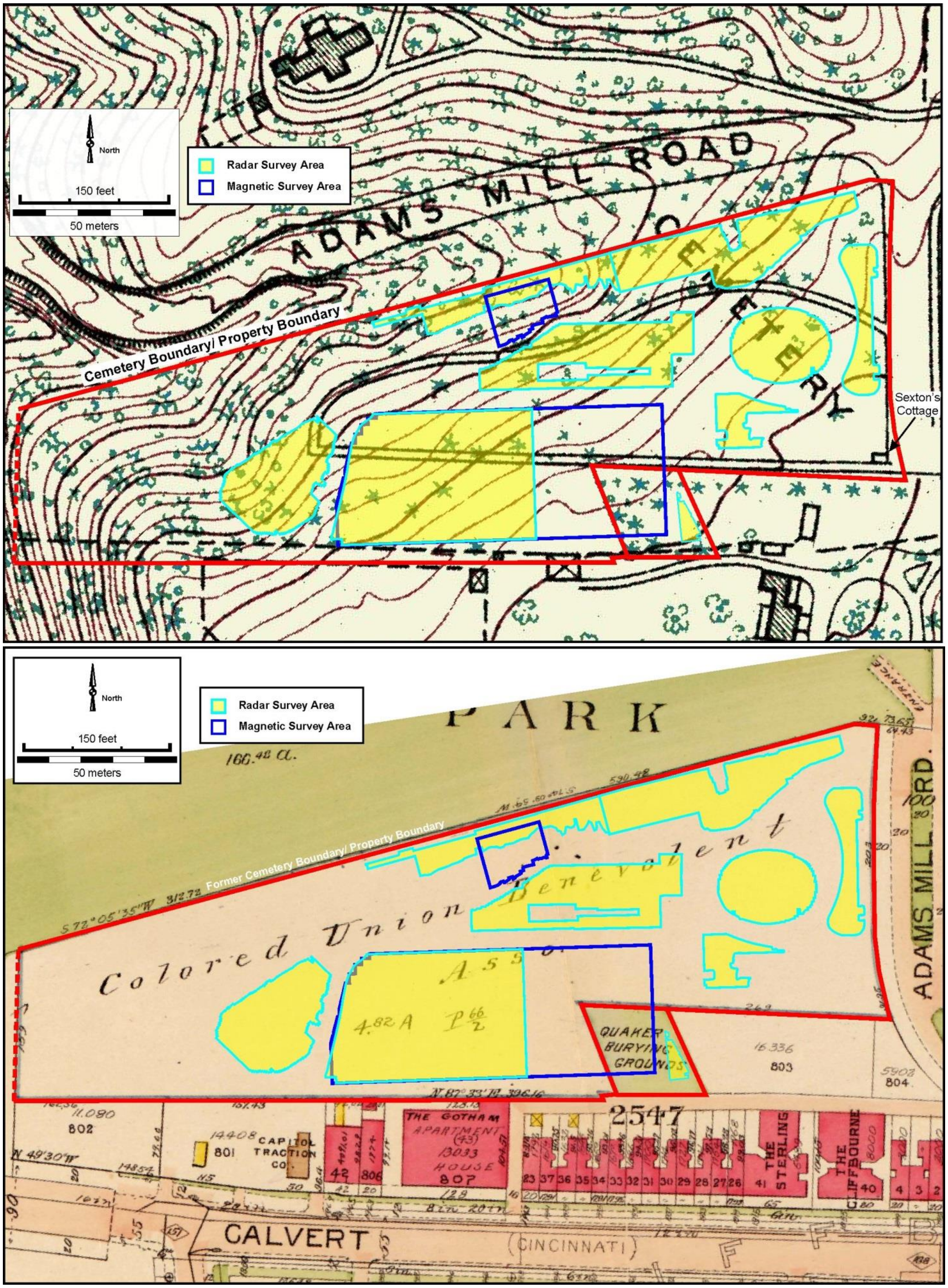

Figure 3. The geophysical survey areas overlaid on a portion of the (top) 1888 *Topographic Map of Washington and Vicinity*, Sheet 34, Coast and Geodetic Survey and (bottom) the 1919 *Baist's Real Estate Surveys of Washington, District of Columbia*, Volume 3, Plate 7.

individuals interred at the organization's previous cemetery, the Free Young Men's Cemetery at 12th and V Streets, N.W., were moved to the newly established Mt. Pleasant Plains Cemetery along Adams Mill Road. In the mere twenty years of its active use, the Mt. Pleasant Plains Cemetery became the final resting place for at least 8,428 African Americans, including those formerly enslaved, Civil War veterans, and other prominent community members. According to Mack and Belcher (2013:28), nearly 60 percent of those buried in the cemetery were children under the age of five. This is a rather important detail for the geophysical survey work as the graves of young children tend to be quite small and thus are harder to detect and identify in geophysical survey data.

Graves reflecting many levels of affluence were present in the cemetery, from those with expensive headstones and surrounds of post-and-chain fences to those marked simply with an unmodified stone. Graveside offerings were quite common, especially with children's graves. Mack and Belcher's (2013) report indicates that the west end of the cemetery, the area with the steepest slopes, was some of the last ground to be used for burial, requiring the construction of terraces in some areas to make the ground flat enough for graves.

At least two buildings were present in the cemetery. The first is a Sexton's cottage that stood in the southeast corner of the cemetery and is visible in the 1888 map presented in Figure 3. The second, a brick burial vault, was located "down the hill" from the entrance gate along the east side of the cemetery, off Adams Mill Road. It likely was a small brick structure that was part in ground and part above ground. While the location of this vault does not appear on maps, using the topographic contours on the 1888 map in Figure 3 we can see that any movement from east to west would take one downhill, though the hill became notably steeper toward the middle of the cemetery. Thus, it is likely that the brick vault was on the less steep part of this slope, in the north half of the cemetery. Remains of this brick vault were still evident in 1940 (Mack and Belcher 2013:43).

Use of the Mt. Pleasant Plains Cemetery came to an end in 1890 as the trustees of the Colored Union Benevolent Association were pressured to close the cemetery's gates because, as some claimed, the conditions in the cemetery had become unsanitary. Furthermore, neighbors were itching to buy the cemetery property for a variety of reasons. Sale of the property began with the National Zoo/Smithsonian buying 1.7 acres of the cemetery's north side. Enough money was set aside to disinter and move up to 1000 individuals, though the number actually moved was never recorded. These individuals were all moved into other portions of the cemetery by December of 1890; no new graves were opened in the cemetery after this point (Mack and Belcher 2013:38).

After the sale of the 1.7 acres to the National Zoo, the Mt. Pleasant Plains cemetery and the Quaker Burying Grounds became an overgrown, "empty" parcel. Given the slope of the ground, one can imagine that erosion started cutting away at sections of the cemetery, slowly erasing visible portions of it. Mack and Belcher (2013:39) note seven major events that have furthered the degradation of the property since the closing of the cemeteries:

(1) the 1890 purchase of 1.7 acres by the National Zoological Commission, and the disinterment of the individuals buried in that portion of the cemetery;
(2) widening of Adams Mill Road in 1904;

(3) the sale of the western portion of the cemetery in 1929, which included the sloped portion of the cemetery overlooking Rock Creek;
(4) the Calvert Street bridge construction and reconstruction in 1890 and 1934-35, respectively;
(5) the 1940 disinterment of 129 sets of human remains from 390 excavation holes;
(6) excavations by the Shapiro Brothers developers in 1959 to prepare the property for four large apartment buildings; and
(7) the construction of Walter C. Pierce Community Park in 1982.

Of these seven major events documented by Mack and Belcher, two led to very extensive modifications to the property, making it appear as it does today: the 1959 Shapiro Brothers excavations and the creation of Walter C. Pierce Community Park. The aerial photographs in Figure 4 provide us a before-and-after view of the Shapiro excavations from 1959. In the 1951 photograph we can see that most of the cemetery area is covered in trees, with two large open areas at the east end of the property. Perhaps these were the areas from which the 1940 disinterments were recovered? While Mack and Belcher uncovered documents stating that the cemetery was divided up into 14 areas during the 1940 disinterment project, there is no further indication where these 14 areas were located. The light colored ground in this photograph is certainly exposed soil with no vegetation growth, and it could be from where most of the graves were removed. However, by this point the Shapiro Brothers already owned the land and these light areas could be early leveling efforts, ahead of the massive excavations in 1959. In the 1968 aerial photograph (Figure 4, bottom) we can see that all of the larger trees on the higher part of the property have been removed.

While it is hard to see in the 1968 aerial photograph what actually happened to the ground between 1951 and 1968, newspaper accounts from 1959 make it plain that the Shapiro Brothers' development project excavated away large portions of the cemetery, disturbing and removing many graves with steam shovels (reported by Mack and Belcher [2013:52] from the *Washington Daily News*, May 23, 1959). While many dump trucks worth of fill, and human remains, were removed from the site, the topographic analysis presented below shows that much of the ground that was removed from the southeastern third of the site was pushed over the bank toward the northwest to create a large, level area on which to build the proposed apartment buildings.

After all of the disturbance to the two cemeteries in 1959, the Shapiro Brothers never built any apartment buildings on the site and the land remained vacant until community activism resulted in Congress approving the spending of $1 million, plus another $1 million from the City, to purchase the property for a community park (Mack and Belcher 2013:57). In the 1980s, Community Park West was created with additional earth moving on the site. The southeast corner of the property (where the Quaker Burying Ground once was located) was further lowered and the fill was pushed to the northwest to make a large flat surface for a playing field. This large flat area was extended to the north by filling in behind a gabion wall that was constructed at about the original location of the northern leg of the cemetery road from the 1888 topographic map (see Figure 3). The recent aerial photographs in Figure 5 show the latest configuration of the park, which was renamed Walter C. Pierce Community Park in 1995.

Figure 4. Geophysical survey areas shown on 1951 and 1968 aerial photographs. (Images from https://earthexplorer.usgs.gov/)

Several archaeological projects of note to the geophysical survey have occurred on the property. In 1981 a Phase I archaeological survey was conducted within the area of the cemetery that was to become the park (Lackey 1981). In addition to extensive archival research, Lackey also excavated seven shovel tests, seven 5x5 ft excavation squares, and one 2x20 ft excavation trench. The work was done to test areas slated for further disturbance during construction of the Community Park West, and not necessarily to look for evidence of intact graves. In the larger excavation units, digging extended down only 6-12 inches—into the top of what Lackey thought was intact subsoil. These larger excavation units were all in areas of the site at higher elevations. As we learned earlier, these are the areas that were intensively disturbed by the 1940 disinterment and the Shapiro Brothers' excavations. Smaller excavations, shovel tests, were used to test the sloped area north of Area 6 (see Figure 2). These were dug down 6-15 inches to what was perceived to be subsoil. All excavated soil was screened. No artifacts related to the cemetery were recovered during Lackey's project. Based on the lack of older artifacts, no signs of graves in any of the excavations, and archival research that showed extensive land modification, Lackey concluded that the work to create the park could proceed, including earth moving to flatten the playing field and digging and filling for the construction of the gabion wall.

By the mid-2000s, erosion had been steadily working away at the more sloped areas of the property and there was some concern that the north slope, the area to the north of the gabion wall, was under threat of sliding downhill. This area of the park had become a community gardening area, complete with mini terraces. The 1999 aerial photograph in Figure 5 shows the extent of these terraces. Once again plans were made to modify the site, this time to help mitigate the erosion threat on the north slope. One test unit by Lackey (1981) in this area suggested that earlier earthmoving activities had destroyed the graves in this part of the property.

Ahead of the planned excavations and stabilization, an archaeological project was conducted in 2005 to determine if possible graves might be present on the east end of the north slope area, what I refer to as Area 5 Upper (see Figure 2). This project involved a limited radar survey that identified three areas of interest that were recommended for further testing (Emory 2005). Follow up excavations were conducted with a mini excavator in three fairly shallow trenches that were dug through the topsoil/overburden to expose the intact subsoil (Emory and Weinberg 2005). A 4.9x1.2 meter trench (with a north-south orientation) dug across anomaly Areas 2 and 3 failed to find any evidence of intact grave shafts, but a 15.2x15.2 cm flat marble fragment, a probable grave marker stone fragment, was found sitting on top of the subsoil. The overburden sitting on the subsoil was found to vary in thickness from 22.9-66 cm in Area 3, becoming thicker from south to north. This thickening of the overburden is likely a product of terracing for the community gardens—additional soil was brought in to thicken the north sides of the terraces, making the ground surface level. Two trenches, side by side and covering a total area measuring about 3.3x5.5 meters, were cut across the radar anomalies in Area 1. The overburden was fairly shallow in this area, just 15.2-30.5 cm thick and again with increasing thickness from south to north. In this area five soil stains, dubbed features, were found to extend down into the intact subsoil. These soil features measured 1.7-1.8 meters long by 0.6-0.7 meters wide and their long axes were running roughly east-west—exactly what might be expected of adult-sized graves. A white metal screw/tack, likely

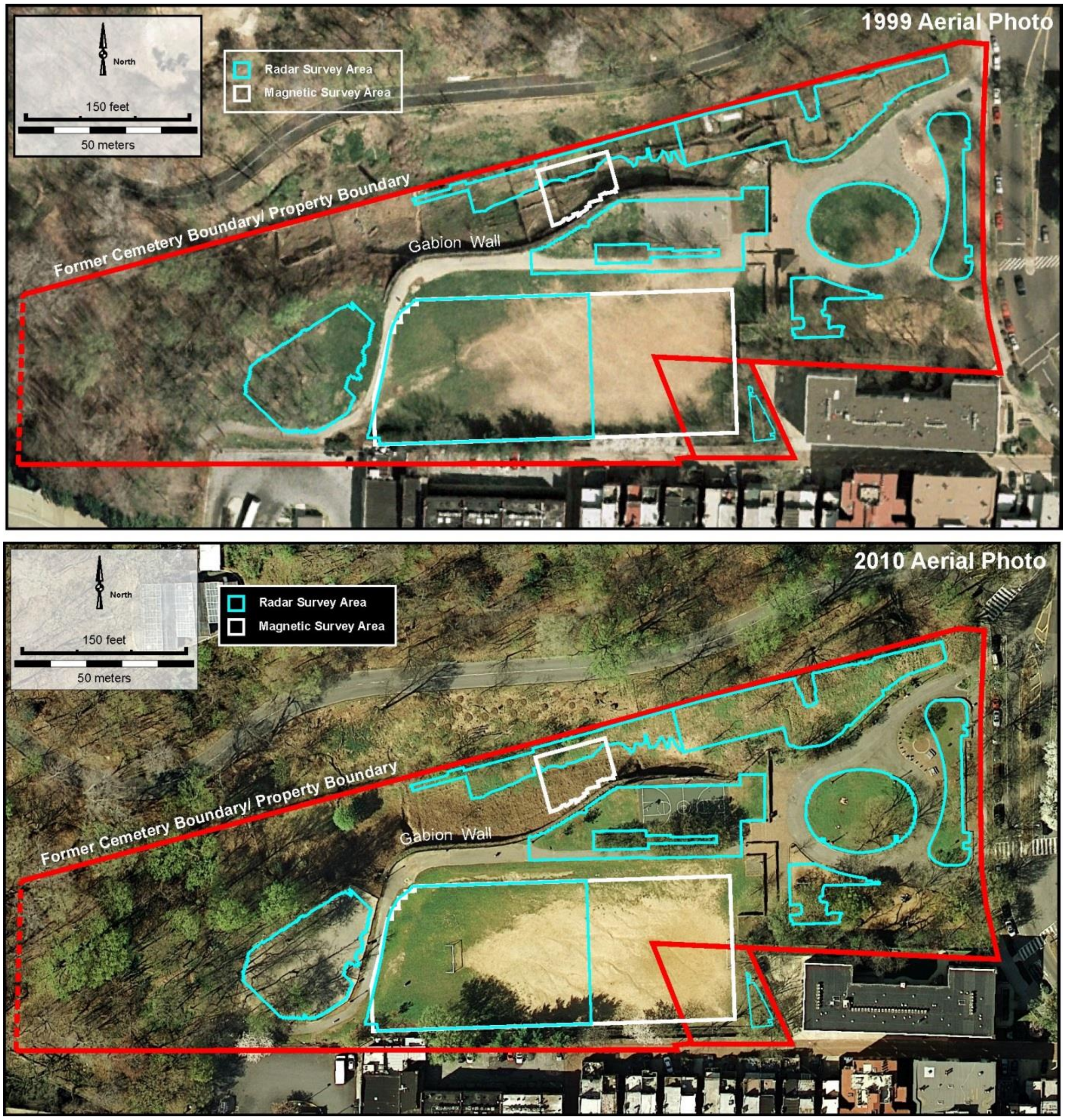

Figure 5. Geophysical survey areas shown on 1999 and 2010 aerial photographs. (Google Earth)

from a coffin, was found associated with Feature 4 and was recovered next to an "iron flared-neck 'urn'" (Emory and Weinberg 2005:15). A slightly deeper trench extending another 50 cm down into the intact subsoil was cut across two of the other soil features. The features were readily visible in profile and found to only extend down another 15.2 cm below the contact point between the overburden and the intact subsoil. Nothing was found in the feature fill. If these features were graves, and the graves had been dug down into the ground 5-6 ft in the nineteenth century, then several feet of soil has been removed from this area of the site—but enough is left that the bottoms of the grave shafts are still intact. In addition to the probable grave shafts, a square posthole was also found.

Because no human bone was found during their excavations, Emory and Weinberg (2005) concluded that the human remains had been removed from these graves. However, they did not fully excavate out each of the features, so we really do not know what might still be present in these features. But what their work did show was a very important thing: the bottoms of possible grave shafts are still present in the northeast corner of the property, despite all of the very destructive excavations in 1959 and the modifications that have occurred from the more recent terracing to create the community garden space. The locations of the Emory and Weinberg (2005) findings will be presented below in the discussion of the Area 5 Upper radar survey results.

The 2005 findings, along with numerous inadvertent discoveries of cemetery-related objects elsewhere in the community garden area (e.g., bone fragments, marker stone fragments, and coffin hardware), spurred a more comprehensive examination of the surface of the site in 2006-2008 and again in 2009-2012. This work was a collaboration between Howard University and local community members, and the results are presented in Mack and Belcher (2013). The 2006-2008 project involved a close inspection of the site's West Slope area, which in Figure 2 is the area to the west and north of Area 6 (Area 6 is currently a fenced dog walking area). The slope to the west of Area 6 is owned by the National Park Service and human bone fragments have been found in this area by volunteers working to maintain a trail that runs through here. The slope north of Area 6 is an overgrown part of Walter C. Pierce Park. The surface inspection began with the layout of a 10x10 meter grid across the slope. The surface in each grid square was carefully cleaned of brush and other debris and examined in parallel transects. This resulted in the identification of bone fragments, numerous fragments of coffin hardware, and grave-side ornaments such as a small stone carving of a bird and a metallic king-like figurine that could be a candle or incense holder. In all, bone fragments from at least four individuals were found on the surface and in rain-washed gullies, including animal and human bone fragments. And most astonishingly, an *in situ* grave with human skeletal remains and coffin fragments was found eroding out from underneath a tree on the west slope (this grave was found by volunteers maintaining the trail in this area, prior to the archaeological project). Clearly there are intact graves present on the west slope of the site, to the west of Area 6 (on NPS property). The many fragments of coffin hardware and other bone fragments found on the slope to the north of Area 6 suggest that this area too may contain the remains of graves.

The 2009-2012 work focused on the area north of the gabion wall, an area that Mack and Belcher refer to as the North Slope. This is the area where in the mid-2000s the community garden terraces were located, and where in 2005 Emory and Weinberg found evidence for intact graves. As with the West Slope, the North Slope area was cleared of vegetation and gridded off into 10x10 meter blocks; each block was carefully inspected for signs of cemetery-related materials. This area also proved to be rich in signs that a cemetery was once located here. Numerous marker stones were located during the surface survey, including what appeared to be nearly complete headstones (though they lack engravings). Also found were fragments of coffin hardware, a human vertebra and cranial fragment, probable graveside offerings (e.g., shells), and rock piles and terraces that could be related to the community garden or the cemetery.

In sum, the historical research to date indicates that at least 8,428 individuals were once buried in the Mt. Pleasant Plains and Friends Burying Ground cemeteries. In fact, the actual number could be even higher since the city only started keeping death records in 1855. Interment was stopped in 1890 and thereafter the cemetery began a slow process of attrition, as various projects disturbed different portions of the cemetery grounds. In 1940 a mere 129 individuals, complete or in part, were exhumed to make way for further development of the property. The exact locations of these disinterments is not known, though digging was likely focused on the graves on the higher elevations of the property—where the playing field is located today. In 1959 steam shovels went to work modifying the property, cutting down and moving large amounts of soil. However, the planned construction of apartment buildings associated with this massive disturbance of the cemeteries never materialized. While large amounts of soil, much of it containing human remains, was hauled off the property, it would appear from aerial photographs that some of it was pushed over the north and west edges to create a larger flat area where the buildings were to be constructed.

Archaeologists first appeared on the scene in 1981. Extensive archival research revealed the extent of the cemeteries, past ownership of the property, and the degree to which disturbance had likely impacted the site's graves. An archaeological examination of the site in 1981 failed to locate any signs of the former cemeteries, but this work was very limited in the number and size of the excavation units used in the field work. While the lead archaeologist on the project clearly was aware that soil was removed from the crest of the slope and pushed over the edge to the north and west, little thought was given to what this soil might have covered over. The 1981 archaeological project gave the green light to further develop the property, which was then transformed into a park. The crest of the slope in the southern half of the site was further flattened through grading and by installing a gabion wall part way down the north slope of the property. Dirt was then piled on behind the wall, extending the flat ground even farther to the north.

It was not too long after the park was complete that individuals working on trails and digging in a community garden on the north slope of the park began to find evidence of the cemeteries in the form of coffin hardware, marker stones, and human bone fragments—including an intact grave that was eroding out of the west slope of the site. In finding the bottoms of intact grave shafts in the northeast corner of the park, archaeological work in 2005 confirmed that the intensive earth moving of the 1940s and 1950s, and the work done in the 1980s to create the park, had not completely erased all vestiges of the cemeteries. This work alone begs the question of just how much more of the cemetery could be intact—how many of the other thousands of graves that were not disinterred in 1940 might still contain human remains? The systematic surface survey work reported by Mack and Belcher (2013) suggests that there is surface evidence of the cemetery on two sides of Walter C. Pierce Park, on the west and north slopes, and there is at least one grave actively eroding out of the ground on the west slope.

But what about other areas of the park? Might there still be intact graves preserved elsewhere in the park? And which areas are most sensitive for possibly containing intact graves? These questions are more thoroughly explored in the rest of this report using two kinds of data. First, a detailed topographic study is performed using cut-fill analysis to determine just how much soil has been removed from some areas and how much was piled onto others. The results are quite revealing and they very nicely corroborate the archaeological findings to date. For a closer look in the ground, noninvasive geophysical surveys were also performed in eight areas spread all across

Walter C. Pierce Park. Though these instruments can only "see" down into the ground a few feet, the results help confirm the conclusions garnered from the topographic analysis and they show where possible graves may be present near surface.

Topographical Study of the Park and Its Surroundings

The landscape including Walter C. Pierce Park has changed considerably in the century since it was an active cemetery. In the 1888 *Topographic Map of Washington and Vicinity* shown in Figure 3, the cemetery appears to consist entirely of sloped ground, with nearly 100 ft of elevation change from the southeast to the northwest corner of the cemetery (the portion shown in Fig. 3). Today, with its flat soccer field, basketball court, and dog walking area, it is clear that creating level land has been the primary reason for modifications to the property. What is not immediately evident is how this has affected the ground containing the thousands of graves known to have been part of the cemetery.

One way to assess the amount of change in the ground surface at Walter C. Pierce Park is a cut-fill analysis. This technique for examining topographic change subtracts one topographic dataset away from another, leaving the difference between the two. The main requirements of such an analysis are two sets of topographic data from the same location—essentially, before and after maps. Both datasets need to be reasonably good in quality, with high-density topographic data and good geographic coordinates anchoring both datasets in space.

The cut-fill analysis for the Walter C. Pierce Park area was performed by Jamie Davis (Ohio Valley Archaeology) and the author using ArcGIS 10.2. The two datasets used in the analysis are derived from the 1888 *Topographic Map of Washington and Vicinity*, Sheet 34 (Coast and Geodetic Survey) and the more recent LiDAR (Light Detection and Ranging) data from the USDA. Georeferencing the 1888 topographic was the first challenge. Select roads and intersections on the 1888 map were used to fit the 1888 map to modern aerial photographs of the area. Once the 1888 map was anchored, its contour lines were carefully digitized, creating georeferenced 1888 contour lines (in feet) for the park area. A digital elevation model (DEM) was then created using the digitized contour lines as the source data. DEMs are grids of points arrayed in space and each point is assigned an elevation. Ultimately, the 1888 contour map was used to produce a 1-meter DEM in the Universal Transverse Mercator (UTM) coordinate system.

The LiDAR data used for the cut-fill analysis were downloaded from the Natural Resources Conservation Service (NRCS) Geospatial Data Gateway (http://datagateway.nrcs.usda.gov/GDGOrder.aspx). These are relatively new data (c. 2004), and they came into ArcGIS as a 1-meter bare-earth model GeoTIFF file in the UTM coordinate system. Since LiDAR data are collected by firing a laser down from an airplane, all kinds of things end up being mapped besides the ground surface, including trees, buildings, and anything else sticking up above the surface. To create the bare earth model, which is as close as we can get to a DEM of the ground surface, the LiDAR data were filtered to remove points perceived to be from above the ground surface. This is a critical step in creating the DEM, and is not a step that we had any control over. The GeoTIFF LiDAR file was then converted into a 1-meter grid file, a file format native to ArcGIS. At this point we had two topographic datasets for the Walter C. Pierce Park area, one from before all of the land modifications of the twentieth century (1888 topographic data) and one after (LiDAR-based DEM). The big question is how accurately do these two datasets represent the ground surfaces at the time they were created, and how good of a job did we do in readying the data for the cut-fill analysis?

