Ground Penetrating Radar Survey at the Bullhead Bluff Cemetery

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Introduction

Archaeological investigation at the Bullhead Bluff Cemetery in Camden County, Georgia was provided by the LAMAR Institute, Savannah, Georgia. This work included Ground Penetrating Radar survey of a small sample of the suspected cemetery site. Fieldwork for this project was conducted on August 13, 2006. These results are detailed in this report. The LAMAR Institute’s survey team was led by Daniel T. Elliott. Mr. Elliott was assisted by Rita Folse Elliott. Additional support was provided by interested Camden County residents.

Background

The Bullhead Bluff Cemetery is located in rural Camden County on a low terrace southeast of the Great Satilla River (Figure 1). The site was recently recorded as archaeological site 9CM326 by the Camden County Archaeological Survey Project (Rock 2006).

Figure 1. Cemetery Location (Shown in Red).

Bullhead Bluff was used as a camp for Georgia militia in the 1790s. Tara Fields, a local historian, noted that the Bullhead Bluff Plantation was originally owned in the early federal period by Joseph Thomas, Sr., who deeded the property to his son, Joseph, Jr. in 1829. The Manning family owned extensive acreage at Bullhead Bluff from the mid-1800s to the present. A Manning family cemetery is identified on the Camden County highway map, southwest of the study area.

Fields (2006a-c) reported that another old cemetery at Bullhead Bluff probably began as the Freedmen cemetery from Robert Stafford’s Cumberland Island plantation. She noted that the cemetery is known locally by several named, including Stafford, Gibbs, and Silco. This cemetery is now generally known as the Bullhead Bluff Cemetery. Fields
recently commented on the poor condition of the cemetery, “Several times the river has flooded the cemetery and caused the coffins to rise out of the ground. County workers put them back but of course the damage to the stones is great. Most graves aren't legible anymore” (Fields 2006a; Tara D. Fields personal communication August 13, 2006).

In an inventory of the cemetery, Fields (2006a) listed 29 identified graves and 37 unidentified graves, or a total of 66 graves. Those that are marked with epitaphs range in age from 1903 to 1996. Surnames included: Alberti, Atwaters, Bradley, Choien, Clark, Gibbs, Hester, Hill, Jenkins, Lawrence, Linsky, Littles, Mainor/Maynor, Raynor, Whitehead, and Williams. One of the unidentified graves were marked by a stone with the inscription, “Mother”. In a more recent online cemetery inventory of the Gibbs/Bullhead Bluff Cemetery, however, Fields (2006b) lists only 16 identified graves.

Fields commented that she saw no marked Stafford graves when she visited the cemetery in the late 1990s, although she noted that local historian Mary Bullard, in her book, "Robert Stafford of Cumberland Island" reported finding many Stafford graves when she [Bullard] visited in 1988. Bullard provided this summary of the cemetery,

> In Camden County on the south side of the Great Satilla River, there is a freedmen's cemetery, where nearly all the surnames are Stafford. On a fine autumn day in September 1988 the author visited Bull Head Bluff, where Owen Manning, its present owner, runs a hunting camp. The land is little changed from how it looked in 1880, when a large number of ex-Stafford slaves allegedly settled nearby. Manning said that in the early 1890s the economy of Camden County was boosted by timber interests in nearby Charlton County. The Suwanee Canal Company built a railroad to Bull Head Bluff from its sawmill at Camp Cornelia on the edge of the Okefenoke (sic) Swamp. Once a thriving terminal for lumber steamers coming up from St. Andrews Sound, Bull Head Bluff provided plenty of employment. According to Manning's father, the nearby black settlement found work at Bull Head Bluff as stevedores and loaders. They were "all named Stafford.