The results of our topographic analysis efforts are presented in Figures 6 and 7. Figure 6 shows perspective views of the colorized DEM models from the LiDAR data (marked "Today," top of the figure) and the 1888 contour map. Both look remarkably similar to one another. Note the ravine coming off of Rock Creek, which would have bounded the northwest corner of the cemetery. It is also easy to see where the two topographic models differ. Today's map shows a big flat area where the playing field and basketball court are located, while in 1888 this was a sloping surface heading down into the ravine.

In the bottom image of Figure 6, the results of the cut-fill analysis are presented. The colors show the differences between the "Today" and the "1888" DEMs. Magenta, red, and yellow areas in this image indicate places where dirt has been added since 1888, white areas indicate no change and are close to the original 1888 ground surface level, and green, light blue, and dark blue colors are areas where dirt has been taken away from the 1888 landscape. The cut-fill results closely match what historic accounts tell us has happened to the cemetery area: large amounts of soil have been removed from the southeastern one third of the park and large amounts of fill have been dumped or pushed on to the north and west slopes to create a flat area in the middle of the park property. Some areas within or near the park, such as old Adams Mill Road to the north of the park, have changed very little since 1888. Note the scale bar associated with the cut-fill results. At the extremes, more than 9 meters (ca. 30ft) of fill have been removed from some areas (southeast of the park) and more than 9 meters have been dumped on the surface (near the middle of the park). What we need to know is how these differences specifically relate to the geophysical survey areas and other work that has occurred within the park.

The map in Figure 7 is the most telling result of the cut-fill topographic analysis. It shows today's topographic contour lines overlaid on the colorized results of the cut-fill analysis. It also shows the locations of the geophysical survey areas and the Mack and Belcher (2013) cemetery-related surface discoveries from the west slope. For example, survey Area 6, which is the dog walking area, is sitting on about 3-10 meters of fill. And yet, just to the west of this area the surface survey work reported by Mack and Belcher (2013) located numerous cemetery-related objects at the surface of this supposed fill. Is the cut-fill analysis showing us valid results? How could there be cemetery-related objects at the surface and yet there is supposed to be as much as 12 meters of fill on the west slope? The answer to the validity and general accuracy of the cut-fill analysis is yes, it is valid and relatively accurate, and we can see why by noting on the map the location of the grave that was found eroding out of the west slope (Figure 7, the grave is a small black square referred to in the legend as "Articulated Burial"). Recall from the previous section of this report that trail workers found the remains of what appeared to be an intact grave, with human bones and fragments of coffin wood, eroding out of the west slope of the cemetery on what is now NPS property. While we do not know the original depth of the graves in this area, finding remains of a coffin and its contents at the surface implies that the ground surface in this portion of the west slope has been eroded or dug away by as much as 2-3 feet. If this coffin is visible at the surface, there cannot possibly be any fill sitting on top of it (unless the coffin is not actually *in situ* and instead is in fill). A look at

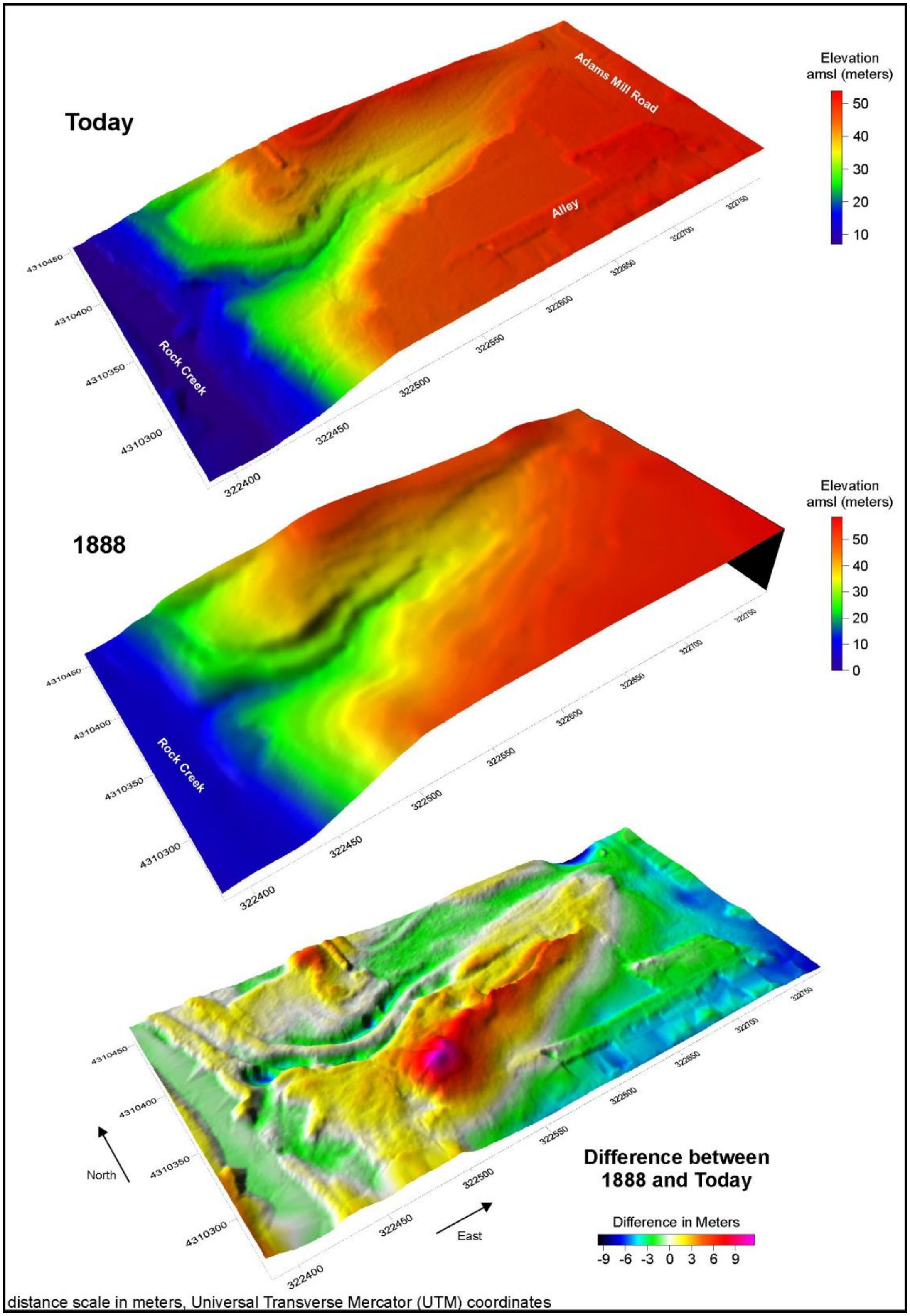

Figure 6. A comparison of 3D versions of the 1888 (digitized) and modern, LiDAR based topographic data of the Walter C. Pierce Park area, showing the difference between the two.

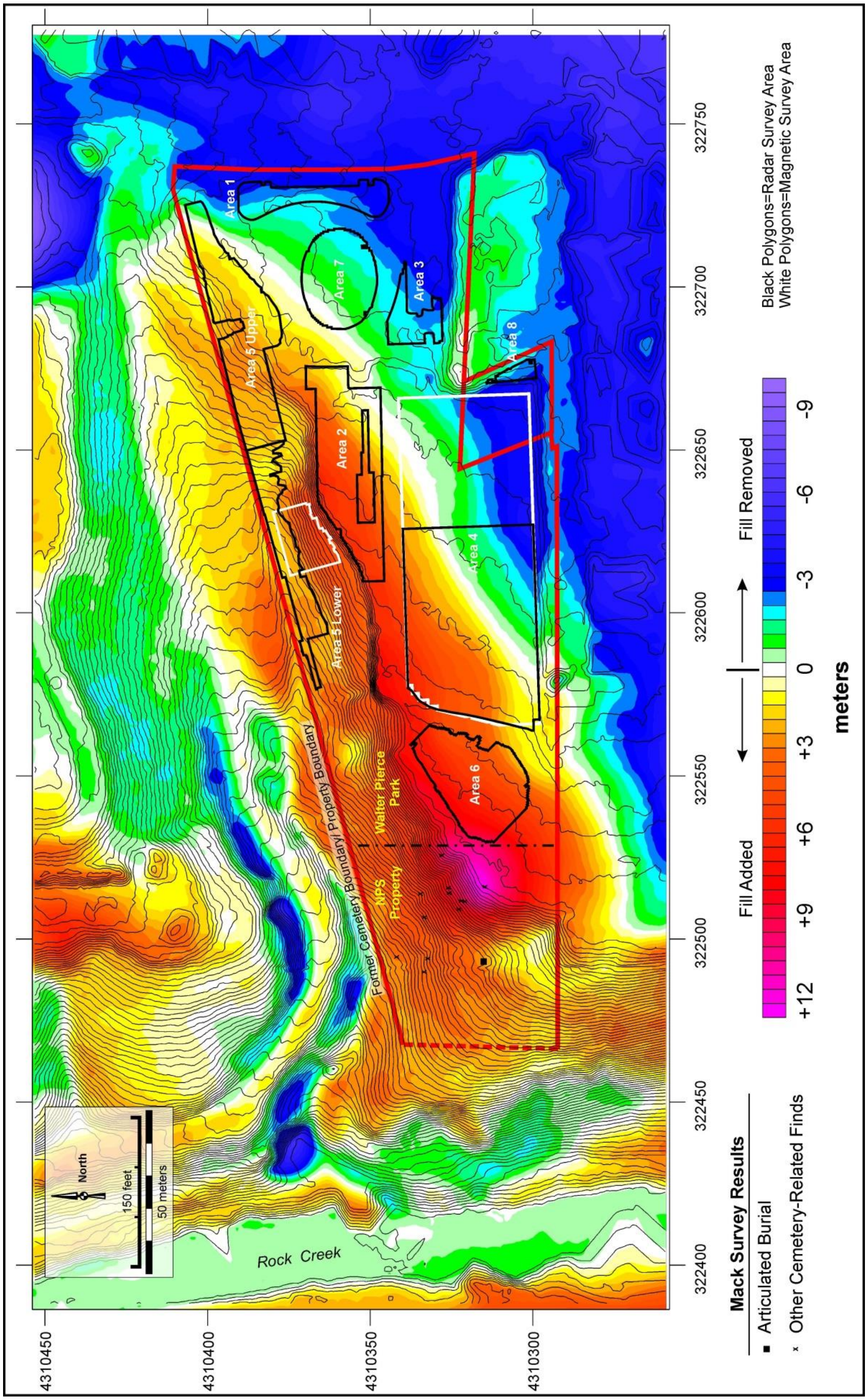

Figure 7. A map of elevation difference between 1888 topo map and modern LiDAR digital elevation model, with an overlay of LiDAR topographic contours and the locations of the geophysical survey areas and cemetery-related surface finds (from Mack and Belcher 2013).

the cut-fill analysis results shows that the location of the coffin (the small black square in Figure 7) has relatively little fill on top of it. If the cut-fill model results were not valid or spatially accurate, the chances seem pretty low that the model would show the area of the coffin as having little to no fill on top of it. Therefore, it would appear that the results of the cut-fill analysis are valid and fairly accurate. No doubt, there is some give and take in the results, and based on the location of the coffin we might expect the results to be within plus or minus 2-3 ft of actual.

Implications of the Cut-Fill Analysis

If we accept the results of the cut-fill analysis as reasonably valid and accurate, and all signs point to this, then the results of the topographic analysis present us with several very important implications:

(1) Large amounts of soil have been removed from the southeast one third of the park/cemetery. The graves in these areas were dug away and there is no chance of finding intact graves here. Since topsoil is present in most of this area, it is likely that topsoil was brought back in as fill. Human remains and other cemetery related objects are unlikely to be found in this area—to the southeast of the white band running across the park in Figure 7.

(2) Large amounts of fill occur in a band running through the park from southwest to northeast. It is thickest just west of the fenced dog walking area (Area 6) and follows along on either side of the gabion wall, though mostly to the inside of (behind) the wall.

(3) While we know that many dump truck loads of soil were removed from the property, with some of the soil containing human remains, a lot of excavated soil from the southeast third of the property likely remains on site. The southwest-northeast band of fill cutting across the property likely comes from the ground dug away in the southeastern portion of the property, and therefore it includes fragments of human bone, coffins, and other cemetery-related objects from the Mt. Pleasant Plains and Friends Burying Ground interments. We can see in Figure 7 that numerous cemetery-related objects and bones have been found on the surface of the west slope. The same is true of the north slope (i.e., north of the gabion wall). These surface finds likely derive from the displaced graves excavated from the southeast portion of the cemetery.

(4) The large amounts of fill in the central third of the property are sitting on top of the original surface of the cemetery. This fill is likely covering hundreds of intact graves. The 1940 project to remove burials from the cemetery only resulted in the recovery of 129 full or partial sets of remains. While we do not know from where these were excavated, we do know that only a small portion of the 8,000 individuals buried in the Mt. Pleasant Plains and Friends Burying Ground cemeteries were exhumed. Therefore, there were many graves left behind after the 1940 exhumations. Hundreds of intact graves could be present beneath the fill, within Walter C. Pierce Park and beyond to the north and

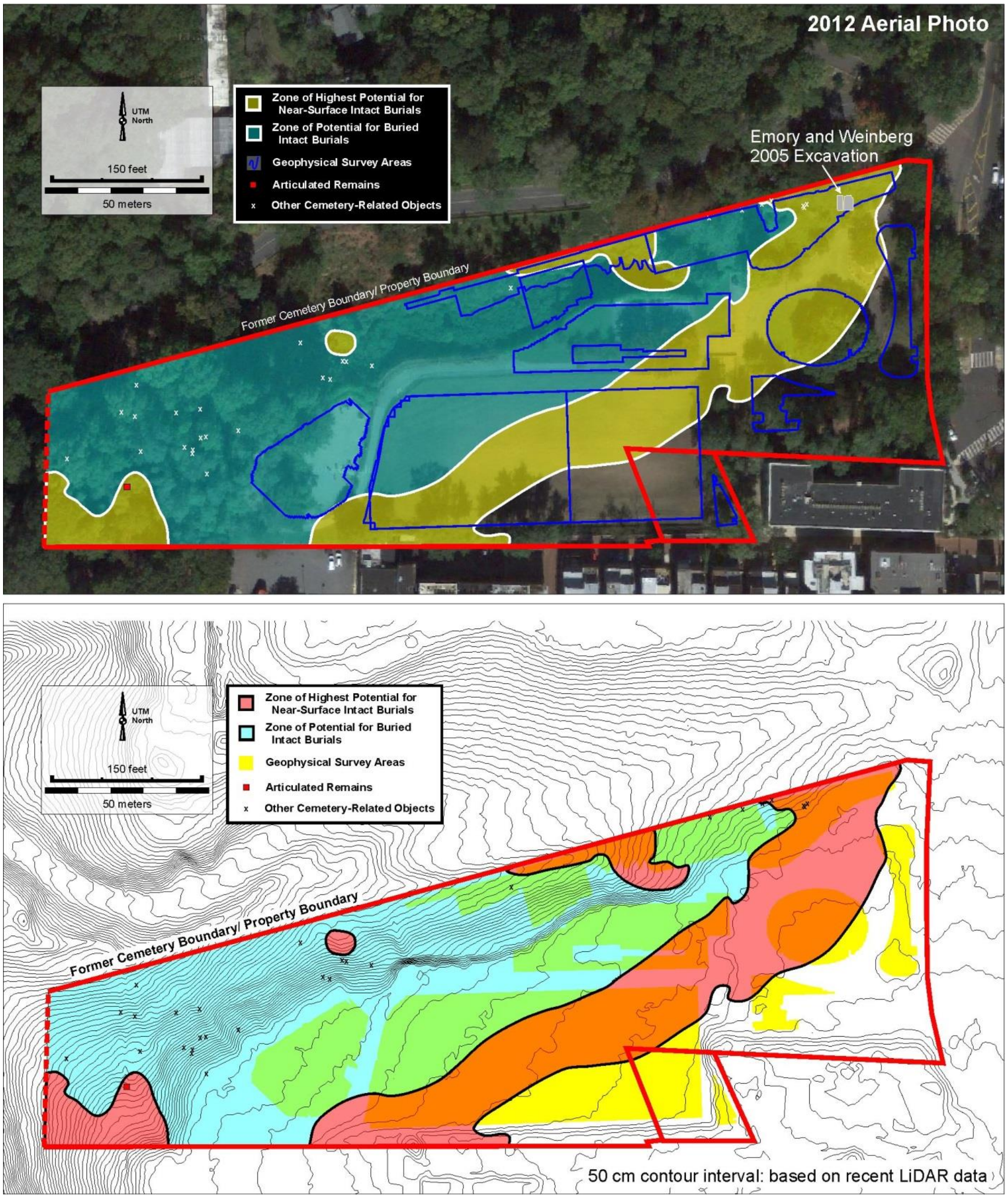

Figure 8. Zones of highest potential for intact burials based on topographic analysis.

west. Excavations in 2005 located the bottoms of a number of intact grave shafts at the east end of the north slope—this is geophysical survey Area 5 Upper. While no human remains were found during these excavations, suggesting that these burials could have been exhumed, the 2005 work shows

> that intact grave shafts are present relatively close to the surface in areas with minimal fill on the north slope. On portions of the west slope, in the area owned by the NPS, there is very little to no fill and graves may be close to the surface. This is supported by the presence of at least one probable *in situ* grave eroding out of the surface of the west slope.

These implications are distilled in the Figure 8 maps, which show the areas with the highest potential for near-surface intact graves (yellow in the upper map and red in the lower map) and areas where buried graves are likely preserved intact (the blue areas in both maps). The areas with possible near-surface graves include three contour intervals (1.5 m) above and below zero on the topographic difference map in Figure 7.

While existing information on the distribution of cemetery-related objects and bones helps show that the topographic analysis results and implications are valid, another way to test these findings is additional field work. Near-surface geophysical survey is one useful way to nondestructively look for signs of subsurface graves. The rest of this report considers the use of geophysical survey in the search for graves and presents the results of surveys in eight areas within Walter C. Pierce Park.

Methods

Geophysical Surveys and Historic Graves

Any frank and honest discussion about cemeteries and geophysical survey must begin with a caveat: graves are notoriously difficult to detect with geophysical survey instruments and often for unpredictable reasons (e.g., Jones 2008). In some cemeteries every single grave might be detected while in others the graves are totally invisible to the instruments. Most of this difference in detectability is related to variability in the types of soils found in areas used for burial, such as sandy soils versus clayey soils. Some soils facilitate grave detection more than others (Bevan 1991; King et al. 1993; Scott and Hunter 2004). Of course, what is in the grave is also a major contributor to detectability—concrete vaults are quite easy to detect with nearly every kind of survey instrument and in any soil type.

Each of the instruments we have at our disposal for detecting graves, from magnetometers to electrical resistance meters and ground-penetrating radar units, works by identifying contrasting geophysical properties in the ground. What is inside the grave shaft must be geophysically different than the surrounding soil if the grave is to be detected. In particular, these instruments are good at detecting (1) differences in soil moisture levels, (2) varying amounts of different materials in the soil and sediment layers (especially the presence of sand, gravel, and clay), and (3) the presence of disturbed ground, especially in the form of increased air pockets. In addition to being able to detect graves by the soil that was used to fill them in, we can also sometimes locate unmarked graves by finding things that were associated with them but are now invisible at the surface, such as the foundations of headstones and footstones, or the remains of objects placed at the graveside.

Several properties of the graves themselves can make them stand out from the background soil in a geophysical survey, including most importantly: the grave shaft and

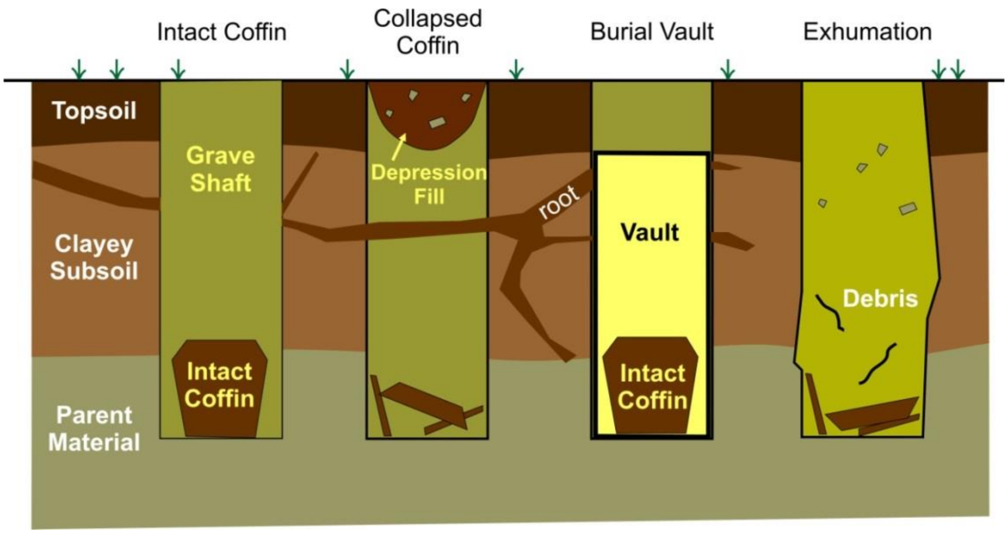

Figure 9. Idealized examples of graves and their components.

its fill (Bevan 1991), the presence of a burial vault, and the type of coffin used and its condition at the time of survey (Conyers 2006) (Figure 9).

Grave Shaft and Fill

Perhaps the most important aspect of older graves (i.e., 19^{th} century and earlier) for successful detection during geophysical surveys is the grave shaft and its fill (Bevan 1991). Grave shafts are oval to rectangular holes excavated two to six feet into the ground. Their horizontal extent varies widely and is dependent on the size of the grave's occupant and the use of a coffin and/or a burial vault. Larger grave shafts, such as those of adult burials, are more likely to be detected by geophysical instruments than those of smaller, adolescent burials. In general, adult graves should be about 5-7 feet (1.5-2 m) long and 1.5-2.5 feet (0.5-0.75 m) wide.

Along with grave size, the type of soil within which the grave shaft is excavated is also important for detection with geophysical survey devices. The sediments in grave shafts are detectable because their properties are significantly different (e.g., they are disturbed) than the surrounding, intact soils. However, a grave shaft dug into soil without distinctive layers will be less detectable than one dug into a well developed soil (one with numerous, distinctive layers). In the extreme, a hole dug into a homogeneous medium such as sand that is then backfilled with the same sand will be even more difficult to detect (if not impossible).

Several other soil characteristics also factor in to grave shaft detectability. Because the soil properties (porosity, compactness, etc.) of grave shaft fill differ from the undisturbed soil that surrounds them, grave shafts tend to hold and drain moisture differently than their surroundings. Thus, differential soil moisture plays a key role in grave detectability. In particular, recent heavy rains can make the tops of grave shafts (i.e., at and just below the ground surface) easier to detect in radar and electrical resistance surveys (assuming the soil contains ions). Interruptions or disturbances of soil layers, which are common to all graves, can sometimes be detected by geophysical instruments, especially ground-penetrating radar (Conyers 2006). In these cases, the instruments detect the intact soil layers that surround graves and the graves appear as gaps in the layers. Finally, many graves, especially older ones lacking burial vaults, experience subsidence as the grave shaft fill settles and the coffin collapses. Often, the soil brought in to fill the subsided grave is obtained from a different source than the original grave shaft fill. This different soil is often detectable to magnetometers because it is usually subsoil from other recently excavated nearby graves or it is fill dirt, perhaps from outside the cemetery, that contains refuse such as building debris or other magnetic materials.

Presence of a Burial Vault

Nearly all modern graves in the United States involve placing a coffin in a subsurface burial vault—this practice is also used in many other parts of the world. Today, these vaults are made from reinforced concrete or fiberglass, for example. Older graves sometimes contain vaults made with brick. Whatever the material, vaults will certainly impact the soil moisture levels present in the grave, making them detectable with most instrument types sensitive to moisture (i.e., conductivity). Reinforced concrete vaults and brick vaults are easily detected during magnetic surveys. Ground-penetrating radar units will likely detect just about any kind of vault, especially if it has not filled up with soil. During times of the year when the soil is moist, an electrical resistance meter should be able to detect vaults. Unfortunately, vaults were not commonly used during the period of burial known for the Friends Burying Ground and the Mt. Pleasant Plains cemeteries. This means that we will have to examine the geophysical data more closely for subtle indications of possible graves.

Type of Coffin Used

Coffin type may also affect a grave's detectability during a geophysical survey. Most wooden coffins cannot be detected because their geophysical properties are similar to the soil they are buried in, and in older cemeteries many wooden coffins have collapsed and rotted away. However, it is possible that intact wooden coffins, if they still contain an air pocket, will be detected by ground-penetrating radar. With only one exception, coffins and coffin hardware are generally not detectable during magnetic surveys because of the small size of the magnetic components of the coffin (mostly the coffin hardware) and the depth of burial, which is usually beyond the range of detection for magnetometers. One type of coffin, on the other hand, is easily detected by magnetometers—cast iron coffins/caskets. The first patent for a cast iron coffin in the U.S. was issued in 1848 and not long thereafter (1850s) iron coffins were used in cemeteries across the country, though in small numbers and largely for affluent individuals (Crane, Breed, and Co. 1858). Large cast iron objects, be they coffins, stoves, or pipes, are highly magnetic and should be detectable with magnetometers even when buried at five to six feet below the surface. Because iron coffins are so magnetic, their magnetic signatures tend to be larger than the actual size of the coffin or grave shaft—this is true for many types of vaults, as well. The ground-penetrating radar can detect metallic coffins of any type and may even be able to detect coffin hardware if it is large enough (nails are not likely large enough to detect with radar)—assuming the radar signal can penetrate deep enough into the ground to reach the coffin, which is not always the case.