> These African-American Staffords lie buried in an old cemetery near what is left of their settlement. Some of the names are still visible on gravestones: Grant Stafford was the eldest (perhaps renamed after General Grant?). Peter Stafford, Isaciah (sic) Stafford, Retha Stafford, Gus Stafford, Lonnie Stafford, Lish Stafford, Birdie Lee Stafford, Nathaniel Stafford, Cora Stafford, Pollie Stafford, and Janie Stafford. Manning's father remembered how the Stafford settlement used tubs and barrels for drums. He often listened to them drumming: "They played the drums very well; it was impressive." When the author visited Bull Head Bluff in 1988, Stafford Road was only a rough track, near Silco. Almost nothing remains of their homes. I am indebted to Richard Owen Manning of Bull Head Bluff and Folkston, Georgia, for my visit. (Bullard, cited in Fields 2006).

The LAMAR Institute’s GPR survey of the Bullhead Bluff Cemetery happened to coincide with current events pertaining to this cemetery. This situation, which is described in a newspaper article by Goodson (2006) is briefly summarized here. The James W. Herrin family, after purchasing six acres in the cemetery vicinity, began construction of a home. That construction project was halted by a stop work order from Camden County because of its potential negative impact on the cemetery. Mr. Herrin, who was interested in knowing if graves were located in the vicinity of his proposed home, granted permission to the LAMAR Institute researchers to conduct GPR
investigations on a portion of his property. This scientific effort was not a compliance effort. This study was not designed with the intent of allowing Mr. Herrin to continue his project, although this GPR research does provide one layer of information that may have bearing on his legal situation.

Methods

Ground Penetrating Radar

The GPR device uses high frequency electromagnetic waves to acquire subsurface data (Figure 2). The device uses a transmitter antenna and closely spaced receiver antenna to detect changes in electromagnetic properties beneath them. The antennas are suspended just above the ground surface and the antennas are shielded to eliminate interference from sources other than directly beneath the device. The transmitting antenna emits a series of electromagnetic waves, which are distorted by differences in soil conductivity, dielectric permitivity, and magnetic permeability. The receiving antenna records the reflected waves for a specified length of time (in nanoseconds, or ns). The approximate depth of an object can be estimated with GPR, by adjusting for electromagnetic propagation conditions.

![Figure 2. The Elliptical Cone of GPR Penetration (Conyers and Goodman 1997).](image)

The GPR sample blocks in this study area were composed of a series of parallel transects, or traverses, which yielded a two-dimensional cross-section or profile of the radar data. These samples are called radargrams. This two-dimensional image is constructed from a sequence of thousands of individual radar traces. A succession of radar traces bouncing off a large buried object will produce a hyperbola, when viewed graphically in profile. Multiple large objects that are in close proximity may produce multiple, overlapping hyperbolas, which are more difficult to interpret. For example, an isolated historic grave may produce a clear signal, represented by a well-defined hyperbola. A cluster of graves, however, may produce a more garbled signal that is less apparent.
The GPR signals that are captured by the receiving antenna are recorded in array of numerals, which can be converted to gray scale (or color) pixel values. The radargrams are essentially a vertical map of the radar reflection off objects and other soil anomalies. It is not an actual map of the objects. The radargram is produced in real time and is viewable on a laptop computer monitor, mounted on the GPR cart.

GPR has been successfully used for archaeological and forensic anthropological applications to locate relatively shallow features, although the technique also can probe deeply into the ground. The machine is adjusted to best probe to the depth of interest by the use of different frequency range antennas. Higher frequency antennas are more useful at shallow depths, which is most often the case in archaeology. Also, the longer the receiving antenna is set to receive GPR signals (measured in nanoseconds), the deeper the search.

The effectiveness of GPR in various environments on the North American continent is widely variable and depends on solid conductivity, metallic content, and other pedo-chemical factors. Generally, Georgia’s coastal soils have moderately good properties for its application.

Ground penetrating radar signals cannot penetrate large metal objects and the signals are also significantly affected by the presence of salt water. Although radar does not penetrate metal objects, it does generate a distinctive signal that is usually recognizable, particularly for larger metal objects, such as a cannon or man-hole cover. The signal beneath these objects is often canceled out, which results in a pattern of horizontal lines on the radargram. For smaller objects, such as a scatter of nails, the signal may ricochet from the objects and produce a confusing signal. Rebar-reinforced concrete, as another example, generates an unmistakable radar pattern of rippled lines on the radargram. Conyers notes: “Ground-penetrating radar works best in sandy and silty soils and sediments that are not saturated with water. The method does not work at all in areas where soils are saturated with salt water because this media is electrically conductive and ‘conducts away’ the radar energy before it can be reflected in the ground” (Conyers 2002).