In sum, three main aspects of graves determine their detectability in geophysical surveys: the grave shaft and the soils within and around it, the presence of burial vaults, and the type of coffin used and whether or not it is still intact. Except in cases of very recent or very shallow burial, it is unlikely that any of the instruments will detect the remains of the individual at the bottom of a grave, especially given that in most cases a skeleton is all that remains. In fact, the radar is the only instrument that can penetrate deep enough into the ground, and with sufficient data density, to even reach the depth necessary for detecting the human occupants of most graves (certain resistance meters can detect down many feet into the ground, but their resolution drops off with depth). But even if the radar can penetrate deep enough, bones and dirt have a similar radar signature. Furthermore, the detection of very subtle features or objects, such as bones in dirt, is complicated by the presence of other, more easily detected things in most cemeteries. For example, tree roots can be very distinctive in radar data and they can obscure any subtle radar reflections next to and below them.

In addition to graves, cemeteries also contain burial plot markers and walls, paths, roads, small buildings, perimeter fences, wells, and other kinds of decorative/garden features. Finding the geophysical signatures of these kinds of features can be important to determining the structure of the cemetery, and by extension the general locations of graves, as well as the locations of the cemetery boundary. Cemetery edges can also be distinguished by activities that have occurred outside the cemetery. For instance, plowing around the edges of burial areas or cemeteries often creates distinctive plow patterns in geophysical data that are notably absent within the cemetery.

Notes on Geophysical Survey Instruments

Geophysical survey instruments are commonly used around the world by archaeologists to find buried features, such as graves. Most things of archaeological interest are no more than a few feet below the surface. At these depths, the instruments detect archaeological features and graves by measuring subtle changes caused by differences in the soil, including for example changes in its electrical conductivity, electrical resistance, and magnetism (e.g., Bevan 1998; Clark 2000; Conyers 2004, 2012; Gaffney and Gater 2003; Heimmer and DeVore 1995; Lowrie 1997; Weymouth 1986). Certain types of *objects* can also be detected with regularity. Each instrument is designed to measure a different property of the ground, and some of these properties, like magnetism and electrical resistance, vary almost totally independent of one another. This means that when looking for buried things that are subtle and difficult to detect, such as graves, it is worth using multiple instruments when possible because it is difficult to anticipate which will work the best and often each instrument detects a different aspect of the target feature.

Three geophysical survey instruments were used in Walter C. Pierce Park to search for graves: two **magnetometers** and a **ground-penetrating radar** (Figure 10). Geophysical surveys are typically conducted by using the instruments to take numerous readings along parallel lines (a.k.a. transects) in a rectilinear block (a.k.a. block). Data points are recorded at timed intervals, or based on distance, as the instruments are moved

Ground-Penetrating Radar

Magnetometer: 4-gradiometer system

Magnetometer: single gradiometer

Figure 10. Geophysical survey instruments used during the Walter C. Pierce Park survey.

along the transects in each block. While one can learn things from a single line of radar data, for example, it is almost always better to survey an area that is considerably larger than the target feature to provide a context within which to see that feature. It also is important to collect high-density data when possible, especially when looking for graves or other small features.

Generally, the data collected by geophysical survey instruments during cemetery surveys must be transferred to a computer where special software is used to process the data and make maps of the survey results. In these maps the data values are assigned a range of colors related to their strength. In areas with little change in the readings, the colors are all similar—think of these areas as the typical background signature of the site. Areas in the data with unusual values that differ from the background are referred to as *anomalies*, and the goal is for graves to appear as anomalies in the data. Of course, the real challenge is knowing which anomalies are important and which are caused by tree roots, animal burrows, and other things not significant to the goals of the project.

Magnetometers

Magnetometers detect subtle changes in the earth's magnetic field caused by the magnetic properties of things close to the instrument (Figure 11). They can detect the presence of magnetic objects (e.g., iron objects) and subtle changes in the soil, especially if these soil changes involve the local accumulation or removal of topsoil or other magnetically distinct sediments (Aspinall et al. 2008; Clark 2000; Gaffney and Gater 2003). While small objects in the ground such as coffin nails (iron ones, anyway) are quite magnetic, they are usually too far away from the instrument to be detected during a survey. Nevertheless, most iron objects larger than the average nail and located in the top several inches of soil are detected. Old fence wire, iron pins used to mount or repair headstones, and wrought iron fencing are all quite magnetic and can be found in cemeteries. Sometimes, graveside offerings that have broken up and become incorporated into the soil contain magnetic components that give away the locations of graves, as well. More recent iron-based things at cemeteries and in parks can essentially blind the magnetometer to graves. These include playground equipment, chain link fences, manhole covers, iron rebar that holds landscaping blocks and timbers in place, and the wire cages used to create gabion walls.

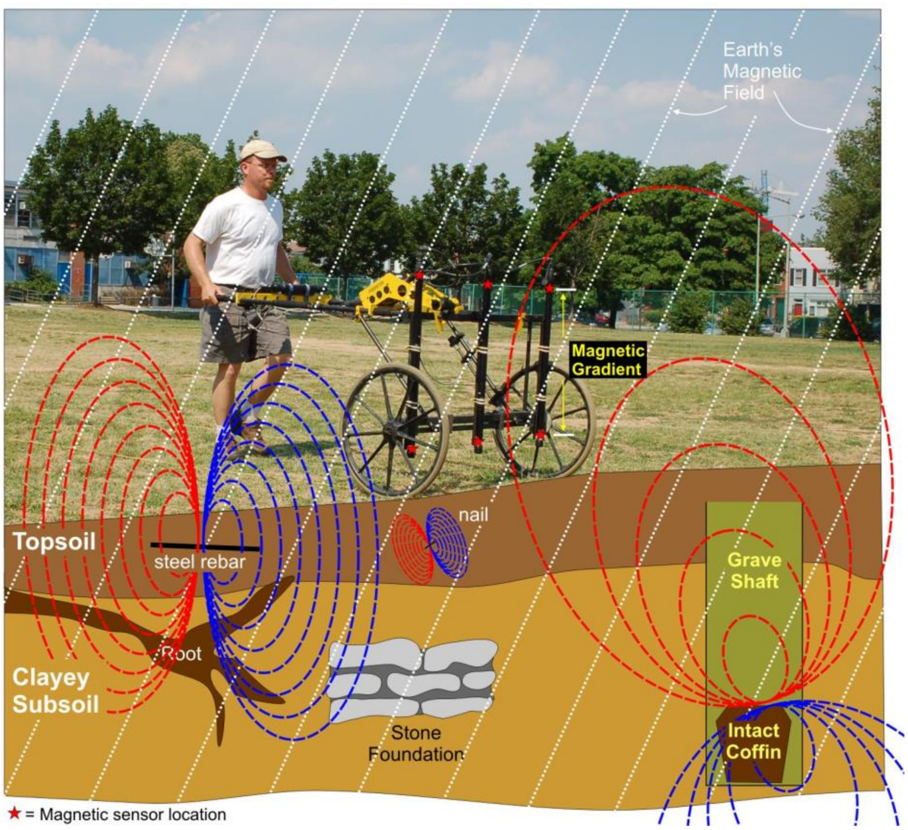

Figure 11. An illustration of magnetic fields on an archaeology site—red and blue lines are the magnetic fields of objects and features; white lines represent the earth's magnetic field.

Two different magnetometers were used at Walter C. Pierce Park. In the sloped portions of Area 5, a Geoscan Research FM256 fluxgate gradiometer (50 cm sensor separation) was used because it is a handheld instrument that can be easily carried over uneven terrain (Figure 10, lower right). Eight readings were collected per meter along transects spaced 50 cm apart. This data collection density has been used in many cemetery settings to detect graves. In general, this magnetometer can detect down into the ground about three feet, unless there is something exceptionally magnetic in the area—which could be detected even deeper. Buried features such as wells, cisterns, privies, burned areas, and some kinds of foundations can be detected with magnetometers. Graves can also be detected, and usually it is the soil within the grave shaft that the magnetometer detects. If the area surveyed has lots of other magnetic things on or near the surface, such as iron or steel fences, this can make it difficult or impossible to detect subtle graves. In the flat, open ground in Area 4 (the soccer field), a different kind of magnetometer, a Foerster Instruments Ferex 4.032 DLG 4-probe magnetometer cart (with fluxgate sensors, 65 cm sensor separation per gradiometer), was used to rapidly collect ten readings per meter along transects spaced 50 cm apart (Figure 10, lower left).

Though often complicated with many kinds and shapes of anomalies, magnetic data can be distilled down to a small selection of anomaly types that are useful for understanding what has been detected. Figure 12(a) presents the three primary types of magnetic anomalies, along with some variants, that are typically encountered during surveys on archaeological sites and in cemeteries. Monopolar anomalies are small areas where stronger or weaker readings have been detected. These anomalies are often associated with pits that have been dug into the ground. If topsoil or magnetically enhanced soil ends up inside the pit, then a monopolar positive anomaly will be created. If subsoil or sand is used to fill up the pit, and occurs near the surface, then it is possible that a monopolar negative anomaly will be created, though these are rare (Figure 12b). Dipolar simple anomalies are the easiest to identify in magnetic data as they have side-by-side positive and negative peaks. They most often are associated with iron objects and magnetic rocks—the larger the object or rock, the larger and stronger the magnetic anomaly. Vaults in cemeteries often appear as large dipolar anomalies (Figure 12c). Sometimes dipolar anomalies are found clustered together or as very irregular areas of negative and positive readings. These clusters of anomalies are referred to as dipolar complex anomalies and they often are associated with historic refuse dumps, building foundations, and burned areas. Utility lines can also produce linear arrangements of complex anomalies (see Figure 12a, left column, bottom).

The magnetic data presented here are processed using the Geoplot 3.0(s) software. Several different data processing steps are used to clean up and prepare the data for analysis, including zero mean traverse, interpolation, and low pass filter.

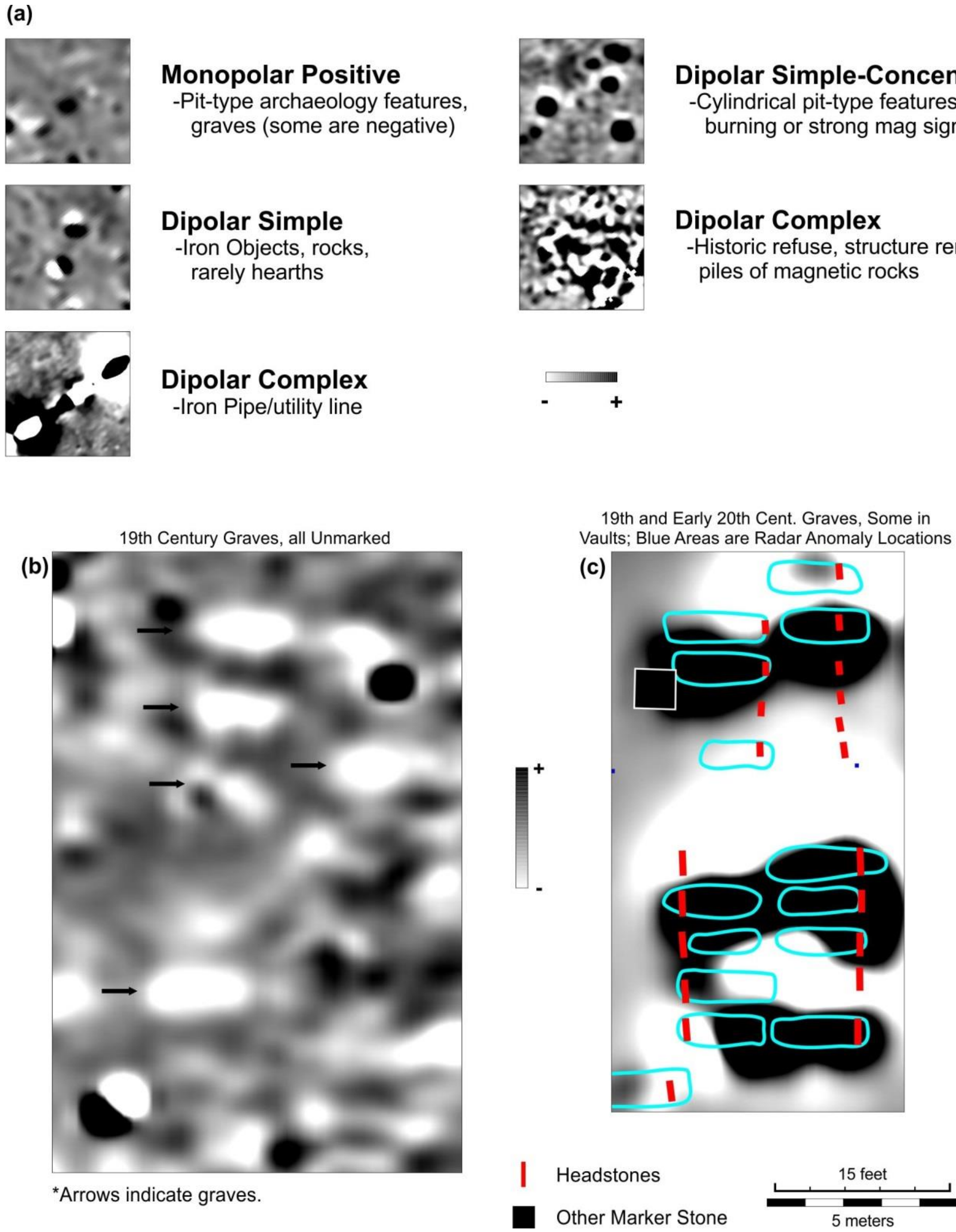

Figure 12. Magnetic anomaly types (a) commonly encountered in archaeological surveys and (b-c) examples of the magnetic signatures of graves in 19th century cemeteries in the Midwest.

Ground-Penetrating Radar

Ground-penetrating radar (GPR) works by moving a radar antenna along the ground as it transmits thousands of pulses of radar energy per second (Figure 13). As these waves of energy travel into the ground and encounter objects and layers, especially those with distinctly different electrical properties, some of the energy is reflected back to the surface and received by the antenna (Conyers 2004, 2012; Gaffney and Gater 2003; Witten 2006). The instrument records the strength of the reflections and how long it took the energy to travel away from and back to the antenna. This radar travel time can be used to calculate the depth of a detected object or feature.

Many things below ground can cause strong and weak radar reflections, including tree roots, pipes, larger rocks/bedrock, distinct layers, foundations, shaft-type features (e.g., graves, wells, cisterns, and privies), and disturbances to the natural soil layers. Radar energy can also penetrate asphalt, concrete, and gravel. In fact, concrete and asphalt are excellent materials on which to survey because they are very good at allowing the radar energy to pass into the ground. Other materials, especially clayey, moist soils, tend to absorb radar energy and do not allow it to pass. At the extreme, radar energy cannot penetrate metals, so metal pipes and other large metal objects are easily detected, but they do obscure things below them. Ultimately, the depth of the radar signal penetration, and the depth to which objects can be detected, depends on the frequency of the antenna being used and the conductivity of the ground. Higher frequency antennas (e.g., 1000 MHz) can detect very small things but only at shallow depths, while lower frequency antennas (e.g., 50 MHz) can penetrate into the ground much deeper but can only detect larger things. The frequency of the antenna, however, can be irrelevant if the ground is so conductive that all of the radar energy is absorbed (i.e., attenuated) before it can make its way back to the surface.

For the Walter C. Pierce Park survey, a Sensors and Software Noggin Plus 500 MHz system was used to collect radar data (Figures 10 and 13). It is a mid-range frequency system that is ideally suited to most archaeological applications. Two different data densities were used. In most areas, forty traces were collected per meter (essentially, a "reading" [a.k.a. trace] taken every 2.5 cm) along transects spaced 50 cm apart. In areas with a higher probability of containing graves, based on the topographic analysis, higher density data were collected—forty traces per meter along transects spaced at 25 cm intervals. Collecting data at this density with a single antenna system is a very time consuming process but it increases the odds that subtle features such as graves can be detected and discerned in the data. A 40 nanosecond time window was used to "listen" for return reflections from each pulse.

Each radar trace is a very narrow profile of the ground. When all of these narrow profiles, or traces, are put together side by side they form a radargram (Figures 13). These radargrams are the nuts and bolts of a radar survey; they show the locations, shapes, and strength of the radar reflections. However, it can be difficult to interpret what has been found based on the radargrams alone.

Radargrams can be turned into three-dimensional blocks of data by lining them up side by side and having the computer software fill in the gaps by estimating (i.e., interpolating) what should be in between the radargrams. The block of data can then be "sliced" horizontally and examined from the top rather than the side—making it seem as

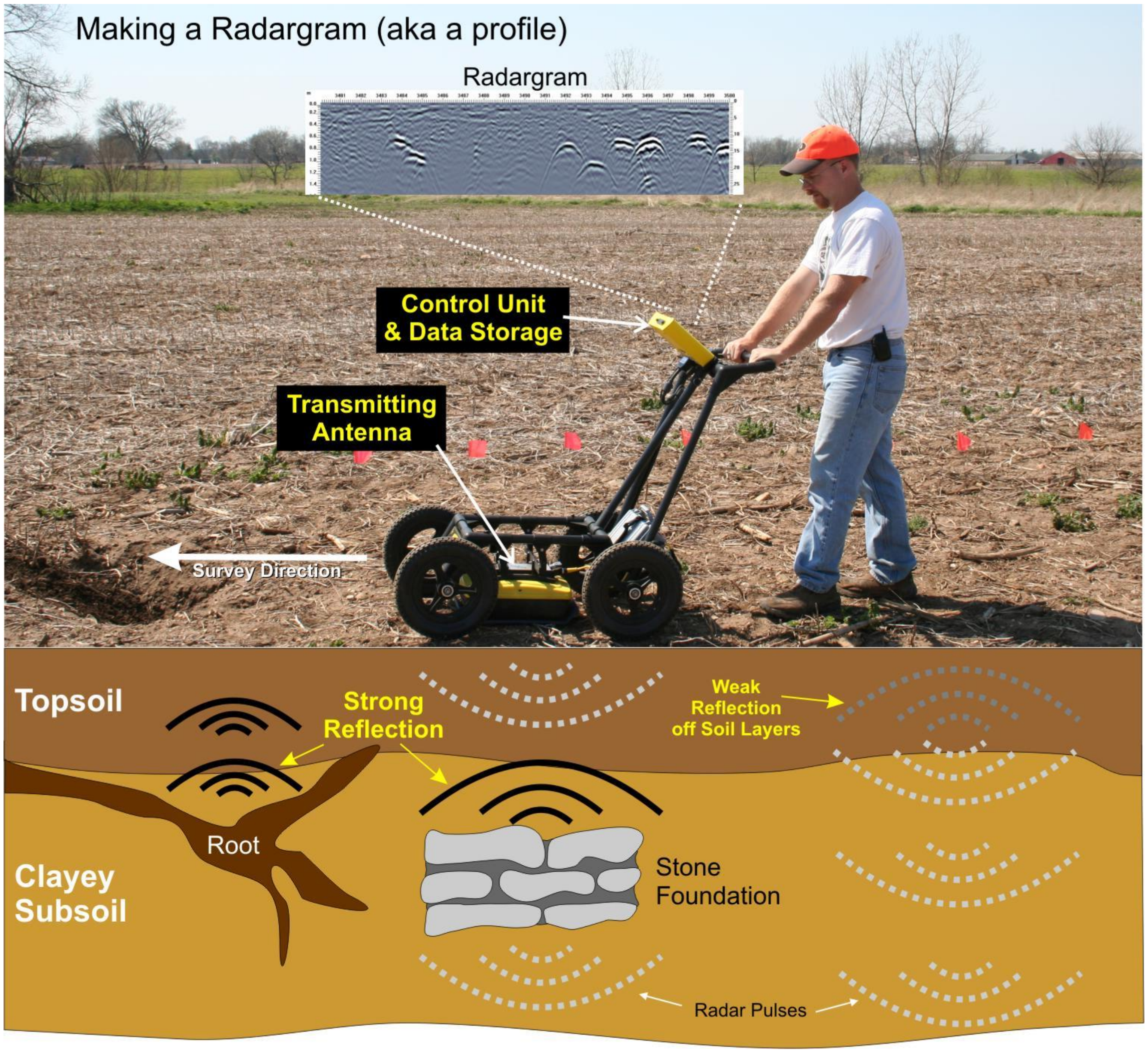

Figure 13. A demonstration graphic showing use of the ground-penetrating radar instrument.

if one is excavating down through the data, and the site, one layer at a time (Figure 14). These horizontal data slices are called "time slices" or "amplitude slices" and they show a horizontal map of the radar reflection strength at a desired depth. Graves should appear in the slice images as small anomalies, about 2x7 ft (for adult graves), that often occur in rows. The graves can be positive anomalies, where the graves themselves are what is causing the reflections (Figure 15a), or graves can appear as gaps (i.e., negative anomalies) in an otherwise reflective layer (Figure 15b). In some cases the graves are obvious in the radar data, and in others they are more subtle. Sometimes, even when graves are detected, they do not show up well in the time slice maps; therefore, it can be important to closely inspect all of the radargrams for the telltale signs of a grave.

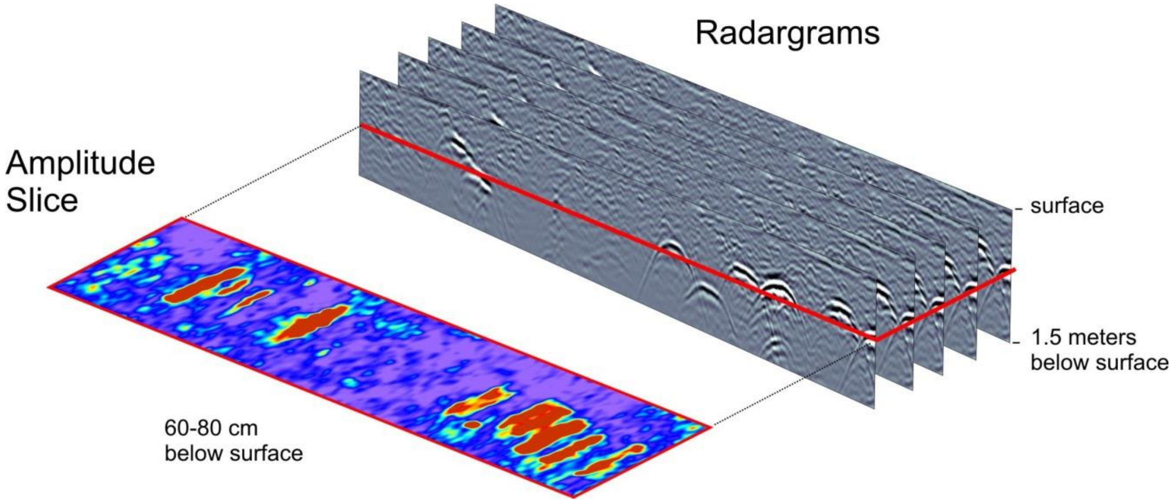

Figure 14. A demonstration graphic showing the creation of a radar amplitude slice from radargrams.

Figure 16 shows how interpreting both amplitude slice maps and radargrams can work together to produce a more complete interpretation of the radar data. In the top two images (Figure 16a) only the amplitude slice maps are used to identify graves, of which there are many and most occur in rows. In the bottom two images, Figure 16b, we see that an examination of the radargrams, with a plotting of distinctive anomalies from the radargrams (the small red dots), has led to the identification of at least six more probable and possible graves. Therefore, it is important to include both amplitude slice maps (and at varying depths and thicknesses) and radargrams in an analysis of radar data focused on detecting graves. This technique was used in a selection of survey areas at Walter C. Pierce Park.

The radar data presented here are processed using Sensors and Software's Ekko_Mapper 4 software. All of the radargrams are processed using a combination of the following steps: dewow, migration, enveloping, background subtraction, gain, and interpolation. Even with good data processing and conscientious interpretation, graves can be difficult to detect in radar data. Therefore, a lack of graves in the radar data should not be used as the only indication that graves are absent from a survey area.