GPR has been used to a limited extent on archaeological sites in Georgia yielding mixed results. Thomas and his colleagues employed GPR technology in his study of the Guale Spanish mission on St. Catherines Island, Georgia in the early 1980s (Royce Hayes personal communication May 31, 2006). Recently, the LAMAR Institute team conducted GPR survey at St. Catherines Island. In the period since the previous GPR work, advances in software imaging have substantially increased the value of this technology in identifying subsurface features. The results of this test study are currently in preparation, although the preliminary results indicate that GPR technology is well suited for archaeological survey on St. Catherines Island.

GPR is particularly well suited for the delineation of historic cemeteries. Historic graves are often easy to recognize in radargrams, as evidenced by a pronounced hyperbola. When 3-D slices intersect these hyperbolas the graves are usually clearly evident in plan
view. When a series of graves are closely spaced, however, the grave radar “signature” is less clear-cut. By slicing the radar data at various depths along the hyperbola, the aerial perspective can be refined for optimal viewing and recognition. Since not all graves were dug to the same depth, 3-D slices at different depths can often yield very different views of graves in plan by varying the slice only a few centimeters.

Using the same Ramac X3M GPR system as that used in the Bullhead Bluff cemetery study, Elliott conducted several GPR studies of 18th and 19th century archaeological sites in coastal Georgia. The first study was at the New Ebenezer town site in Effingham County, Georgia (Elliott 2003a). The results of the GPR work at New Ebenezer were quite exciting and included the delineation of a large portion of a British redoubt palisade ditch and the discovery of several dozen previously unidentified human graves (both within and beyond the known limits of the Jerusalem Lutheran Church cemetery). The Ebenezer work was followed by a GPR survey of the colonial-era Horton House site (and DuBignon Cemetery) in Glynn County, Georgia (Rita Elliott et al. 2002). More recently, GPR survey was conducted by Elliott and his colleagues, at Fort Morris and Sunbury Cemetery (Liberty County), Sansavilla Bluff (Wayne County), Woodbine Plantation cemetery (Camden County), and Garden Homes [east Savannah] (Chatham County), and the Gould-Bethel Cemetery (Chatham County) with satisfactory results (Elliott 2003b; Elliott 2004; Elliott 2006b).

The equipment used for this study consisted of a RAMAC/X3M Integrated Radar Control Unit, mounted on a wheeled-cart and linked to a RAMAC monitor. A 500 megahertz (MHz) shielded antenna was used for the data gathering. MALÅ GeoScience’s Ground Vision (Version 1.4.5) software was used to acquire and record the radar data (MALÅ GeoScience USA 2006a). The radar information was displayed as a series of radargrams. Easy 3D software (Version 1.3.3), which was developed by MALÅ GeoScience (2006b), was used in post-processing the radar data and 3-D imaging. This entailed merging the data from the series of radargrams for each block. Once this was accomplished, horizontal slices of the data were examined for important anomalies and patterns of anomalies, which were likely of cultural relevance. These data were displayed as aerial plan maps of the sample areas at varying depths below ground surface. These horizontal views, or time-slices, display the radar information at a set time depth in nanoseconds. Time-depth can be roughly equated to depth below ground. This equivalency relationship can be calculated using a mathematical formula. An estimated soil velocity of 55 (an approximate value for wet sand) was used to generate the GPR maps in this report.

The GPR data from the present study was further processed with more robust imaging software, which was developed by Dean Goodman and called GPR-Slice (Version 5.0). Goodman’s GPR-Slice program is recognized as the world leader in GPR imaging (Goodman 2006).