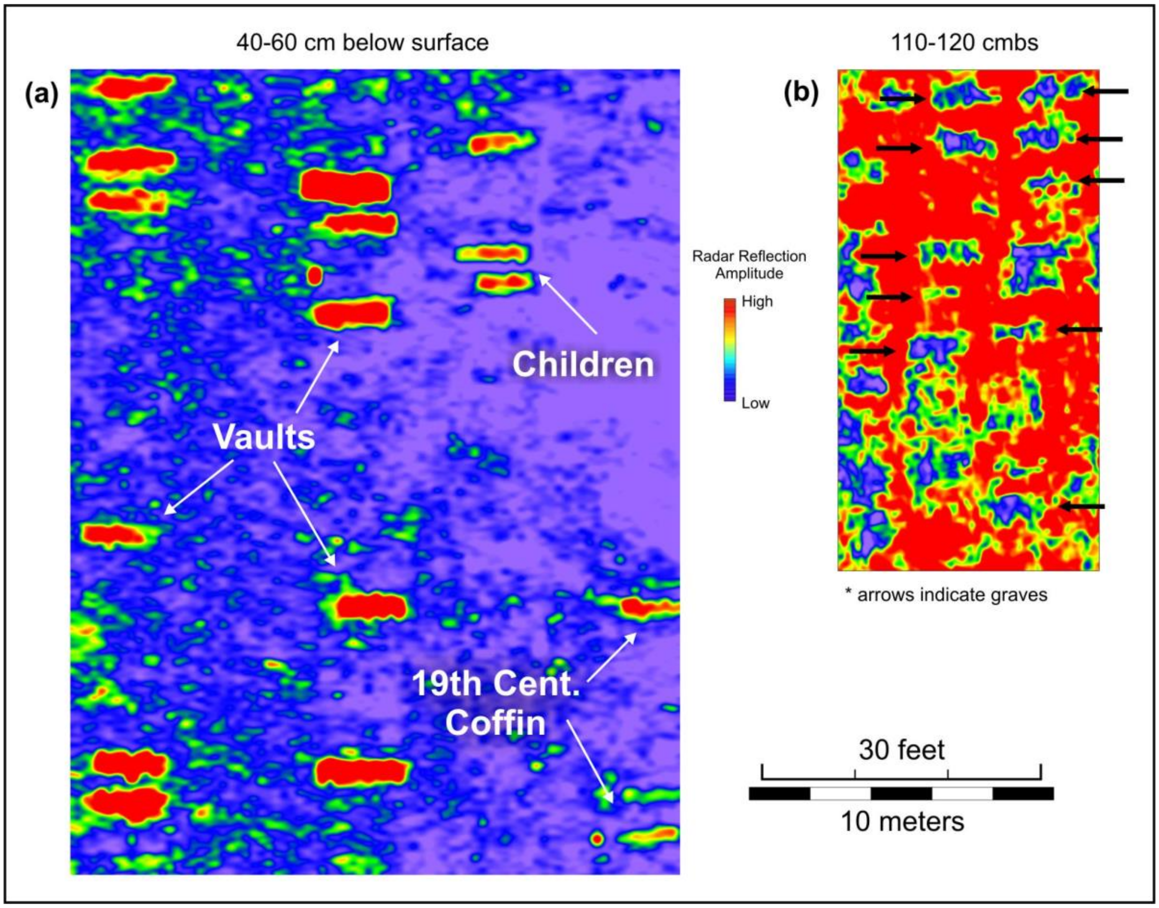

Figure 15. Examples of graves in amplitude slice maps detected at nineteenth and early twentieth century cemeteries in the (a) Ohio and (b) Pennsylvania.

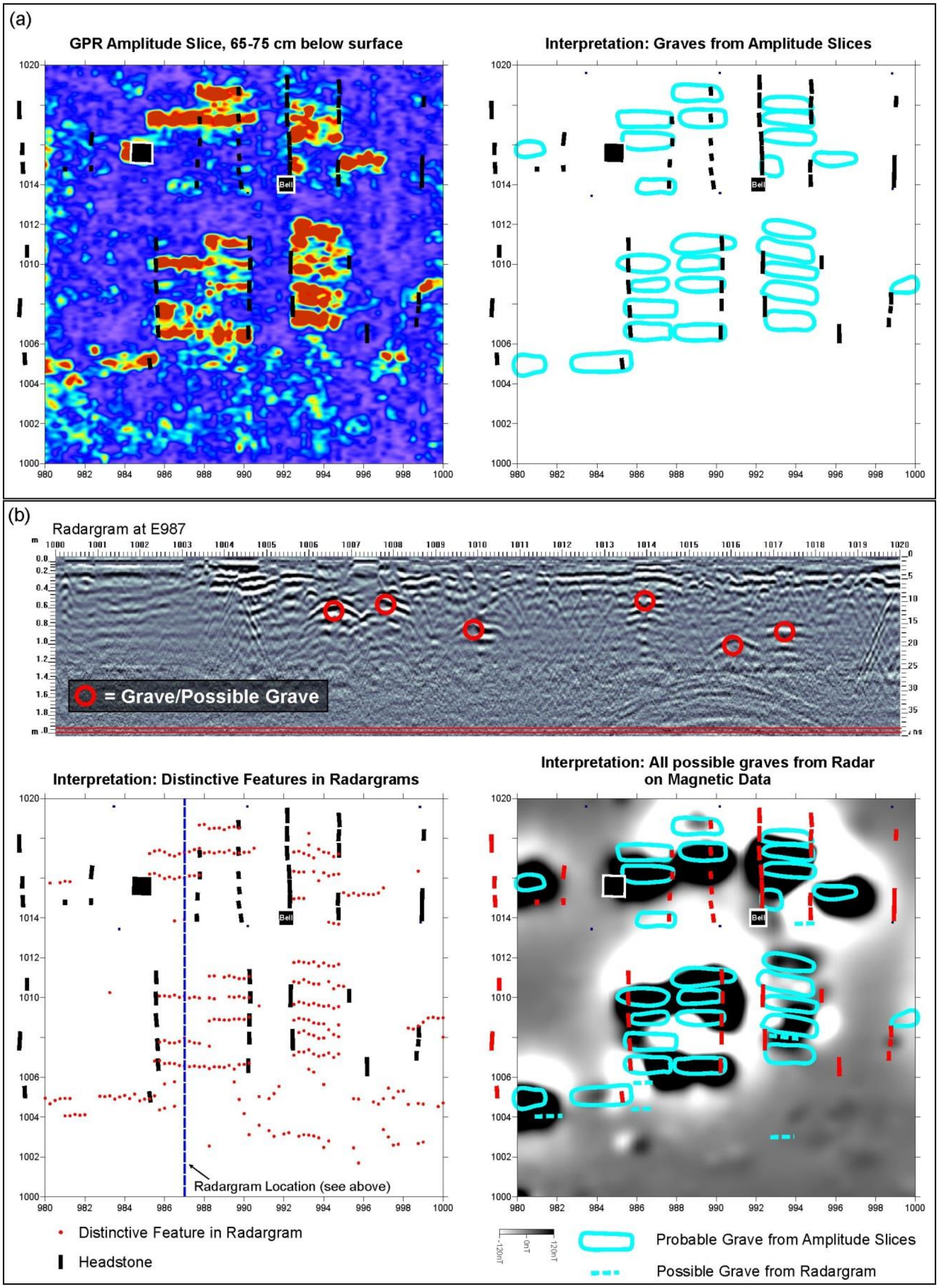

Figure 16. An example of radargram analysis to identify graves.

Geophysical Survey Results

Survey Grids

The geophysical surveys in Walter C. Pierce Park were conducted in eight distinct survey areas, each with its own survey grid (Figure 2). At least two datums (10-inch galvanized nails pounded down flat with the surface) were set for each of the survey grids, and their locations are shown in Figure 2, as well as on each of the interpretation maps presented below. Datum coordinates, on the local survey grids and in UTM, are provided in Table 1. A Trimble GeoXT (sub-meter) handheld global position system (GPS) was used to record UTM locations; each datum location is the average of at least ten real-time corrected GPS positions. A sub-meter or better GPS and a metal detector should be sufficient to relocate the datums, with the help of the Figure 2 map. With the two datums, any of the survey grids can be reproduced and the locations of anomalies found on the ground.

Table 1. Coordinates related to the site datums.

	Local Grid North	Local Grid East	UTM North*	UTM East*
Datum 1-1	1000	1000	4310346.08	322726.14
Datum 1-2	1046.8	1000	4310392.38	322725.44
Datum 2-1	1000	1000	4310347.53	322667.60
Datum 2-2	1000	940	4310346.35	322608.13
Datum 3-1	1000	992	4310328.41	322680.98
Datum 3-2	1015	992	4310343.62	322680.44
Datum 4-1	1000	1000	4310301.79	322665.52
Datum 4-2	1000	960	4310300.64	322625.79
Datum 4-3	1000	920	4310299.02	322584.39
Datum 5-1	1000	1060	4310385.88	322648.65
Datum 5-2	1000	1020	4310390.76	322667.90
Datum 5-3	1000	1000	4310399.68	322705.70
Datum 6-1	1000	1000	4310334.42	322564.12
Datum 6-2	960	1000	4310306.56	322536.12
Datum 7-1	1000	1000	4310358.92	322685.39
Datum 7-2	1000	1032	4310359.21	322716.49
Datum 8-1	1000	1000	4310299.59	322670.52
Datum 8-2	1018	1000	4310314.94	322669.03

* UTM coordinates are Zone 18 North, WGS84.

Area 1 Results

Area 1 (347.7 m^2) is located near the east edge of the park (Figure 2), very close to the former front gate of Mt. Pleasant Plains Cemetery—in fact, Area 1 should be straddling the main road coming into the cemetery from Adams Mill Road. At the time of the radar survey, this area existed as a raised landscape feature within a low brick wall (Figure 17). The surface was covered with mowed grass, a couple of signs, some planting containers, and several trees. Given that the entire area is surrounded by lower ground, it is likely that the soil within the low brick wall was brought in as fill. Regardless, on the

Figure 17. Photograph of Area 1 looking from south to north.

cut-fill map (Figure 7) this area appears to have had 2-3 meters of fill removed from it, putting it in the topographic zone where all graves have been completely excavated away (Figure 8). Nevertheless, this is one of the few areas at the east end of the park that is not paved, making it possible to collect radar data that are unhampered by the effects of pavement.

Figure 18 shows an amplitude slice map from Area 1 at 15-20 cm below surface (cmbs). This should still be at a depth that is above the base of the brick wall surrounding the area—i.e., this slice shows reflections that most definitely are still within fill. In this and subsequent amplitude slice maps, red areas are strong radar reflections while blue areas are weak reflections. There are no notable reflections at 15-20 cmbs.

In Figure 19 a series of increasingly deeper radar amplitude slices are presented. No grave-sized anomalies are evident in any of these slices. However, note the stronger radar reflections near the middle of the survey area in the 70-75 cmbs slice. In the Figure 20 interpretive map this area is highlighted by the blue-dashed line. While it may be that these radar reflections likely are related to the tree roots of the two trees sitting on top of this anomaly, this is also the approximate location where the cemetery road should be crossing through Area 1 (see the upper map in Figure 3). The cemetery road was likely a gravel road and buried gravel in silty or clayey soil often causes distinctive radar anomalies. That said, at about 5 meters wide, this anomaly is much wider than the cemetery road would have been. This area is also obviously disturbed in the historic aerials (Figure 4) and according to the cut-fill analysis at least 2-3 meters of fill have

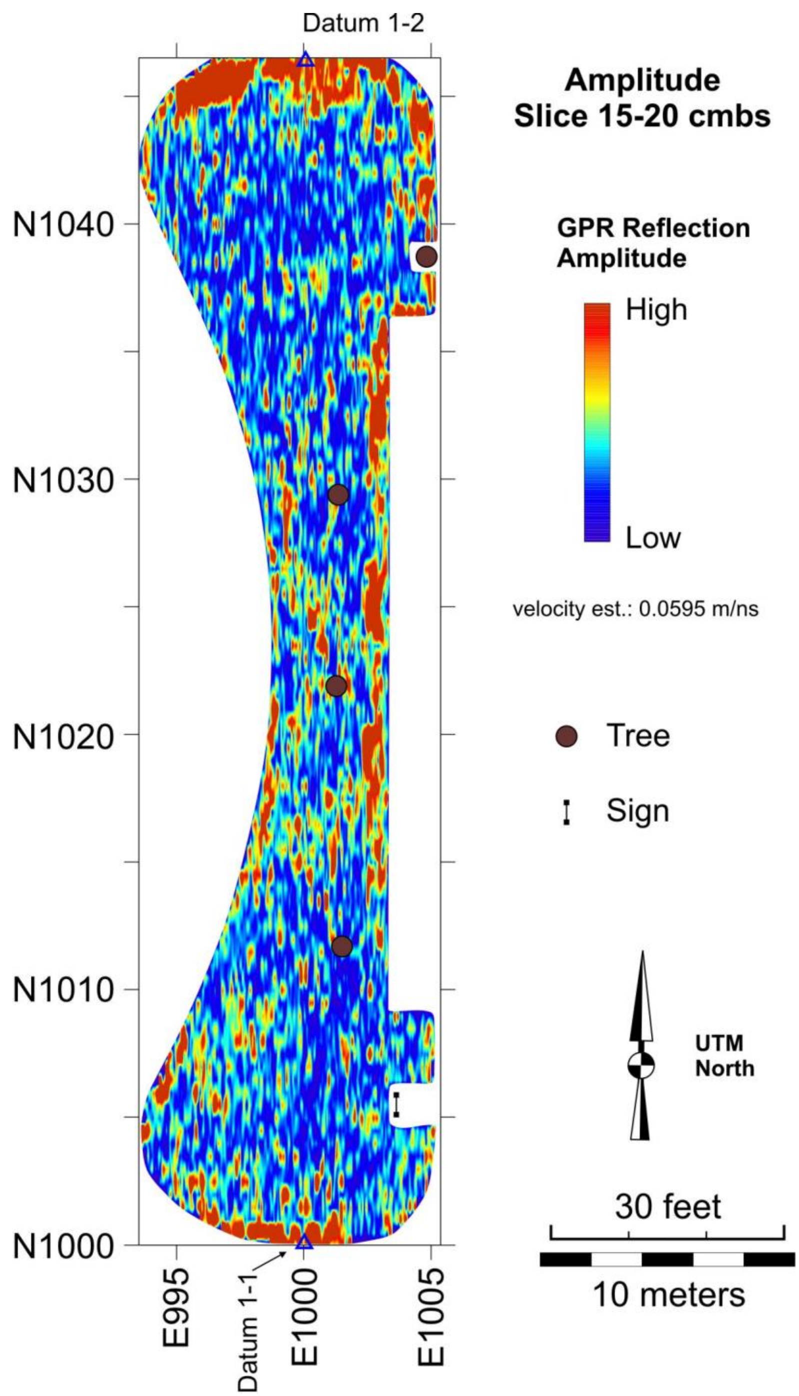

Figure 18. Area 1 radar amplitude slice detailed view.

been removed from the surface in this area. Thus, it seems unlikely that any of the cemetery road would still be intact at this location. However, it would be worth testing this archaeologically before completely dismissing this anomaly as not being remains of the cemetery road.

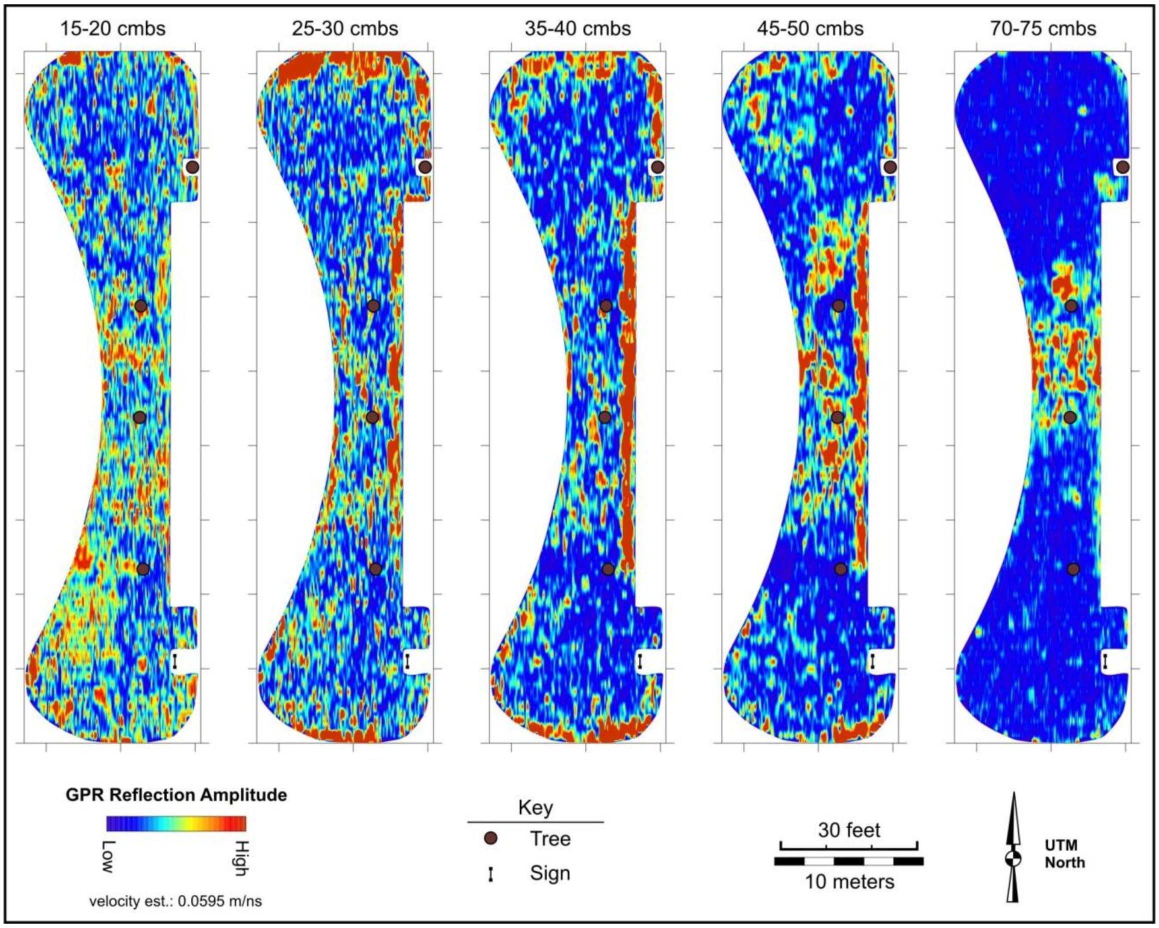

Figure 19. Area 1 radar amplitude slice series.

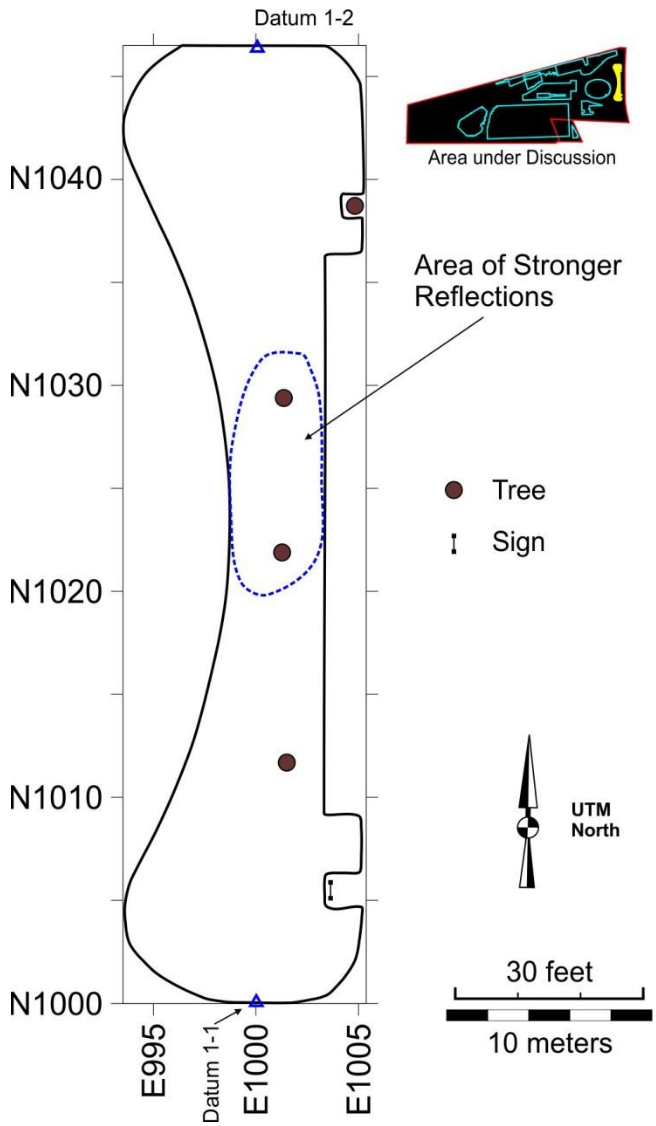

Figure 20. Area 1 interpretation map.

Area 2 Results

The Area 2 survey block covered 1016 m^2 and contains the basketball court, two small areas of mowed grass, and an asphalt sidewalk (Figures 2 and 21). To the south is the chain link fence marking the north edge of the playing field; the north edge of Area 2 is the gabion wall and a steep drop down to the north slope area where community gardens were once located. Moving east from Area 2 requires one to walk up a series of steps, rising about a meter and a half to the level containing Areas 1 and 3. The cut-fill model (Figure 7) shows that the west end of Area 2 is sitting on about 3-6 meters of fill. While there may in fact be graves present below the fill, they are much too deeply buried to be detected by the radar. However, the east end of Area 2 is within the zone of topographic possibility for near-surface graves. Thus, it may be possible to detect potential graves in the east end of Area 2. That said, the installation of a storm sewer located along the east wall likely caused large amounts of disturbance in the east end of the survey area.

Figure 22 presents a radar amplitude slice map of the radar reflections at about 25-30 cmbs. The effects of the basketball court and its substrate are obvious in this slice. No doubt the basketball court is underlain by a layer of gravel and this is producing the distinctive radar reflections at this depth. There also appears to be a rectangular feature to the west of the larger raised planting bed. In the series of amplitude slice maps presented in Figure 23 this rectangular feature is distinctive in all but the deepest slice map. The 50-55 cmbs slice map is perhaps the most distinctive of all of the Area 2 maps, containing a number of discrete radar anomalies.

Anomalies of potential interest are numbered in the Figure 24 interpretation map. Anomaly 1 is the rectangular anomaly west of the raised planter box. Because it is sitting on top of so much fill, it likely is a newly constructed feature, either a planting bed or some kind of utility installed since the late 1950s. Anomaly 2 is an unknown feature type associated with Anomaly 1, but it also likely post-dates the 1950s. Anomaly 3 is a power line servicing the nearby light pole to the southwest. Anomalies 4-6 occur in the topographic zone of greatest potential to contain graves. However, since these anomalies are located under pavement, they may be effects in the radar from the pavement or the gravel beneath it. Anomalies 4-6 likely date to the creation of the park in the 1980s, even though Anomaly 6 is grave-sized and aligned east-west like a grave might be. Anomaly 7 is a modern drainage feature. While graves may be present beneath the fill covering Area 2, it does not appear that the radar survey has detected any graves within 1-2 meters of the surface.

Figure 21. Photographs of Area 2 (a) from the northeast looking southwest, and (b) from the southwest looking northeast.

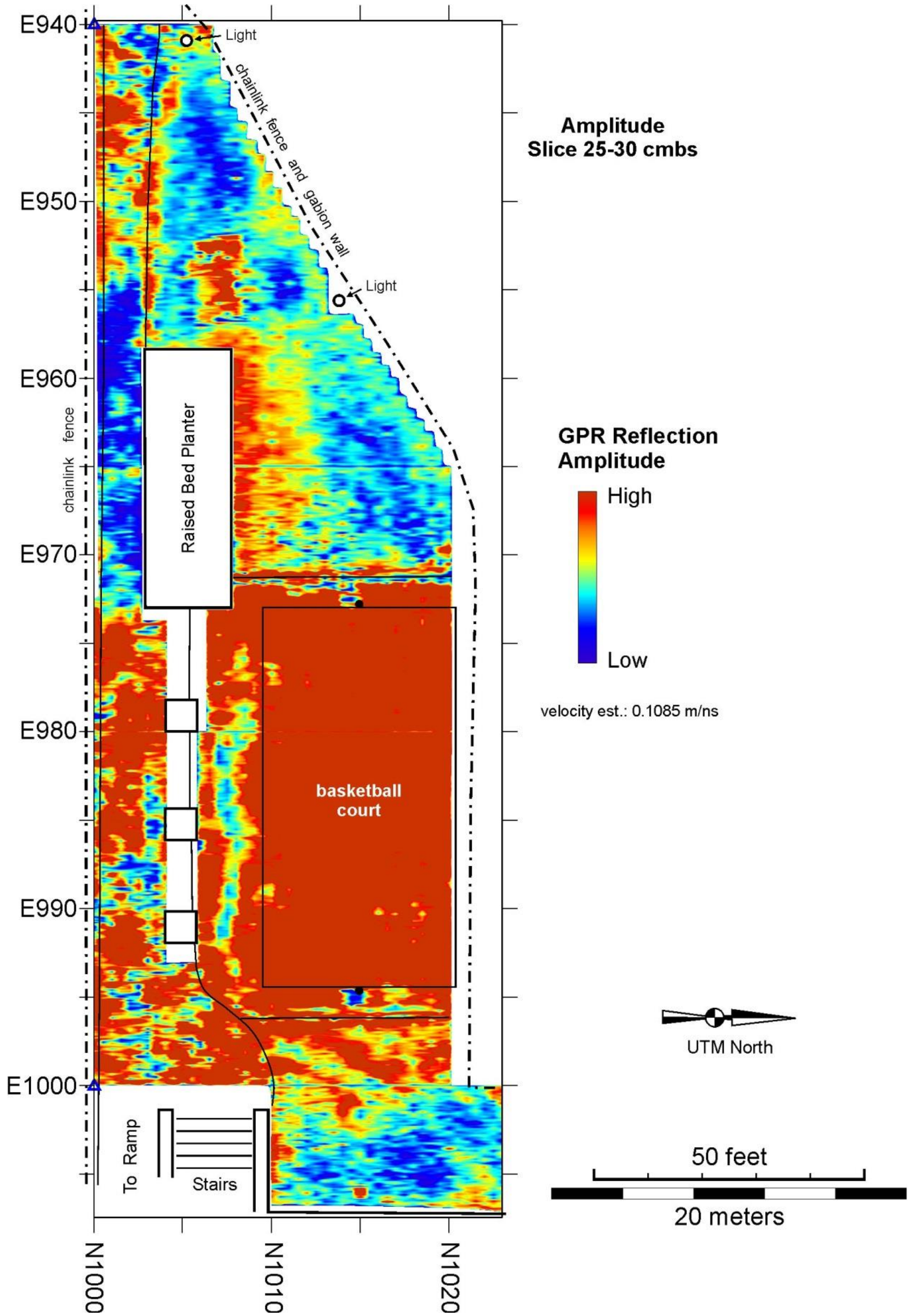

Figure 22. Area 2 radar amplitude slice detail view.