Various adjustments to the GPR equipment were made in the field during the data collection phase. The time window that was selected allowed data gathering to focus on the upper 1.5 meters of soil, which was the zone most likely to yield archaeological deposits. Additional filters were used to refine the radar information during post-
processing. These include adjustments to the gain. These alterations to the data are reversible, however, and do not affect the original data that was collected. This same combination of GPR equipment and radar imaging software was used previously in coastal Georgia with very satisfactory results (Elliott 2003a, 2003b; Rita Elliott et al. 2002).

Upon arrival at the site, the RAMAC X3M Radar Unit was set up for the operation and calibrated. Several trial runs were made on parts of the site to test machine’s effectiveness in the site’s soils. Known graves, which were marked by headstones and footstones, were used to test the machine’s ability to detect human burials.

The GPR survey examined two contiguous areas in the vicinity of the James W. Herrin home (under construction). The arrangement of these survey samples, which were designated Blocks A and B are shown in Figure 3. Grid North for these two survey blocks was oriented at 11 degrees east of Magnetic North. The reference datum for the survey was a steel rebar property survey pin that was located at the intersection point of the Bullhead Bluff Cemetery and the Herrin’s southwestern property line. This datum point is located approximately 16.7 meters from the northwestern corner of the cemetery plot.

GPR Block A was a generally U-shaped block that surrounded the west, south and east sides of the house. The area north of the house was not well suited for GPR survey because of the vegetative cover. This sample block consisted of 69 radargrams, which were spaced at 50 cm intervals. All radar data was collected in a grid south to grid north direction. The progression of radargrams was from grid west to grid east. The southwest corner of GPR Block A was identified by a steel rebar survey pin, which is located on the most recent property plat. Block A measured 33.5 meters east-west by 20.8 meters north-south at its maximum extent.

GPR Block B was a wedge-shaped sample located immediately south of Block A. This sample covered portions of the Bullhead Bluff Cemetery, as defined by previous land survey. The survey extent of Block B was limited by the vegetative cover. The sample block consisted of 38 radargrams, which were spaced at 50 cm intervals. All radar data was collected in a grid north to grid south direction. The progression of radargrams was from grid east to grid west. The common boundary of GPR Blocks A and B is the property line for the cemetery exclusion. Block B measured 19 meters east-west by 15.5 meters at its maximum extent.
Machinery settings included the following:

Time Window: 75 ns
Number of Stacks: 4
Number of Samples: 716
Sampling Frequency: 9605 MHz
Antenna: 500 MHz shielded
Radargram orientation: Block A, 11 degrees; Block B, 191 degrees
Radargram progress: Block A, south to north; Block B north to south
Radargram Spacing: 50 cm

Results and Interpretation

The initial test runs that were conducted in the known cemetery area yielded somewhat surprising results, particularly when compared with previous experience on historic cemeteries in the Georgia coastal plain. Strong reflections, such as that often observed when the machinery passes over a coffin, were uncommon. Many rectangular depressions, which clearly represented unmarked graves, often did not reveal the predicted radar anomaly that coffins more typically produce. The machine was passed over a series of graves that are covered with concrete slabs. The grave radar signatures were remarkably shallow, as shown in the radargram in Figure 4. Several of these slabs appeared to contain steel rebar within them, as indicated.
One area in the northwestern part of the Bullhead Bluff cemetery (southwest of the formally surveyed blocks) revealed a cluster of strong reflections that were more typical of graves. A single radargram from this vicinity is shown in Figure 5. In this case, however, no surface signs of human graves, such as depressions, stone or cement markers, were visible. These data suggest that at least some portions of the cemetery may be amenable to grave detection by GPR survey.

**GPR Block A**

GPR Block A yielded many radar anomalies, but none exhibited the characteristics of human graves. Many of the strong radar reflections that were observed in the radargrams did not display grave-like characteristics when imaged in plan view. The area immediately south of the Herrin house was dominated by a strong cluster of radar reflections, which, when processed in plan view, displayed the dendritic patterning of tree roots. This area, which is circled in red in Figure 6, probably once contained a very large tree with an extensive root system. If any graves are present in this vicinity, these have been obscured by the tree disturbance and could not be isolated from the GPR data.
The area immediately north of the Herrin house, as well as the area directly beneath the house, were not subjected to the GPR survey because of access or vegetative terrain issues.