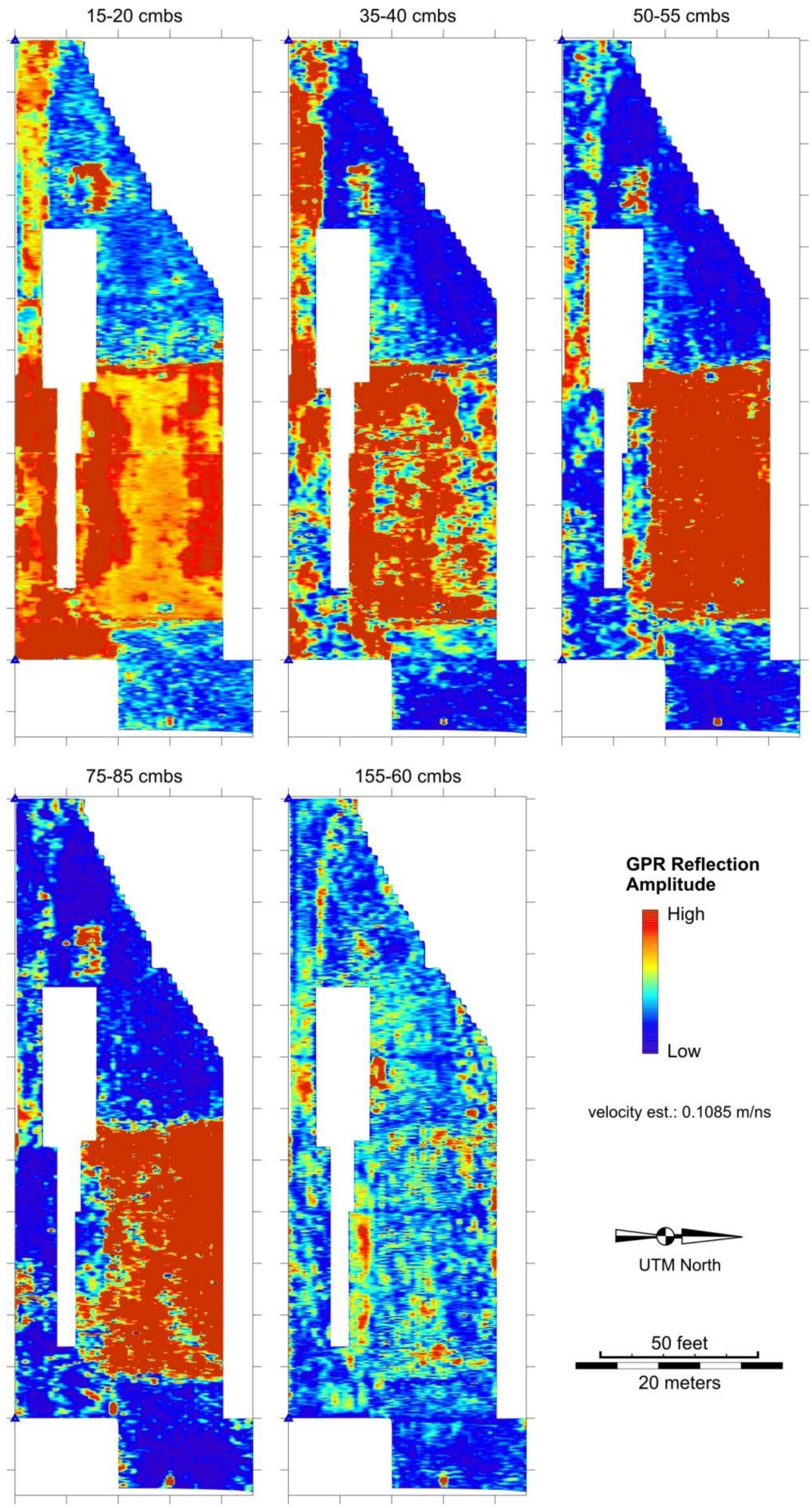

Figure 23. Area 2 radar amplitude slice series.

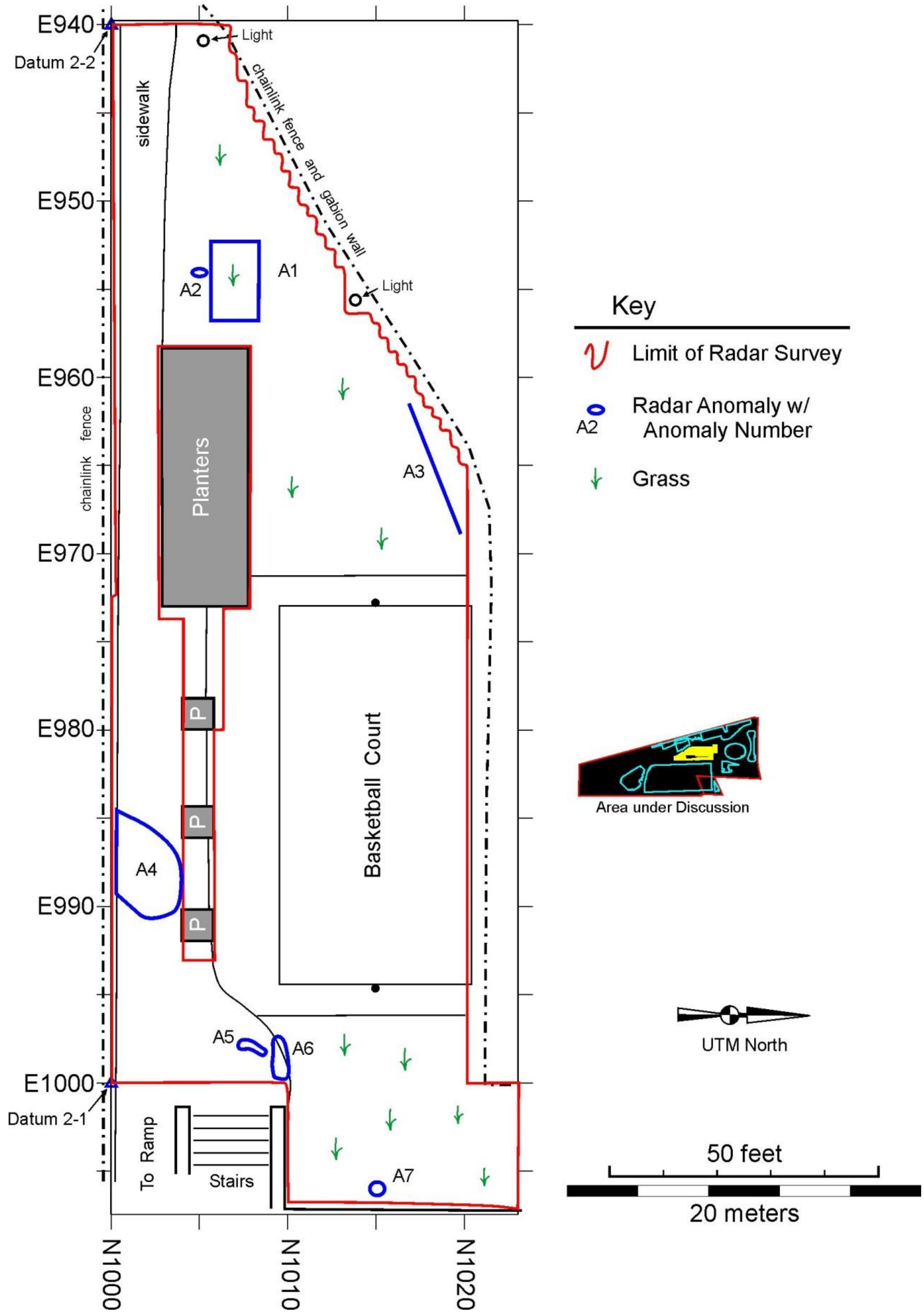

Figure 24. Area 2 interpretation map.

Area 3 Results

Area 3 is an irregularly shaped survey area covering 201.9 m^2 located in the southeast corner of the park (Figure 2), where it is covered by playground equipment (Figure 25). It is surrounded by an iron fence on three sides; to the south is an embankment that leads up to a residential building. At the time of the survey the various pieces of playground equipment proved to be considerable obstacles, and the surface was covered with mulch, which can have a negative impact on radar survey data. The cut-fill analysis shows that 1-3 meters of fill have been removed from this area (Figure 7), and only the northwest corner has any potential, in terms of topography, of having intact graves (Figure 8).

Figure 26 is an enlarged view of a representative radar slice map (at 60-65 cmbs) from Area 3. The strong reflections in this map (the red areas) correspond to depressions filled with wet mulch located beneath or next to playground equipment. The wet mulch has a wider effect in the more shallow slices presented in Figure 27. The interpretive map in Figure 28 highlights the areas of stronger reflections (in red) and indicates their origin with the wet mulch. No grave-like radar anomalies were detected in Area 3, thus the lack of numbered anomalies. The lack of grave-like anomalies, coupled with the results of the cut-fill analysis suggest that all evidence of any graves that may have once been present in Area 3 are now gone.

Figure 25. Photographs of Area 3 (a) from the north looking south, and (b) from the east looking west.

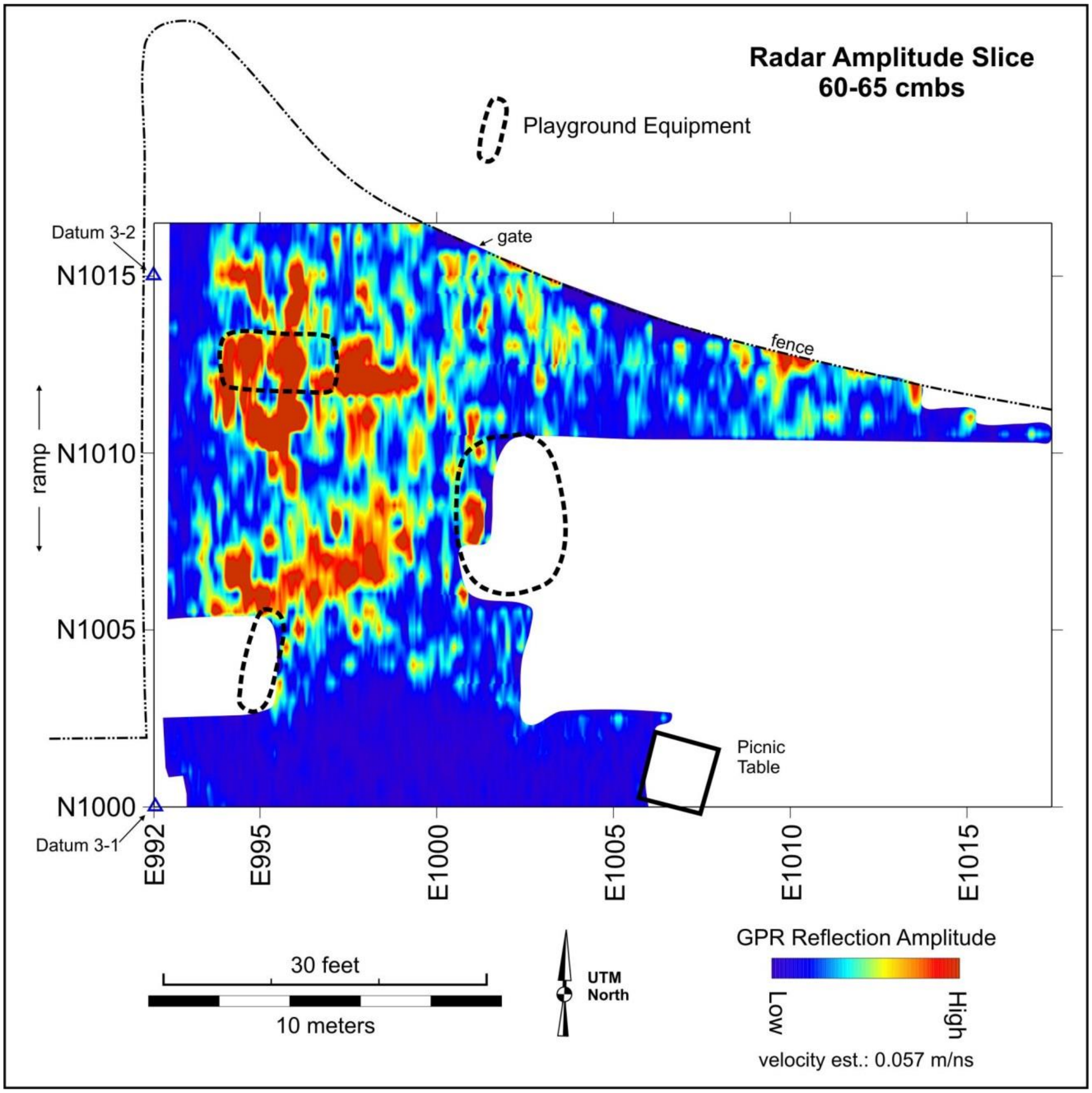

Figure 26. Area 3 radar amplitude slice detail view.

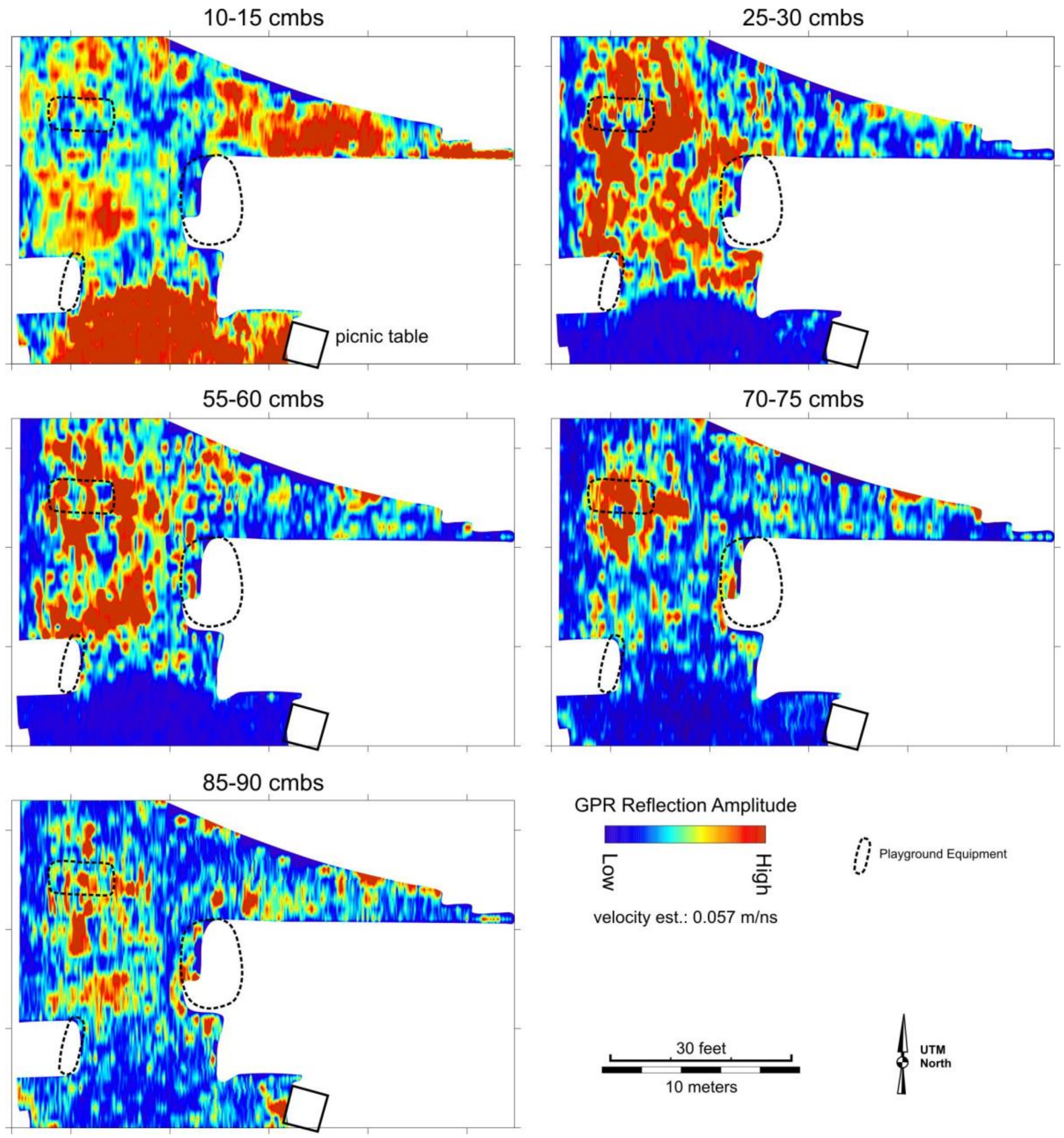

Figure 27. Area 3 radar amplitude slice series.

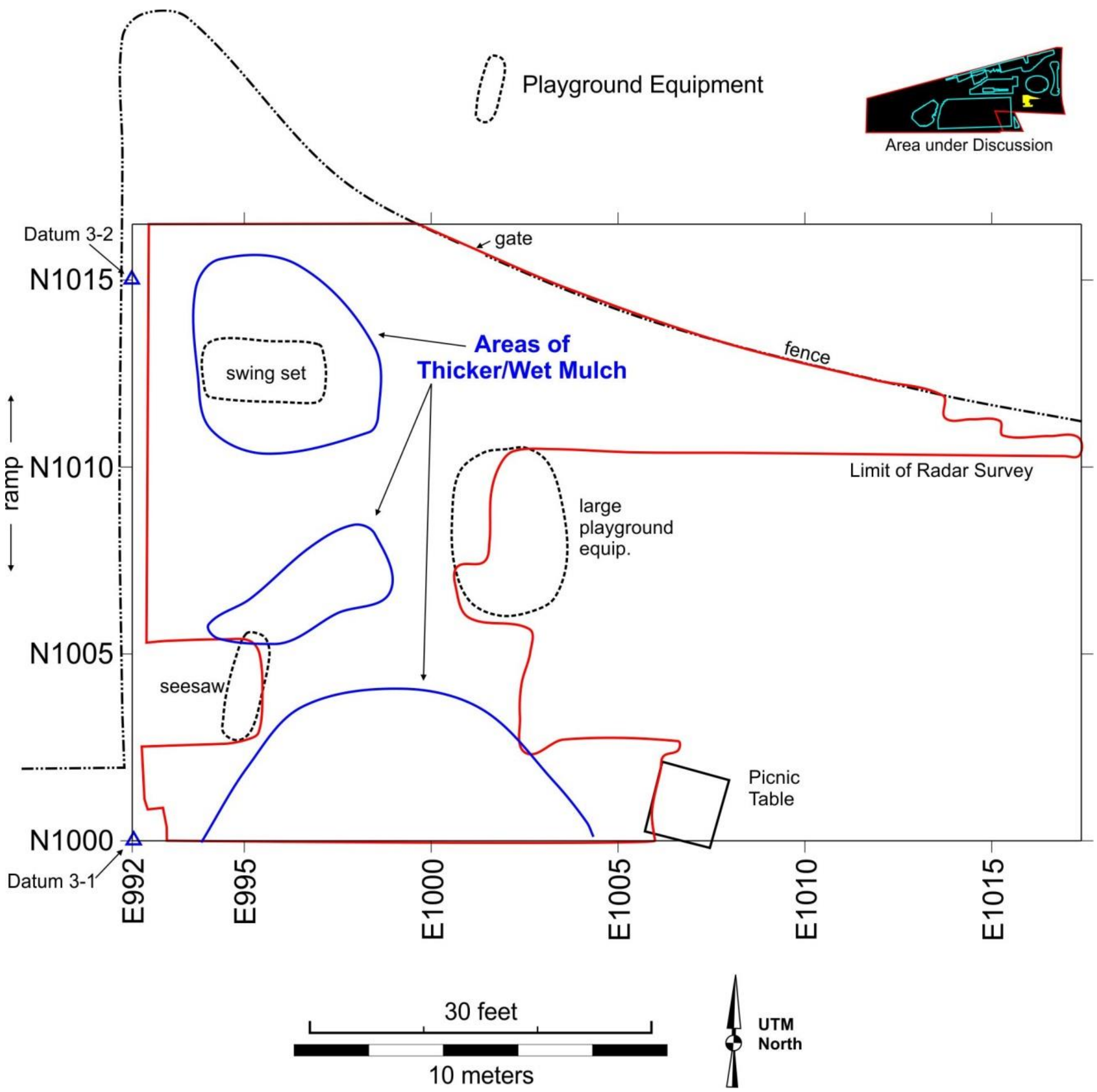

Figure 28. Area 3 interpretation map.

Area 4 Results

Area 4 is the playing field located in the middle of Walter C. Pierce Park (Figure 2). It is a large, flat area covered by mowed grass and surrounded by a chain link fence to the north and west (Figure 29); to the south and east is a block landscaping wall. This area covers portions of both the Mt. Pleasant Plains and the Quaker Burying Ground cemeteries.

An irrigation system, with buried pipes and sprinkler heads, keeps the area watered on a regular basis. Recall that soil moisture is an important factor to consider with instruments such as the ground-penetrating radar. It can help or impede radar surveys, especially given the relatively recent modifications to the field surface. After the creation of the park and the playing field, severe erosion resulted in many gullies forming on the playing field, running from southeast to northwest. More soil was subsequently brought in to fill in the gullies and level off the field. Water can very easily become trapped in these buried gullies and it might produce very distinctive radar anomalies, making it difficult to discern subtler features such as graves.

Area 4 is in a topographically interesting situation within the Park. The cut-fill analysis shows that there is a 20-25 meter band of ground running from southwest to northeast across the playing field that is within 1.5 meters of the 1888 ground surface levels (Figure 7). This indicates that the area covered by this band could contain intact graves and these might be close enough to the surface to detect in the geophysical surveys. To the north and west of this band, the northwest corner of the playing field contains fill more than 1.5 meters thick, which suggests that there could be an intact surface below this fill and thus intact graves below the level that can be reached with the geophysical survey instruments.

Figure 30 presents the results of the magnetic survey in Area 4, which covered 2315.4 m^2 and nearly all of the playing field. The survey was conducted with the Foerster 4-probe fluxgate gradiometer system. This is perhaps one of the most unusual magnetic data sets I have seen in over fifteen years of collecting magnetic data all over the United States and beyond. In particular, the alternating dark (more magnetic) and light (less magnetic) bands in the eastern half of the survey area are curious. What likely is happening here is something related to the large scale earth moving that flattened out this area of the park, either in the late 1950s or more recently when the park was created. The dark areas are likely strips that were dug down lower, perhaps only by a matter of 10-100 cm, and then they were filled with sediment that is somewhat magnetic—or at least more magnetic than the soil around it. It is also possible that these differences in the surface soil magnetism are related to the recent loads of soil brought in to fill in the gullies and smooth off the playing field. Regardless of their source, these light and dark bands in the east half of Area 4 are not related to the cemeteries that were once located here. But this does not mean that there are no possible signs of the cemeteries in Area 4.

The small inset map in the upper right of the figure shows how the cut-fill analysis results relate to the magnetic data—the blue band is the area most likely to have possible graves as it is within 1.5 meters of the original surface. Note how most of the iron objects (the small dipolar simple anomalies) and other magnetic anomalies, those unrelated to the wide bands to the east, occur in the blue and red areas in the inset map. Since these areas are closer to the original surface level, it is possible that these objects and other small anomalies are related to the cemeteries.

Because of the possible presence of cemetery-related anomalies in the magnetic data from the west end of the survey area, the radar survey focused in on this higher probability portion of Area 4. The radar data were collected at a high data density, with 40 traces per meter along transects spaced 25 cm apart. Figure 31 is an enlarged example of one of the radar amplitude slice maps from Area 4. Red areas are strong reflections, blue weaker reflections. Note the large linear features in the middle of the survey area. These appear to run southeast to northwest, very much like the gullies that are visible in the 2010 aerial photograph in Figure 5. As we look through a selection of amplitude slice maps at various depths (Figure 32), it is clear that the filled gullies dominate the data and about the only other thing visible in the radar data are irrigation lines, including a prominent pipe (probably plastic) running north-south across the east end of the radar data.

The interpretive map in Figure 33 shows how the radar and magnetic anomalies of potential interest relate to the three topographic zones. Quite clearly, most of the iron objects occur within the blue (within 1.5 m of original surface) and red zones (probable buried surface beneath fill), with few located in the area (the southeast corner of the surface area) where more than 1.5 meters of the site was removed from the surface. It also appears that the iron objects in the northwestern portion of the survey area line up in rows, perhaps rows of graves, running southwest to northeast. While this may be a bit of a hopeful illusion, it is possible that these iron objects are related to graves. However, they may be disturbed iron objects *once* associated with graves. If we assume that the graves in the cemetery were originally oriented east-west, then it is not possible for the southwest-northeast rows of iron objects to be lines of graves.

Five numbered anomalies are presented in the Figure 33 interpretive map. Anomalies 8-11 are grave-sized magnetic anomalies that could be related to graves, or they may simply be random clusters of iron objects. The radar did not detect any possible grave-like features at the location of these anomalies. Anomaly 12 indicates the boundaries of the densest cluster of iron objects. While these objects may simply be refuse in the fill used to level off the playing field, their coincidence with the high probability topographic zones suggests that these iron objects should not simply be dismissed as refuse unrelated to the cemeteries.

Figure 29. Photographs of Area 4 (a) from the northeast looking southwest, and (b) from the southwest looking northeast.

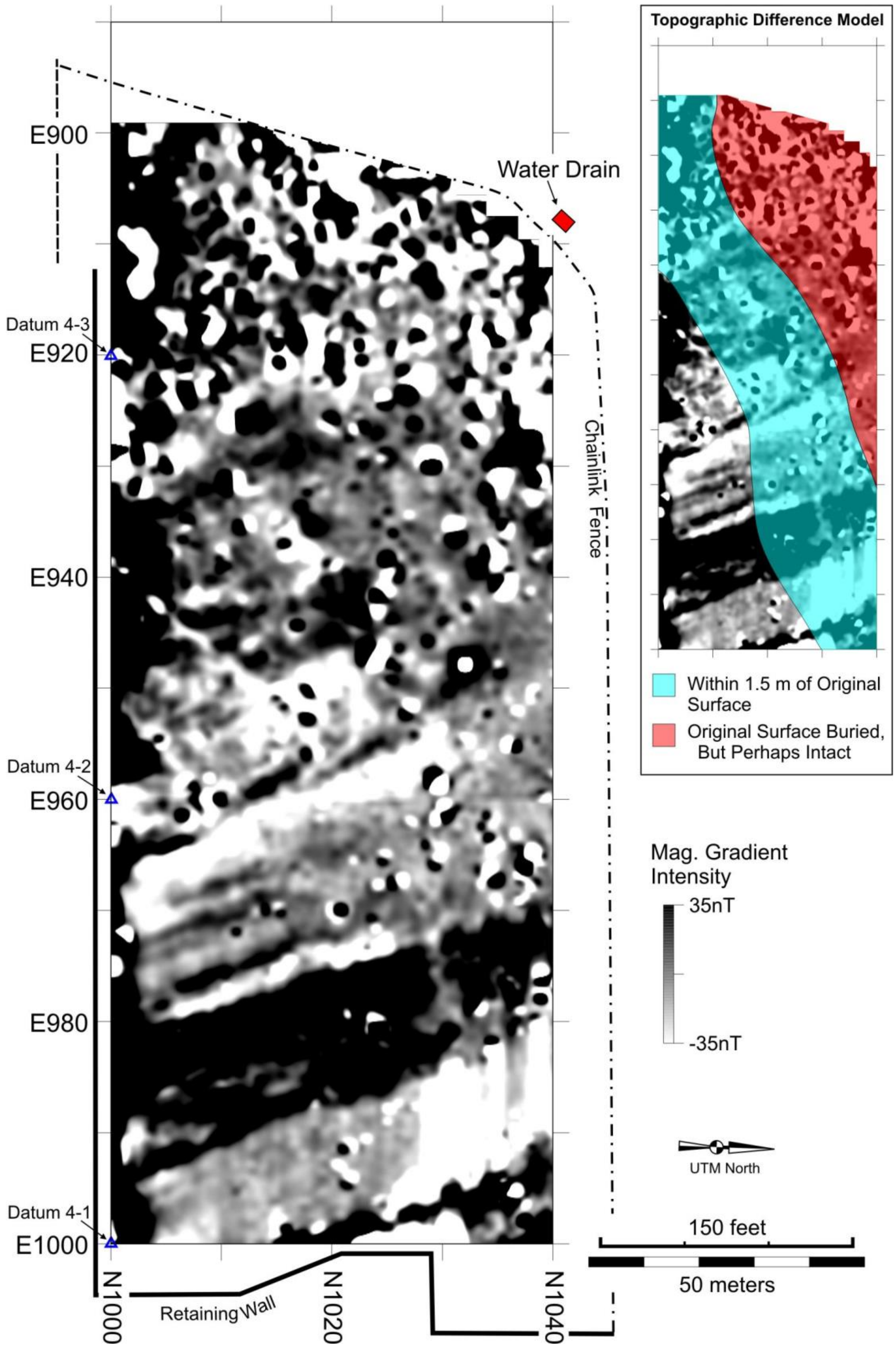

Figure 30. Area 4 magnetic gradient survey results.

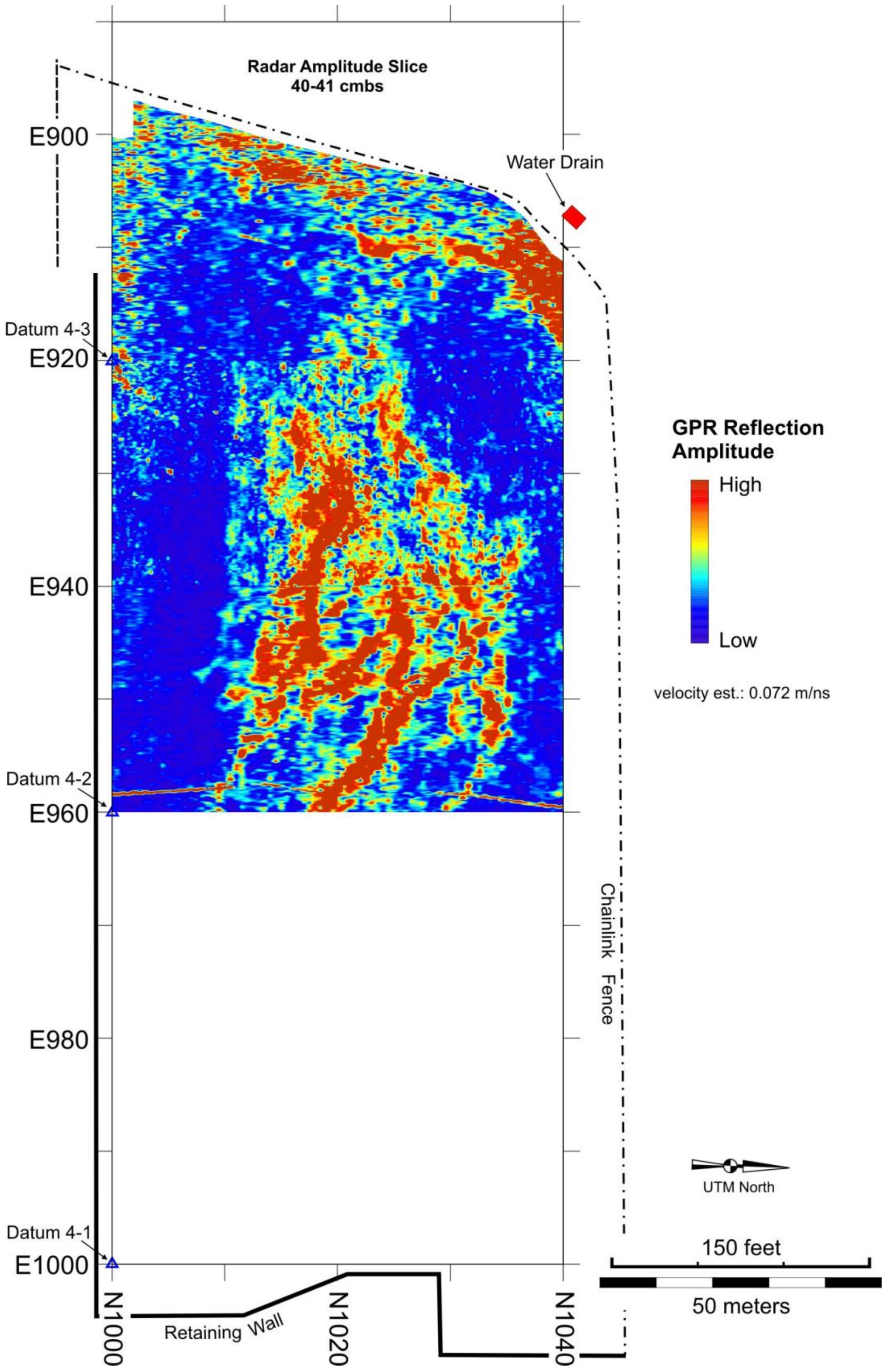

Figure 31. Area 4 radar amplitude slice detail view.

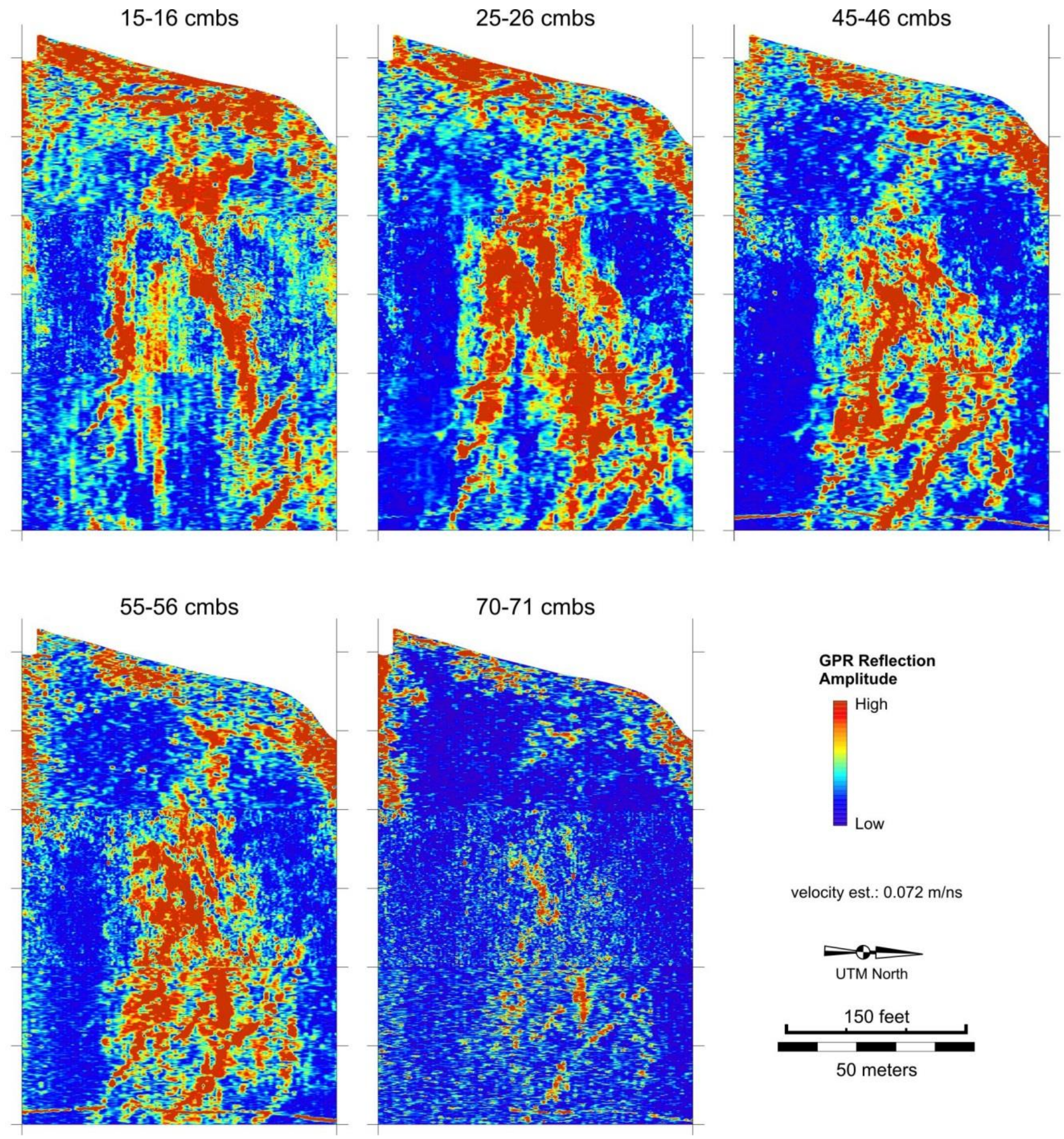

Figure 32. Area 4 radar slice amplitude series.

Area 5 Results

Area 5 is located on the north slope of Walter C. Pierce Park along the northern property fence. It was divided into two sections for reporting: Area 5 Upper (1023 m^2) and Area 5 Lower (422.6 m^2) (Figure 2), though one grid system (with three datums) was used for the survey work. Upper and Lower refer to the topographic positions of these two sections. Area 5 Upper is situated at the east end of the north slope, which is topographically the highest part of the north slope area. At the far east end the area is relatively flat, but as one moves to the west along the northern property fence the ground surface soon starts sloping down (Figure 34b). Area 5 Lower is positioned about midway (east-west) along the northern property fence line. It is severely sloped and was covered in dense vegetation that was cleared by Washington Parks & People staff and volunteers prior to the geophysical surveys (Figure 34a). In the 1990s Area 5 was used for community gardening; garden terraces are clearly visible in a 1999 aerial photograph presented earlier in Figure 5. Steeper areas were flattened out using low stone walls along the downslope sides of the terraces. In the 2000s the terrace walls largely were removed, but evidence of the terraces is still present and most definitely impacted the results of the geophysical surveys in this area.

An enlarged view of a radar amplitude slice map from Area 5 Upper is presented in Figure 35. The Emory (2005) radar survey and subsequent excavations of Emory and Weinberg (2005) were located between E1040 and E1060. Because this earlier work found probable evidence of graves, the OVAI radar data in Area 5 were collected at a high data density, with transect spacings of 25 cm, and data collection transects running north-south. At 70-71 cmbs, the strong radar reflections in the area of the 2005 work likely relate to Emory and Weinberg’s excavation units. The stronger reflections also may be related to the community garden terraces once located here.

Despite the findings of Emory and Weinberg, few grave-like anomalies are readily visible in the series of amplitude slice maps presented in Figure 36. However, closer inspection of the radar profiles reveals a different result. Each radar profile image from Area 5 Upper was examined for possible reflections, especially hyperbolas, possibly related to graves. The locations of these possible grave-like anomalies were then plotted on a plan map of the Area 5 Upper locale. Each red dot in the Figure 37 map is a distinctive reflection identified in the radar profiles. Note how in some areas the dots occur in linear clusters of 3-5 dots, and how some of these linear clusters line up in rows. This is a pattern expected for graves in a cemetery. There appear to be two distinct clusters of linear features that may be graves, in the area of N995, E1010 and between N985 and N1000 along the E1047 line.

In Figure 38 the probable graves identified in the radar profiles are indicated by red ovals and those noted in the radar amplitude slice maps appear as blue lines. At least 33 probable graves and four areas of interest (Anomalies 30, 33, 48, and 49) were identified and numbered as Anomalies 13-50. Also, the location of Emory and Weinberg’s excavation is indicated at the east end of Area 5 Upper and we can see that their small grave-like features have a similar orientation and arrangement as the 33 grave-like radar anomalies. The locations of possible cemetery related objects, including marker stone fragments, from the recent surface surveys of Mack (Mack and Belcher 2013) are shown as Xs on the Figure 38 maps. Their positioning almost exclusively along the northern fence suggests that these objects were moved as a part of the garden terracing from the 1990s. The aerial photograph in Figure 38 shows the relationship between the grave-like anomalies and the garden terraces visible in the 1999 aerial photograph. While some of the grave-like anomalies are associated with terrace edges, perhaps indicating that they could be terrace related rather than graves, others are located in more open ground, suggesting that these are more likely to be graves. Regardless of the garden terraces and their possible impacts on the radar data, Area 5 Upper has some of the best indications of probable graves found in the project area. Area 5 Upper should be considered an especially sensitive area because the bottoms of the graves, and thus any human remains that might be in them, may be located close to the surface.

Figure 34. Photographs of Area 5, of (a) Area 5 Lower looking from west to east, and (b) Area 5 Upper looking from east to west.

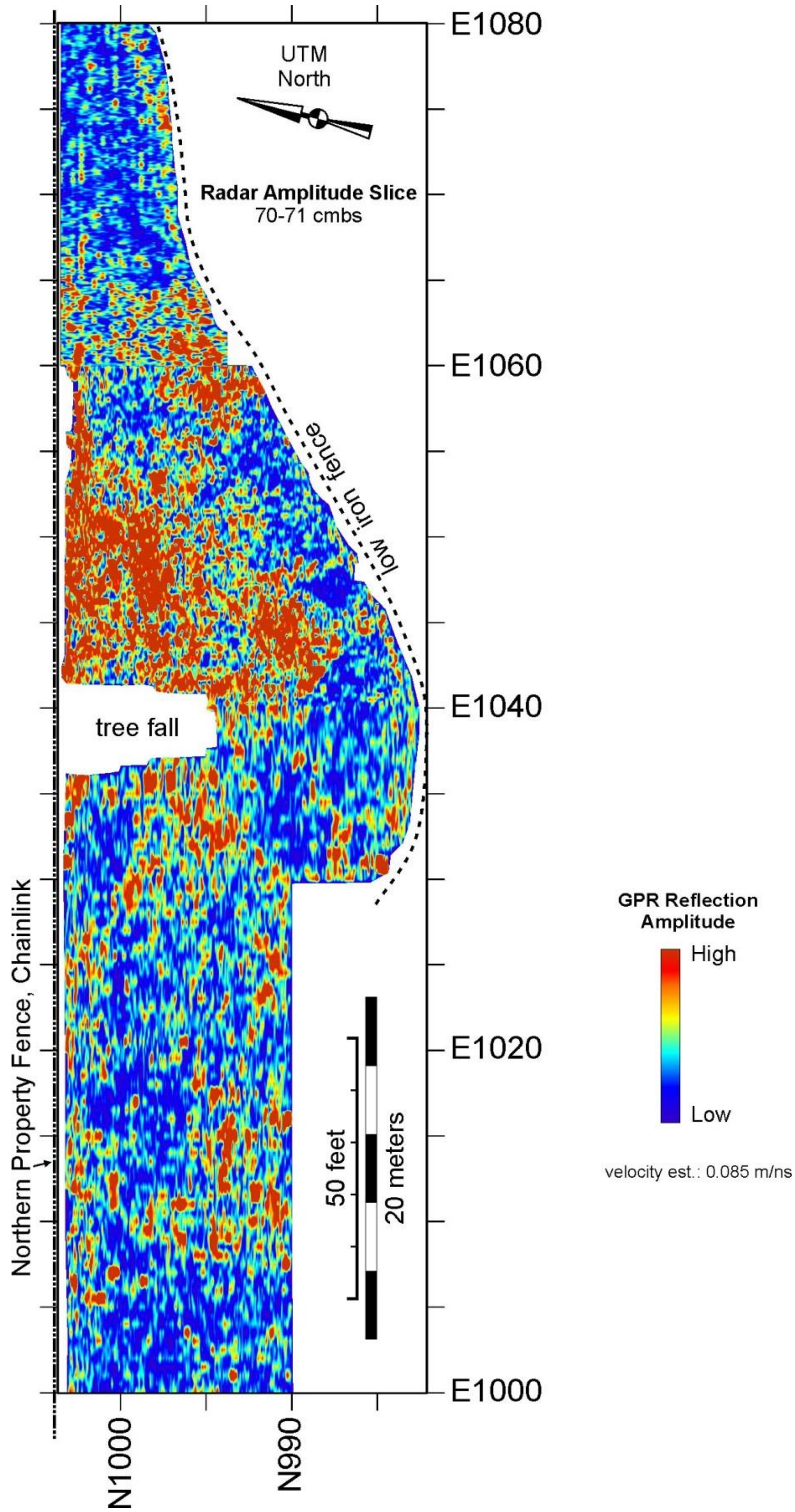

Figure 35. Area 5 Upper portion radar amplitude slice detail view.

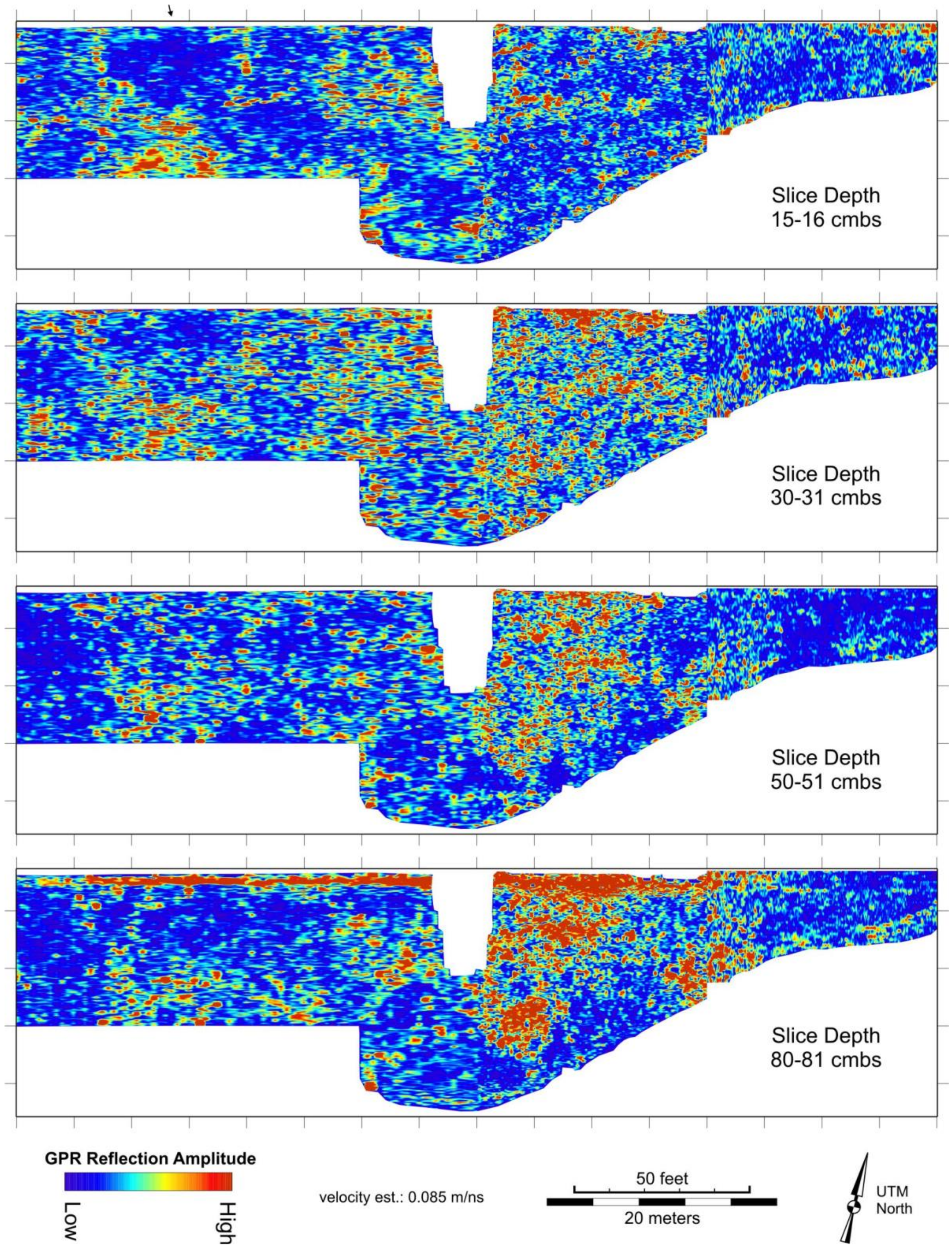

Figure 36. Area 5 Upper radar amplitude slice series.

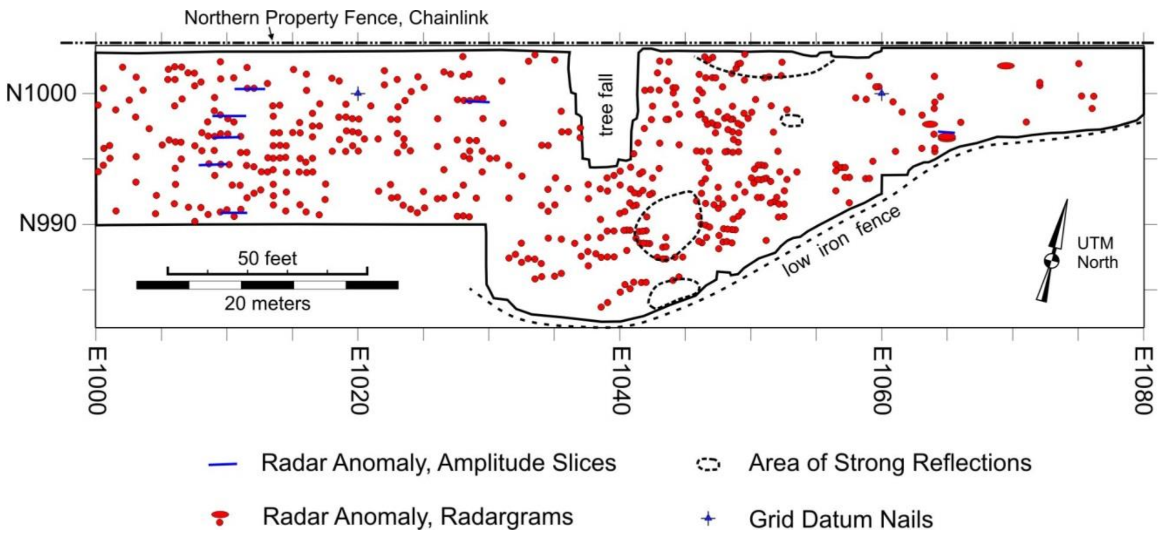

Figure 37. Area 5 Upper, map of potentially significant hyperbola-type anomalies from radargrams compared to possible grave-type anomalies from amplitude slices.

The Area 5 Lower survey data were collected in the space between the base of the gabion wall and the northern property fence. Most of this area is extreme slope—much too steep for radar survey. Furthermore, it is clear that the flatter area near the bottom of the slope is covered by recent fill because the sediment has buried at least 30-60 cm of the bottom of the fence. But it is possible that intact graves might be present beneath this fill.

An enlarged radar amplitude slice map of the flatter portions of Area 5 Lower is provided in Figure 39. High density (25 cm transect interval) data were collected running east-west to the north of the N1000 line; to the south of N1000 high-density data were collected by pushing the radar south from N1000 and running it up the slope as far as possible. As we can see in the amplitude slice maps in Figures 39 and 40, few grave-like anomalies were observed in the amplitude slices, but several areas of stronger radar reflections suggested that it might be important to extend the geophysical survey up the slope to the base of the gabion wall. A handheld magnetometer was used to survey a 20-meter-wide section of the slope and the results appear in Figure 41. The magnetometer has detected numerous large iron objects (the dipolar simple anomalies) at or near the surface on the slope. In fact, numerous pieces of fairly recent refuse were observed on the surface during data collection, which suggests that this area may be covered by fairly recent fill. This could have been brought in when the gabion wall was constructed.