Figure 5. Example of Radargram, Southwest of the Study Area, Exhibiting Multiple Strong Reflections of Possible Graves.

Figure 6. Radargram of Area Immediately West of Herrin Home Showing Extensive Disturbance.
GPR Block B

The survey of GPR Block B explored a portion of the Herrin property that was formerly platted as part of the Bullhead Bluff Cemetery. The vegetation over part of this area was recently denuded by the Herrins and that part of the tract was subjected to study. The vegetated portions of the presumed cemetery on the Herrin land were excluded from the survey coverage. GPR Block B displayed a number of strong radar reflections that probably represent human graves. These radar signatures were recognized both in the radargrams (side view) and in plan view imagery.

Figure 8 shows one example of a radargram from Block B, which exhibits a strong reflection that may represent a human grave. Figure 9 shows Block B in plan view at approximately 50 cm below ground. Several possible human graves are circled in red on this image. Other similar features were observed at slightly deeper and shallower depths in this sample block. These GPR data suggest that more than half a dozen graves are probably located within this part of the Herrin property. Others may exist in the unexplored portions of the property. Although the radar images of these potential graves was not as robust as has been observed on other historic cemeteries in coastal Georgia, they shape, size, orientation and depth of the radar reflections were consistent with other graves in this cemetery.
Figure 8. Radargram from GPR Block B Showing Possible Grave Anomaly.

Figure 9. Plan of GPR Block B at Approximately 50 cm Depth, Showing Several Possible Graves.
Summary

Sample GPR survey of portions of the Bullhead Bluff Cemetery (9CM326) and an area immediately north of the legally-established cemetery on property was completed by the LAMAR Institute research team. Two samples were systematically examined and these were designated GPR Blocks A and B.

GPR Block A examined a 33.5 meter (east-west) by 20.8 meter (north-south) area that surrounded three sides (East, West and South) of the unfinished Herrin house. The survey of Block A revealed many radar anomalies but none were conclusively identified as human graves. Discovery was inhibited on the south-central part of Block A by the presence of a massive tree stump with extensive root disturbances. The areas north of the house and directly beneath the house were not included in the study because those areas were inaccessible. Human burials may exist in the vicinity of the Herrin house, although the GPR survey results do not support this assertion. Additional survey or testing may be necessary to fully resolve the question of the existence, or absence, of graves in this area.

GPR Block B examined a 19 meter (east-west) by 15.5 meter (north-south) portion of the Herrin property that was previously platted as part of the Bullhead Bluff Cemetery. Only that portion of this tract, which was cleared of the vegetation, was available for GPR survey. Several grave-sized anomalies were identified within this study block and these are likely to be human burials. These data suggest that many potential graves are present in the cemetery, which have no visible surface indications. Future land users of this area should recognize the potential for buried human remains on this part of the property.

A more complete and systematic GPR survey of the entire cemetery would undoubtedly provide a better understanding of the full extent of unmarked graves that are present in the Bullhead Bluff Cemetery. This study demonstrated that GPR technology can be applied to this environment for purposes of detecting graves. Other factors, such as extensive tree root systems, flooding effects, and modern land use have affected the clarity and integrity of the GPR data and present challenges in its interpretation. Many of the graves in this cemetery may be quite shallow, which further limits the usefulness of GPR technology. Oral accounts of graves “bobbing to the surface” during past freshets may be validated from the GPR survey record. The shallow water table may also have limited the depth to which grave shafts were originally excavated. Determining the actual depths of these grave shafts would require additional probing or test excavation, which was beyond the scope of the present study.

As the Herrin’s situation demonstrates, there is a need to clearly delineate the outer extent of the graveyard. Doing so will help to prevent future land-use conflicts in this part of Camden County. GPR survey can be one useful component in the search for graves, but it should be combined with other survey methods to insure a more complete cemetery delineatio
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