[redacted]

In summary, the radar and magnetic surveys in Area 5 Lower encountered what appears to be a layer of fill on the sloped and flatter portions of this area. Iron objects in this fill dominate the magnetic data, making it impossible to detect the subtle indications of possible graves. That said, at least one cluster of anomalies may be more than simply an iron object in fill. In the Figure 42 interpretive map, this cluster of anomalies is indicated as A52. This could be a cluster of iron objects related to the garden terraces, or it might be cemetery related. At least one other linear magnetic anomaly (A53) was detected and it has the characteristics of a possible grave, but the large numbers of iron objects in this area (the red triangles in Figure 42) suggest that A53 may also be related to iron objects. The red line associated with Anomaly 54 in Figure 42 indicates the point at which the magnetometer began detecting the gabion wall; thus, areas to the south of A54 are obscured in the magnetic data by the magnetic signature of the wall. Four radar anomalies of potential interest are indicated in the interpretive map. Anomaly 51 is a larger area of strong radar reflections that could be fill or other debris related to the garden terraces or the demolition of the cemetery. Anomalies A55-A57 are grave-sized radar anomalies running east-west. These are fairly closely associated with the garden terrace wall visible in the 1999 aerial photograph presented in Figure 42. Thus, these may be garden-related anomalies; but their size and orientation makes them worth noting as possible grave-related anomalies.

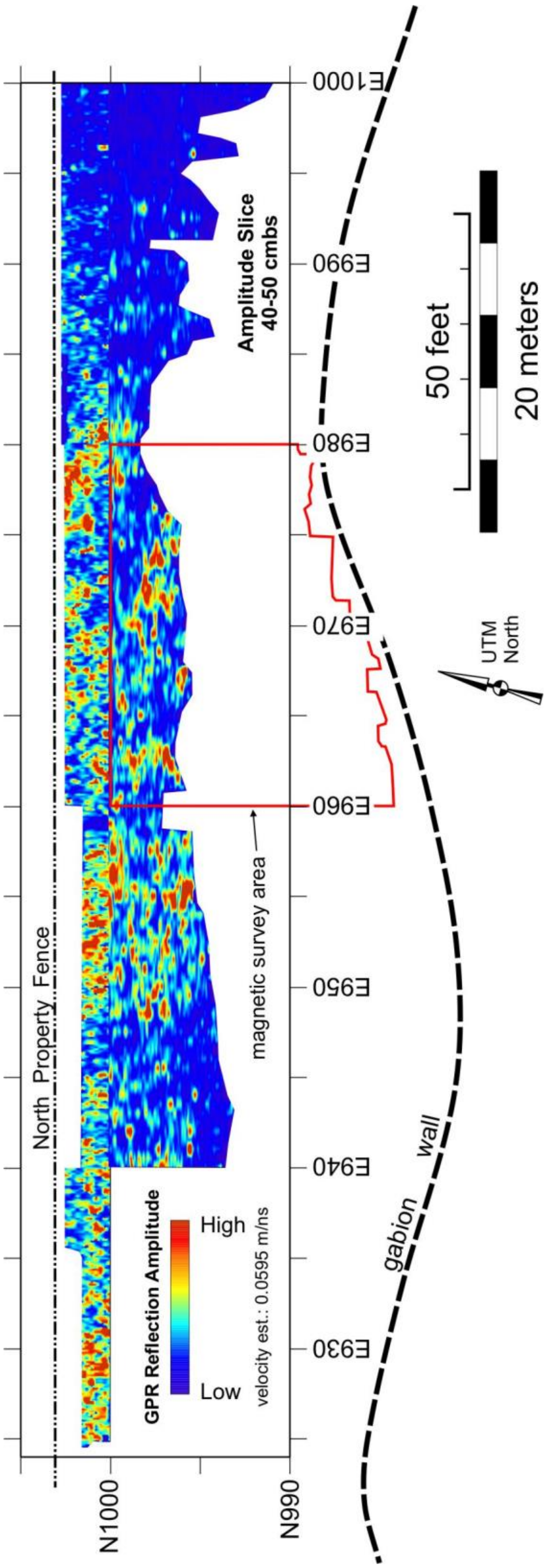

Figure 39. Area 5 Lower, radar amplitude slice map detail view.

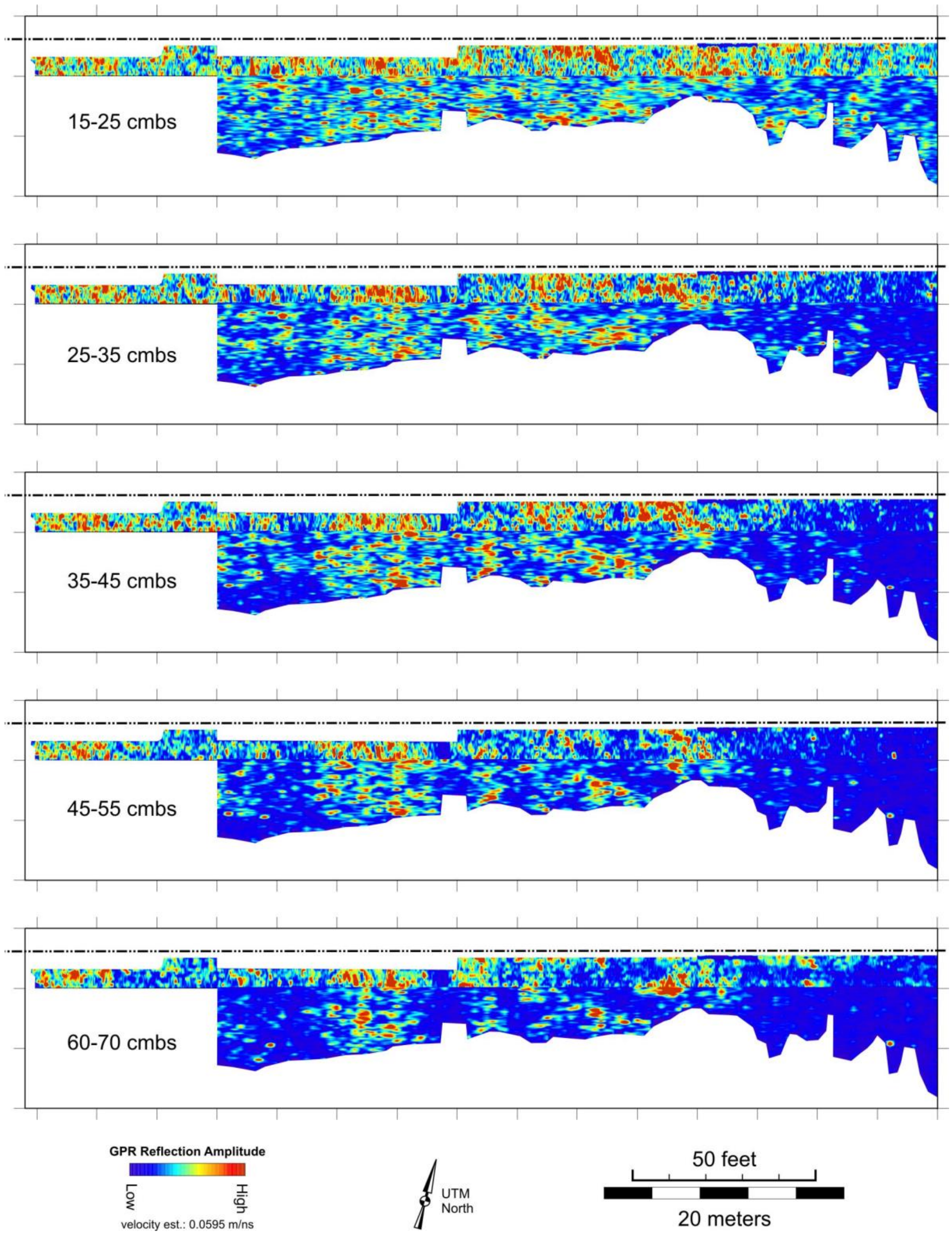

Figure 40. Area 5 Lower, radar amplitude slice series.

Area 6 Results

Area 6 is an irregularly-shaped area covering 823.6 m^2 at the west end of the park that, at the time of the geophysical survey, was being used as a dog walking enclosure (Figure 2). The area was covered by pea gravel and was surrounded by a chain link fence (Figure 43). In the cut-fill analysis, we can see that from 2 m to 9 m of fill has been added to the surface here. Subsequently, scattered large trees have grown into the fill and the surface around the trees was covered by mulch and/or gravel. Several stationary picnic tables and benches were present, as well.

Figure 44 is an enlarged view of a radar amplitude slice map at 55-65 cm below surface. The large area of strong reflections in the west half of the survey area is related to the gravel and probable mulch that underlies it—the ground/substrate here is holding moisture that is creating the strong radar reflections. A similar pattern of strong reflections to the west is present in all amplitude slices from this area down to at least 125-135 cmbs (Figure 45). Besides the effects of the surface gravel/mulch, no other anomalies of potential interest were detected in this area (Figure 46).

Based on the cut-fill analysis and the results of the radar survey, if graves are present in Area 6 they are located beneath a considerable amount of fill. Since the goal of covering this area with fill was to level off the property ahead of a construction project, not remove graves or exhume burials, it is likely that the original surface of the cemetery was simply covered over by the fill and the graves that were present in this area are still intact below the fill.

Figure 43. Area 6 photographs (a) from the southwest looking northeast, and (b) from the south looking north.

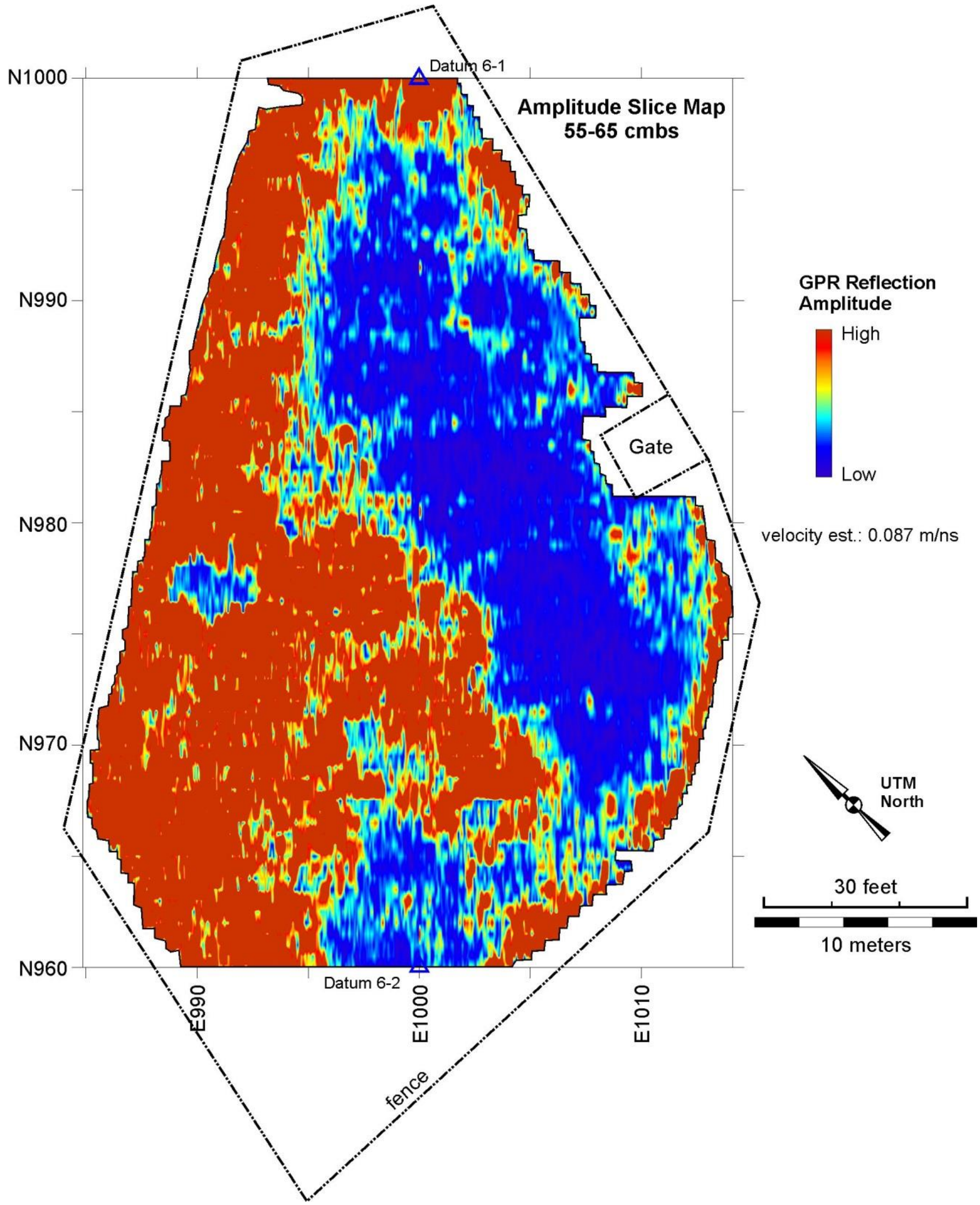

Figure 44. Area 6 radar amplitude slice detail view.

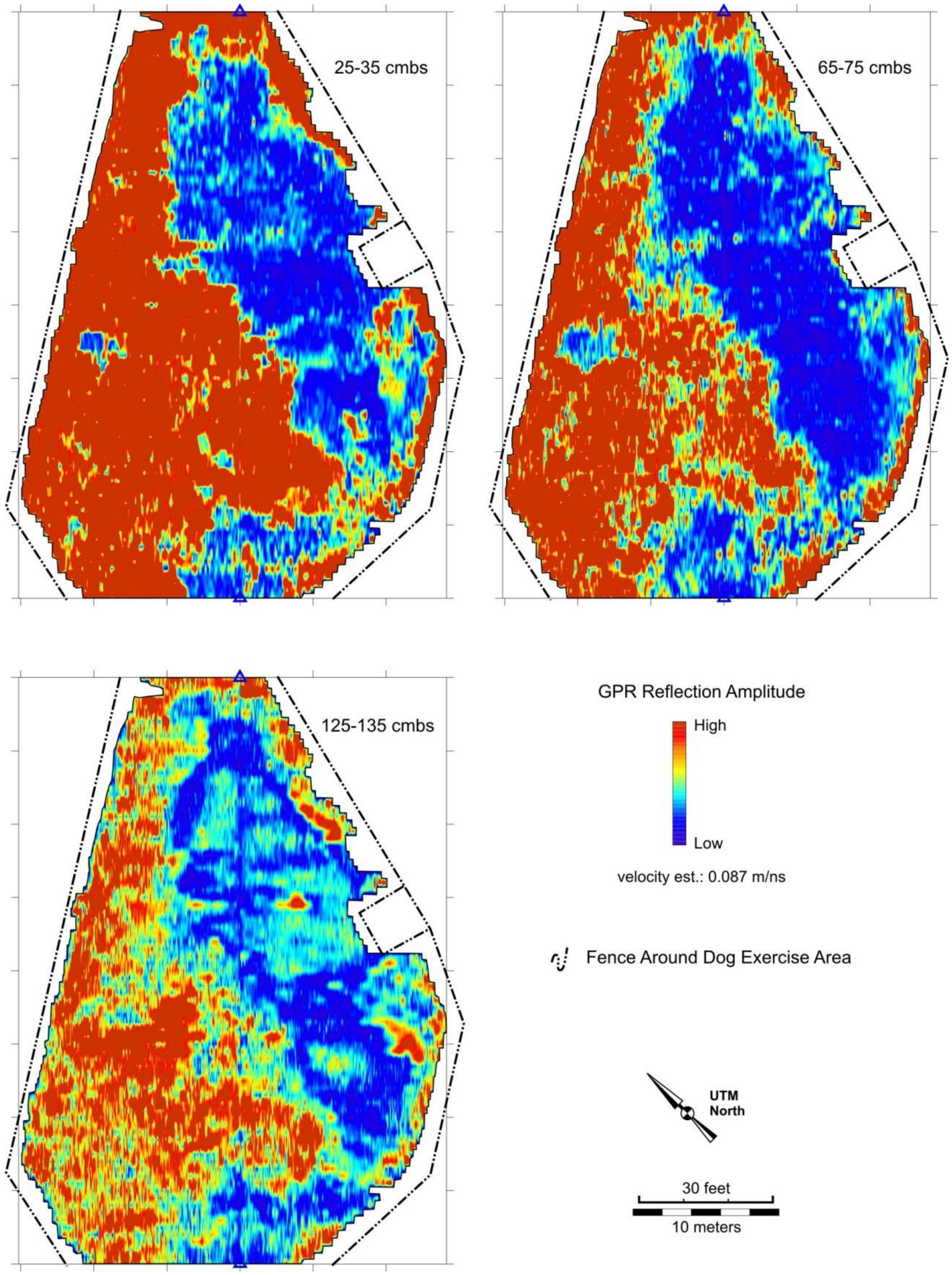

Figure 45. Area 6 radar amplitude slice series.

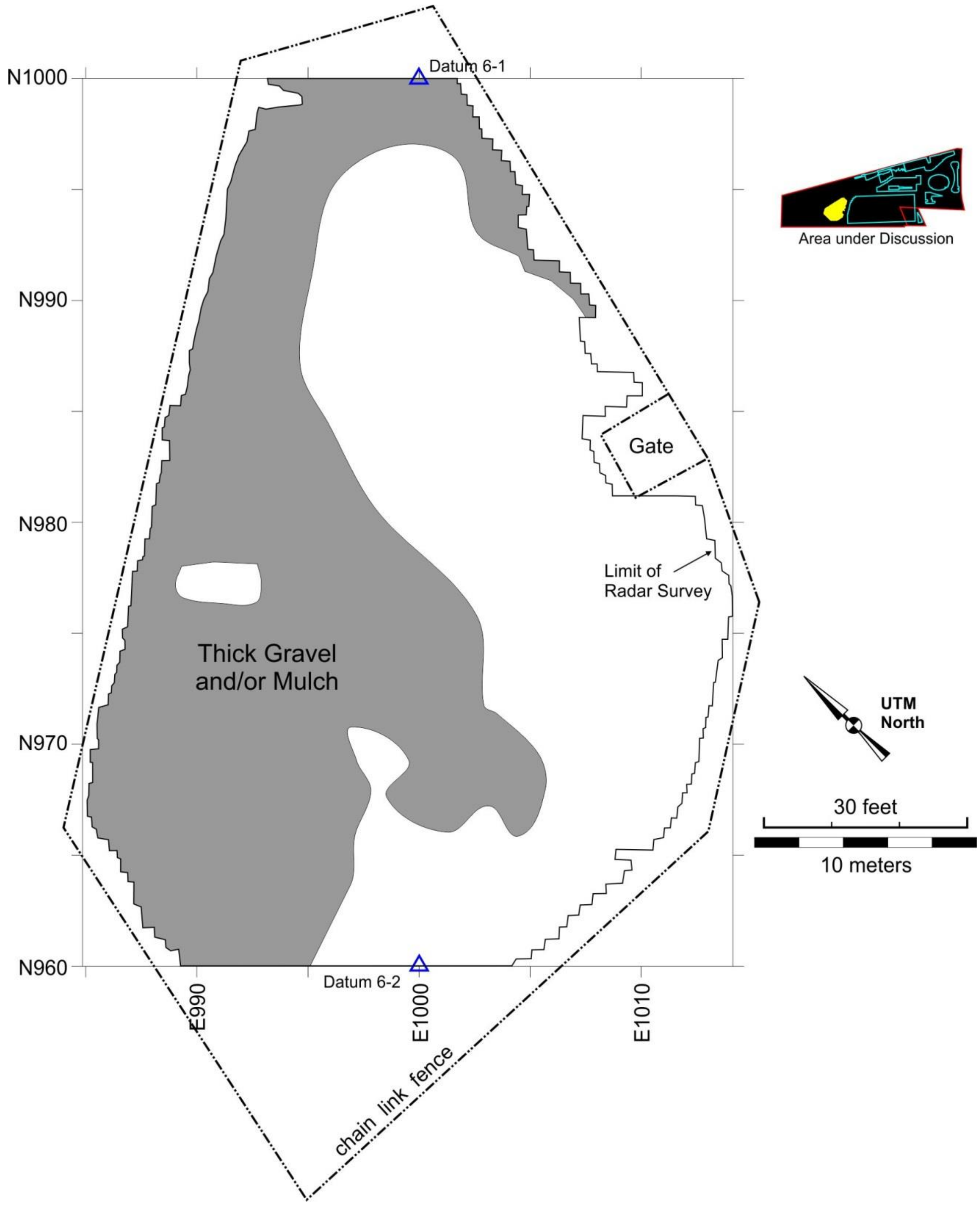

Figure 46. Area 6 interpretation map.

Area 7 Results

Area 7 (575.2 m^2) is the grassy area within the circular drive at the east side of the park (Figures 2 and 47). No doubt the area was heavily modified during the creation of

Walter C. Pierce Park, and it must contain at least one electrical line that powers the three street lamps located along its edges. The cut-fill analysis shows that a considerable amount of fill has been removed from this part of the park, but a large portion of Area 6 lies within the zone of highest topographic potential to contain intact graves (Figure 8); therefore, careful consideration should be paid to the survey results.

Figure 48 presents an enlarged version of the 30-31 cmbs amplitude slice map. The locations of trees are noted as brown circles and we can see that most of the stronger reflections in the slice map are clustered around the area containing the trees. A similar pattern holds across most of the amplitude slice maps at various depths presented in Figure 49. The tree roots created rather significant hyperbola anomalies in the radargrams, examples of which are clearly visible in the Figure 50 radargram. Because fill has been removed from this area and thus graves could be near surface, these hyperbolas are of much interest. A detailed analysis of all radargrams found many such hyperbolas scattered across the survey area (Figure 51), but there are no grave-sized linear clusters of hyperbolas like those found in Area 5 Upper. Thus, while the radar survey has identified an area of gravel near surface (at the northeast edge of the oval) and many objects (rocks?) and tree roots that appear in the data as near-surface hyperbolas, there are no definitive signs of graves in the Area 7 radar data.

Figure 47. Area 7 photographs (a) from the south looking north, and (b) from the southeast looking northwest.

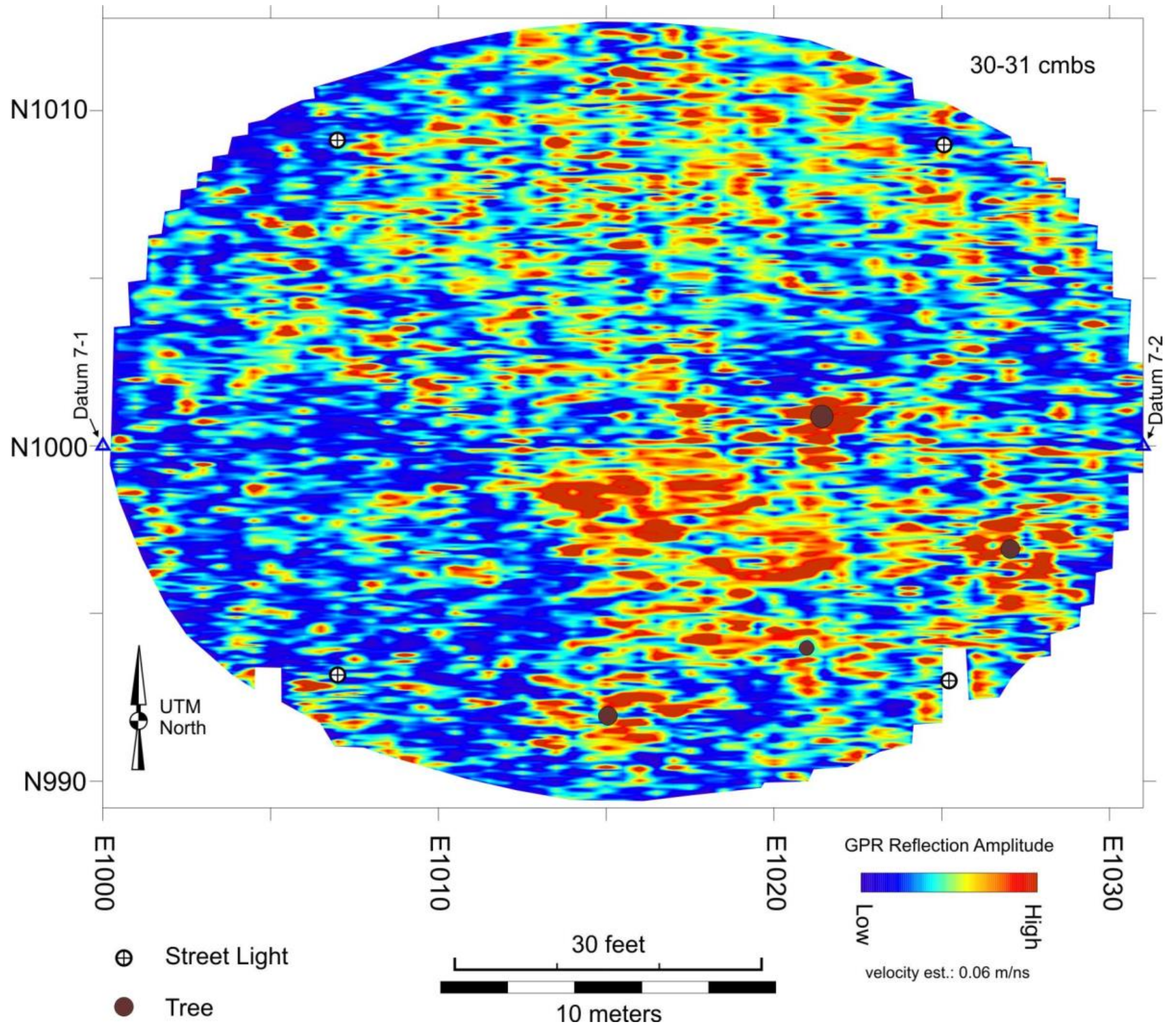

Figure 48. Area 7 radar amplitude slice detail.

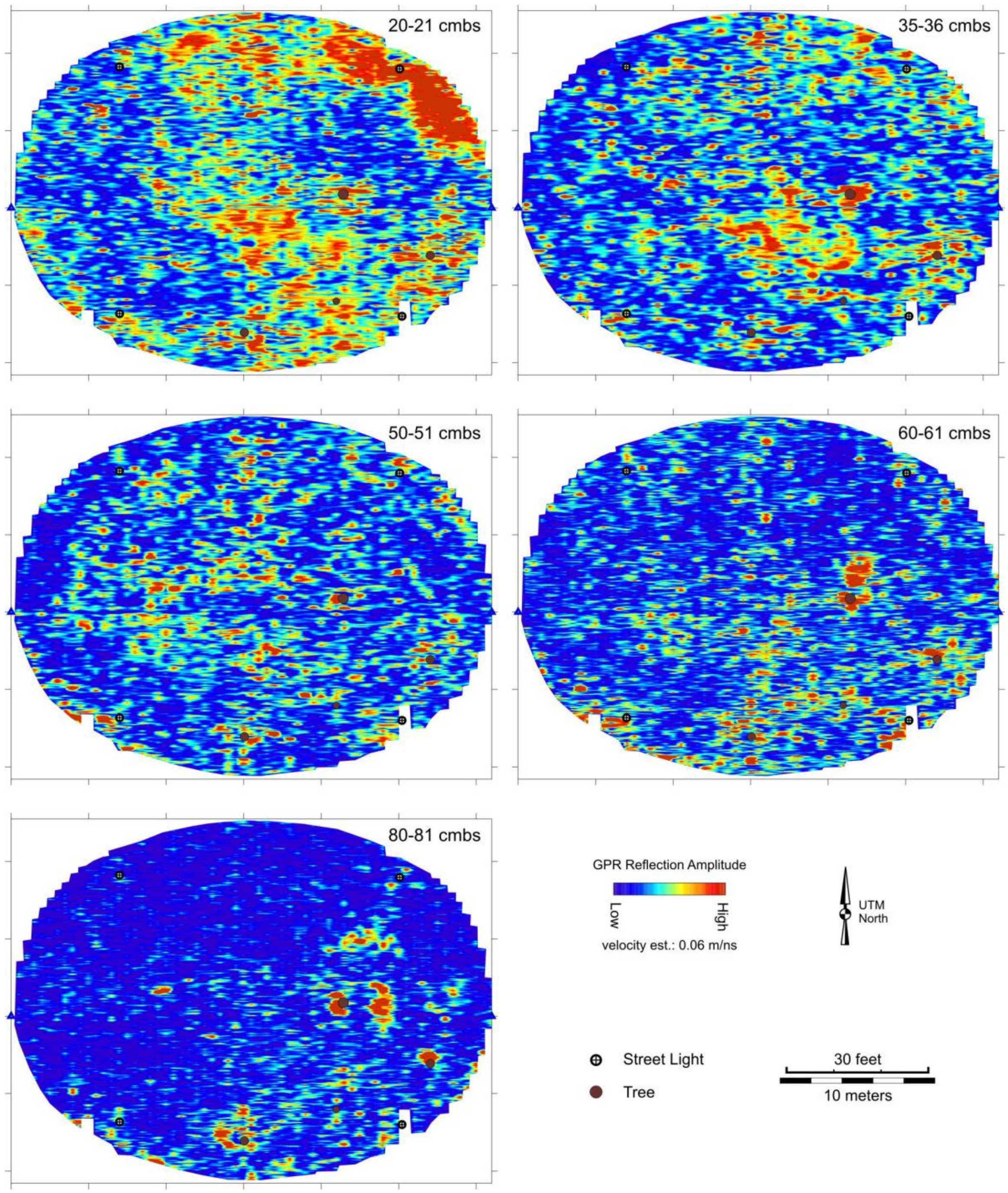

Figure 49. Area 7 radar amplitude slice series.

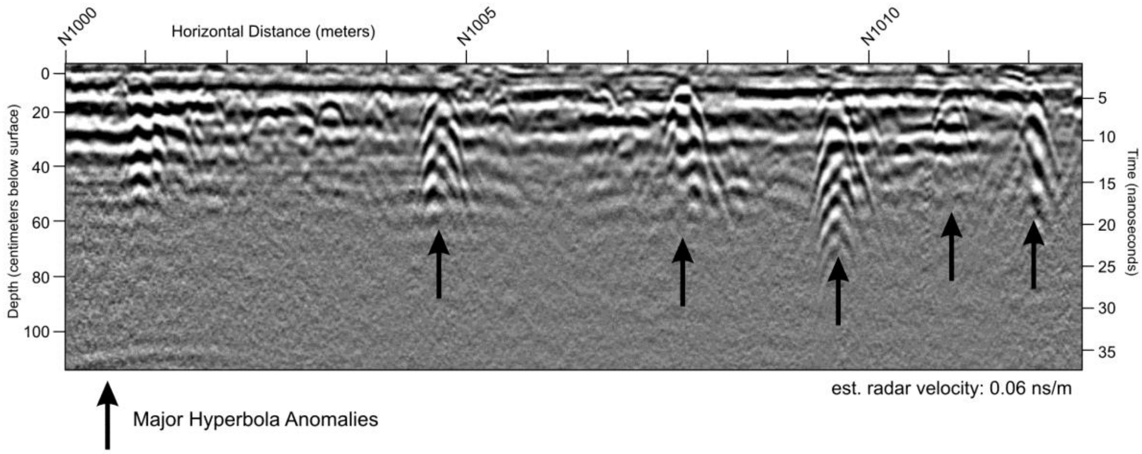

Figure 50. Area 7 radargram example showing hyperbola anomalies.

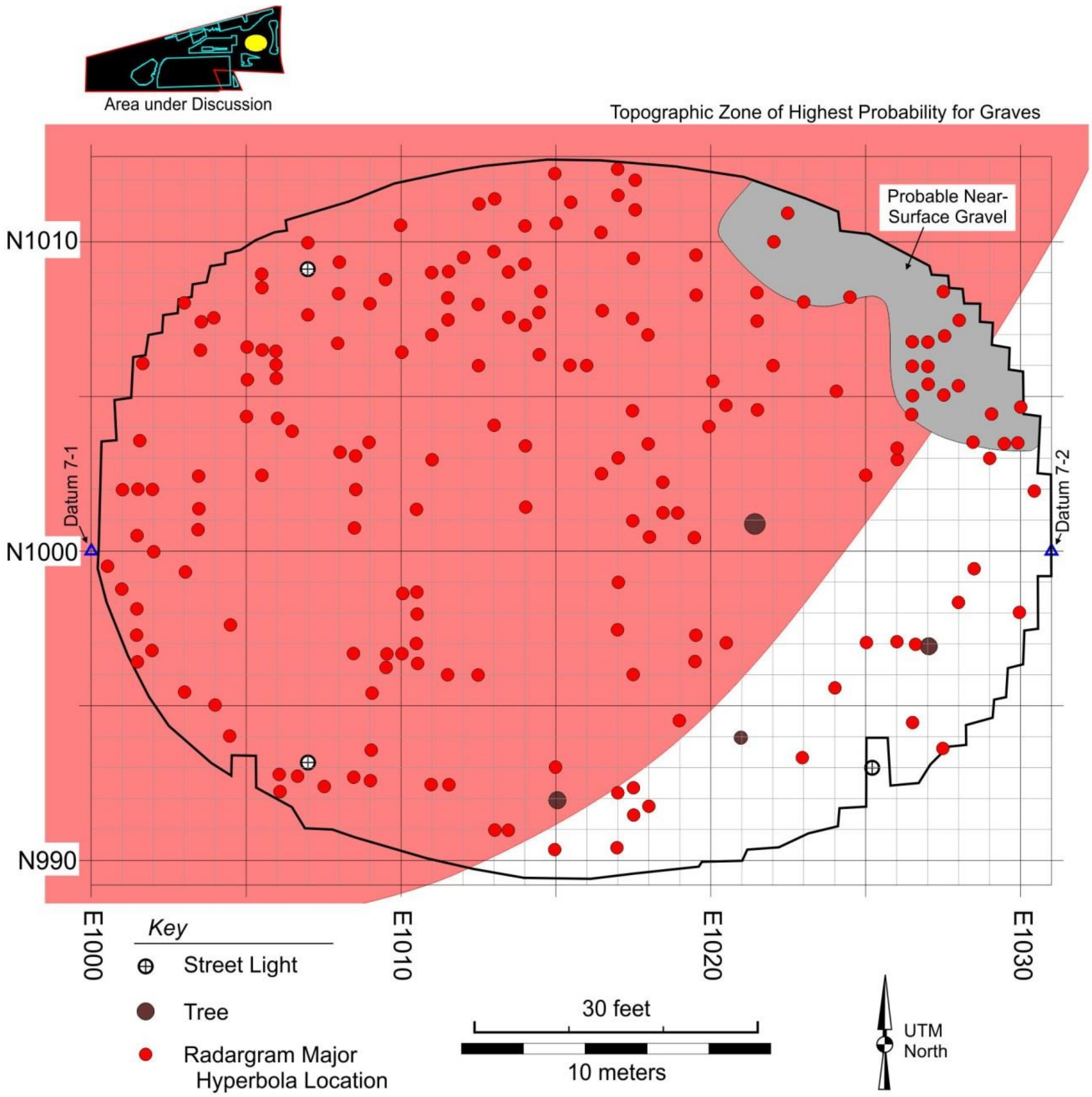

Figure 51. Area 7 interpretation map with the zone of highest probability for graves based on the topographic analysis.

Area 8 Results

Area 8 (76.9 m^2) is located in a small triangle of ground wedged between Area 4 and the neighboring apartment building's parking lot to the east (Figure 2). Landscaping walls surround the area; and like the terrace gardens that once existed in Area 5, the walls around Area 8 are meant to terrace the ground between the apartment building parking lot above and the playing field surface below. Numerous trees have grown up in this small area (Figure 52). Area 8 is located fully inside the Quaker Burying Ground cemetery (see Figure 3). However, the cut-fill analysis indicates that two to three meters of fill have been removed from this area (Figure 7), which suggests that any burials that might have been located here have been completely removed.

Figure 53 presents an enlarged view of the 35-40 cmbs radar amplitude slice map. The large numbers of trees and their roots in Area 8 are primarily what was detected. The somewhat linear radar anomalies from the 25-30 cmbs slice in Figure 54 are near-surface roots. Roots selectively appear in the next three depth slices, and by 100-105 cm below surface the tree roots have largely disappeared from the data. However, no grave-like anomalies were detected in Area 8, supporting the results of the cut-fill topographic analysis.

Figure 52. Area 8 photographs (a) from the northwest looking southeast (the survey area is in the elevated area with the trees), and (b) from the south looking north.

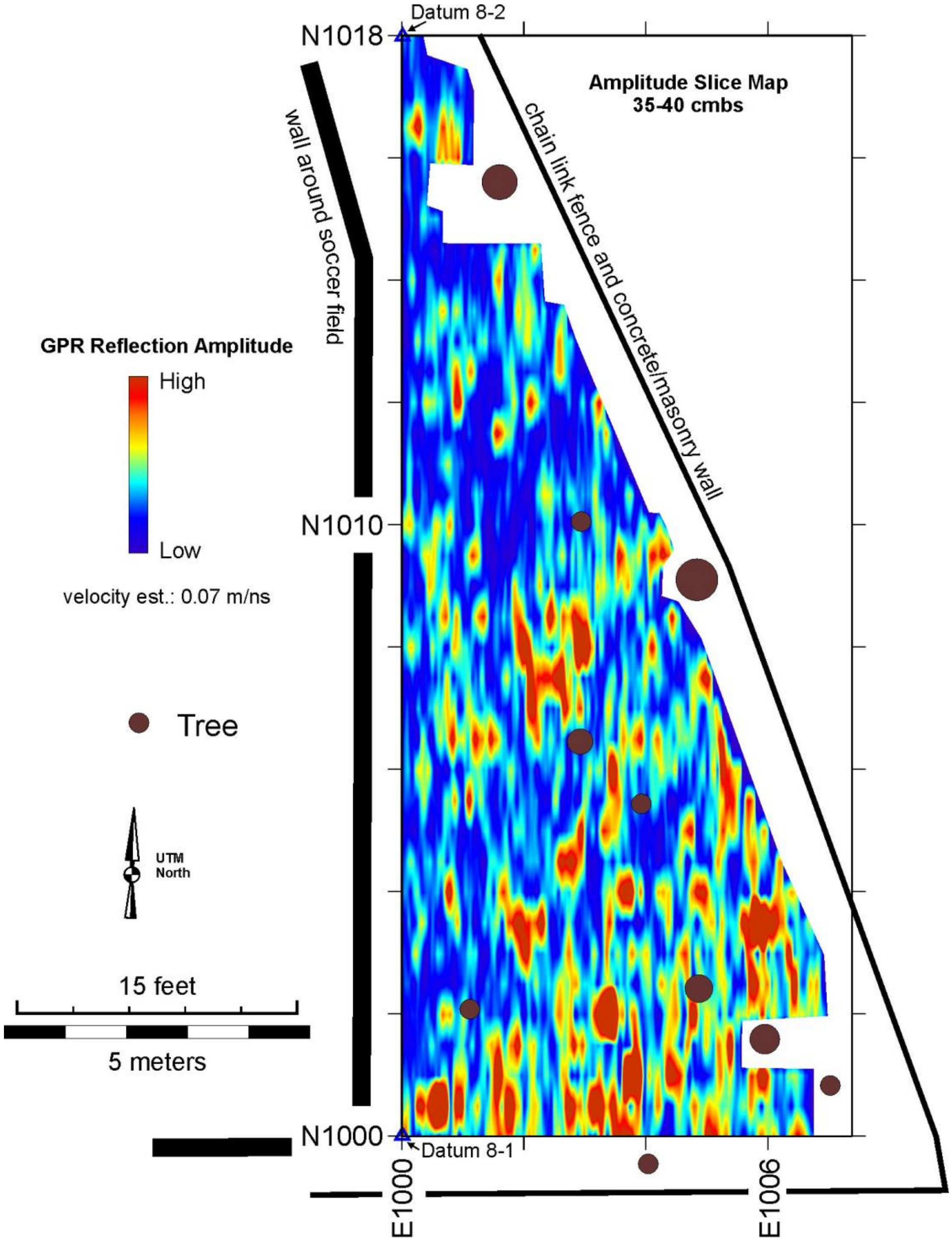

Figure 53. Area 8 radar amplitude slice map detail view.

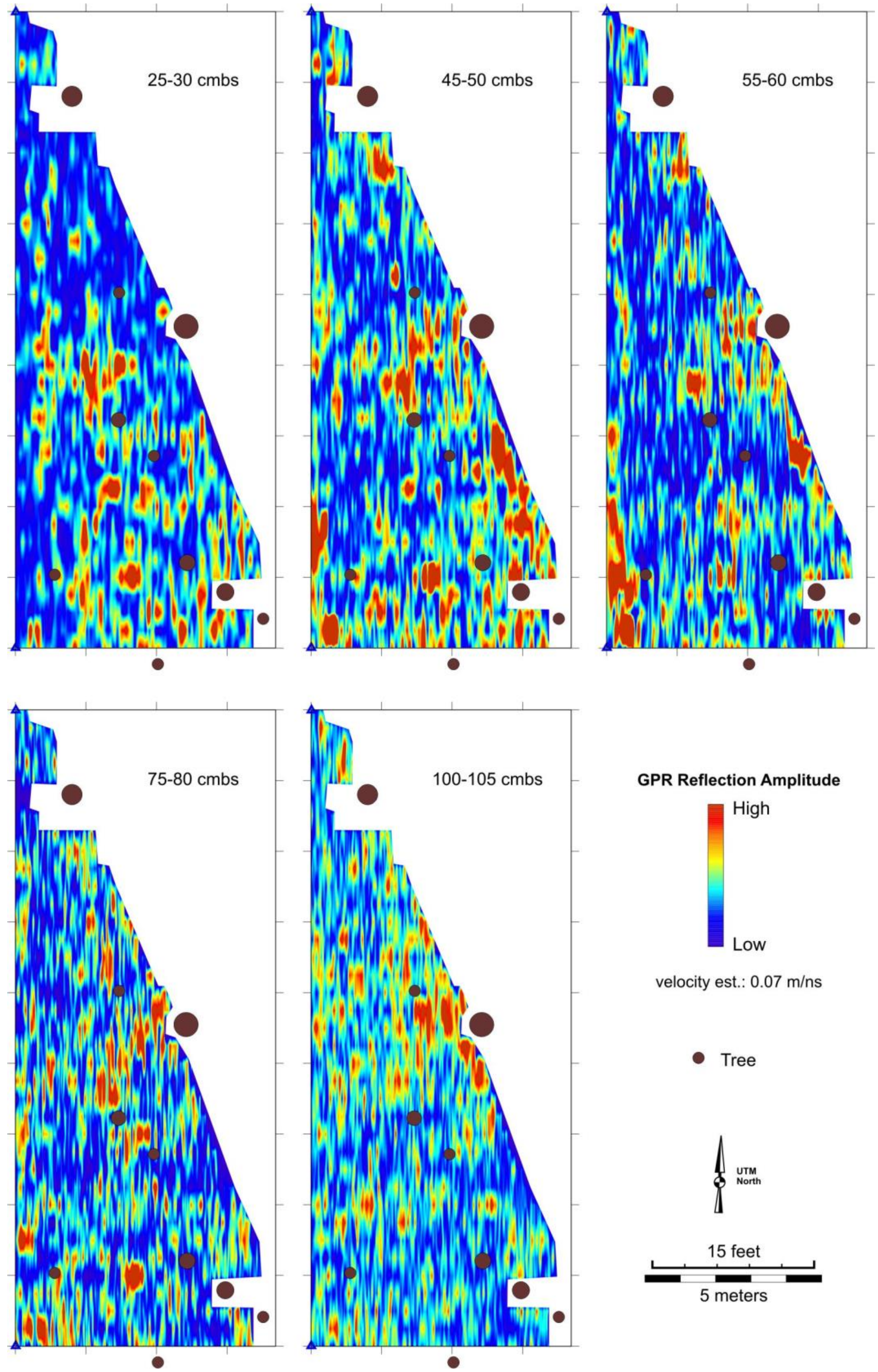

Figure 54. Area 8 radar amplitude slice series.

Summary and Recommendations

In 2013 Ohio Valley Archaeology, Inc. conducted geophysical surveys in eight discrete areas covering 6,802.3 m^2 (1.68 acres) within Walter C. Pierce Community Park in Washington, D.C. In the nineteenth century, the land on which the park was created in the 1980s was home to portions of two cemeteries, Mt. Pleasant Plains and the Quaker Burying Grounds. Together these two cemeteries contained well over 8,000 burials, from which a minimum of 129 sets of remains were exhumed prior to significant amounts of earth moving in the 1950s, ahead of a proposed construction project, and in the 1980s when the park was created. A cut-fill topographic analysis was used to determine the approximate amount of fill removed or added to the areas surveyed.

Together, the topographic analysis and the geophysical surveys found that six of the eight surveyed areas had some possibility of containing the remains of graves. Table 2 provides a summary of these observations. Some areas of the park have had a considerable amount of fill removed from the surface (e.g., Areas 1, 3, and 8) and the graves have been totally removed from these areas. In other areas (e.g., Areas 2 and 6), the original land surface has been buried by up to nine meters of fill. While we do not know if the ground beneath this fill was first disturbed prior to being covered over (to the point of removing the burials), it is likely that the areas covered by fill still contain graves. In those areas with an elevation close to the original (i.e., pre-1950s) surface elevation, the geophysical surveys found probable evidence of graves in one area (Area 5 Upper) and possible evidence of graves, or iron-object-rich cemetery fill, in two areas (Areas 4 and 5 Lower). A final area, Area 7, is somewhat ambiguous in its likelihood to contain evidence of graves. Most of Area 7 is topographically within 1.5 meters of the original ground surface level. While no obvious indications of graves were found in the radar survey here, the presence of numerous hyperbolas in the radar data indicates that the sediment in this area contains numerous large rocks, fragments of marker stones, or air voids (e.g., animal burrows). Some of these radar anomalies could indicate that cemetery-related materials are present within Area 7, even though the graves could have been cut away by earth moving.

A total of 57 anomalies of potential interest were identified across four of the eight surveyed areas. Details related to these anomalies are summarized in Appendix A. Thirty-five of the 57 anomalies are probable graves, eight are possible graves, and the remainder are a mix of other kinds of features or anomalies of note. The most distinctive grave-like anomalies were found in Area 5 Upper, where excavations in 2005 also located soil features consistent with what is expected for graves, though no human remains were found during the excavation.

One of the most important ideas presented in this report is that a large amount of fill now covers most of the northern two-thirds of the park. While this seems obvious just looking at the ground surface in the park, the topographic analysis presented here shows where the fill is located and how thick it might be. This fill is likely sitting right on top of the original land surface—i.e., the original surface of the cemetery. If this is the case, possibly hundreds or thousands of human burials remain in the park, entombed beneath up to nine meters of fill. In areas where the fill is relatively thin, the geophysical surveys found probable and possible evidence of graves. Even more compelling is the grave that was found eroding out of the ground on the National Park Service land to the west. Most, if not all of this fill was excavated and removed from the southern third of the park, where the Quaker Burial Ground (in its entirety) and large portions of the Mt. Pleasant Plains cemetery were completely excavated away to help level the ground surface. We know from newspaper accounts and human remains found in fill taken to the National Zoo, that some of the disturbed human remains were taken away from the park in dump trucks (see Mack and Belcher 2013). However, the grave-side furniture, pieces of head stones, fragments of human bone, and coffin hardware found by Mack and his Howard University students all across the western and northern edges of the park attest to the fact that this fill contains the jumbled up remains of disturbed graves—likely the disturbed remains of graves from the southern two thirds of the park. As long as this fill is exposed at the surface, bits and pieces of the displaced graves will continue to erode out of the ground and be found by park staff and members of the public.

There are two primary ways to avoid further unsupervised encounters with human remains in Walter C. Pierce Park:

(1) Cover over areas now producing grave-related materials at the surface. Within the park, and as of the 2013 field work, this is only the north slope area; however, the west slope area on the National Park Service property has also produced significant amounts of grave-related material, as well as *in situ* burials. Planting and maintaining a dense ground cover on the north slope area (Areas 5 Upper and 5 Lower, plus the area west of Area 5 Lower) will help abate erosion problems and cover over the surfaces where grave-related materials are easily observed. It might also be necessary/advisable to bring in some more fill to increase the soil covering in these areas.

(2) Limit access to areas that might contain grave-related materials. Grave-related remains are present on the surface in Areas 5 Upper and Lower and may occur just beneath the sod in portions of Areas 2, 3, 4, and 7. Disturbed grave-related materials and buried graves likely are present in Areas 2, 4, 5 Upper, 5 Lower, and 6. Digging in these areas should be monitored by an archaeologist, if not outright avoided. However, in some areas the probable intact graves are so deep (e.g., Area 6) that only serious heavy equipment excavations could ever reach the depth of the graves.

City parks are busy places with people coming and going at all hours. With so many sets of eyes scanning the ground, and people wandering into areas with restricted access, further encounters by the public with grave-related materials is almost a foregone conclusion. Parks also often require maintenance and modification that involves ground disturbance. In the case of Walter C. Pierce Park, any such ground disturbance within the topographic zones of highest probability in Figure 8 (top, yellow and blue areas) may encounter grave-related materials or even intact graves. Therefore, future work involving ground disturbance should be monitored by an archaeologist. Large-area ground disturbances in the northern two thirds of the property should be prepared for costly archaeological mitigations to remove the burials that likely are found there.

Table 2. Summary of results by survey area.

	Area	Topographic Condition	Probability of Intact Graves	Detected in Geophysics	Condition of Graves	Number of Graves
Area 1	347.7 m^2	Cut away	None	No	--	--
Area 2	1016 m^2	Covered by fill	High	No	Buried, but perhaps near surface at southeast edge	unknown
Area 3	201.9 m^2	Cut away	None	No	--	--
Area 4	2315.4 m^2	Cut away and covered by fill	Medium	Possible	Buried from about 50 cm -6 m (1-18 ft) below surface	4 possible in geophysics, could be many more
Area 5-Upper	1023 m^2	Covered by fill	High	Probable	Buried, but geophysics suggests numerous and previous excavation found possible graves. Grave-related objects on surface eroding out of fill	As many as 32 in geophysics, perhaps 5 in previous excavation; many more likely
Area 5-Lower	422.6 m^2	Covered by fill	High	No	Unknown, but grave-related objects on surface are eroding out of fill	unknown
Area 6	823.6 m^2	Covered by fill	High	No	Unknown, fill is ca. 2-11 m (6-36 ft) deep. Nearby area without fill has in situ grave at surface	Probably many
Area 7	575.2 m^2	Likely all cut away	Low-None	No	Only the very NW corner of this area may have escaped complete removal, based on topo cut/fill model, but ground likely more disturbed than predicted	Unknown or none
Area 8	76.9 m^2	Cut away	None	No	--	--
total	6,802.3 m^2					

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