Additional Ground Penetrating Radar Survey at Sibley Mill in Augusta, Richmond County, Georgia

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Introduction
In March 2015, the LAMAR Institute was retained by the Augusta Canal National Heritage Area to conduct Ground Penetrating Radar (GPR) survey on portions of the historic Sibley Mill property in Augusta, Richmond County, Georgia. This research was a continuation of GPR survey work conducted by the LAMAR Institute in 2014 (Elliott 2014). Readers are encouraged to consult the 2014 report for more extensive background information on the study site, which is not repeated here. The present report details the background, methods and results of the 2015 GPR survey.

A major component of the Augusta Canal National Heritage Area is the Sibley Mill complex, which is located in the Harrisburg community in northern Augusta, Richmond County, Georgia (Figure 1). It is located on the east bank of the Augusta Canal, southwest of the Savannah River and northwest of King Mill. It is flanked on the southwest side by Goodrich Street. Riverwatch Parkway bisects the tract just northeast of the mill complex. The present GPR survey examined the rear portion of the Sibley Mill grounds adjacent to the Riverwatch Parkway Right of Way. The survey area is highlighted in yellow in Figure 2 (Cranston Engineering Services, P.C. 2010; American Environmental & Construction Services 2011).

Figure 1. Project Location.
Surface conditions in the study area varied greatly. Most of the mill complex is occupied by mill buildings and no GPR survey was attempted within any buildings. Several large asphalt and concrete parking lots occupy the front of the property. A series of access roads and vacant areas within the mill complex are covered with a mix of asphalt and concrete surfaces. The front of the original mill complex is marked by a
narrow strand of grassy lawn. The rear of the mill complex consists of pavement, concrete building pads, sandy ground and scattered metal debris.

The Augusta Canal is a prominent cultural landscape feature in the Sibley Mill study area. The canal was built in 1845 and the first factory on the Augusta Canal was constructed in 1847. In 1872, the canal was widened and deepened. Construction began on the Sibley Mill textile complex in 1880 and it was completed in 1882. This mill, with various expansions and additions, continued in operation until 2006.

An earlier Confederate Powder Works had been constructed at the same site as Sibley Mill in 1861-1862 (Rains 1882; Bragg et al. 2007). The large chimney is the only architectural remnant of that expansive Confederate military stores factory, which stretched for two miles along the Savannah River and included 26 buildings. This chimney was part of the refinery building. The Confederate facility, in turn, was constructed on the site of the United States Arsenal, which operated at this location from about 1816-1826. No remains from the United States Arsenal have been identified. The arsenal changed locations in 1826-1827 from near the Savannah River and the Augusta Canal to a more upland setting in Augusta’s Summerville community.

In 1956, the Georgia Historical Commission erected a historical marker commemorating “The Augusta Arsenal” at its post-1826 location. The marker text noted that, “An `arsenal at Augusta’ to aid the state in resisting invasion was originally provided for by President George Washington in 1793” and that, “In 1816 a U.S. Arsenal was established on the Savannah River where the King Mill is now located, but the garrison having been wiped out in 1819 by `black fever,’ it was removed to this site [on Walton Way] in 1827” (Georgia Historical Commission 1956).

Newspaper articles from 1880 attest to U.S. Army use of the Sibley Mill property in the early nineteenth century. Three newspaper accounts indicate that the construction of the Sibley Mill foundation disturbed prehistoric and historic period archaeological deposits including stone tools, European trade materials, early U.S. Army military artifacts (including ordnance and uniform buttons from the 1st Light Artillery Corps (ca. 1808-1821), Federal Artillery corps (ca. 1814-1821) and the Rifle Corps (date undetermined). At least six military graves (U.S. Army and possibly Confederate) were disturbed. None of the buttons described in 1880 date to the American Revolution or the American Civil War. The buttons that were described are consistent with the dates of the first United States arsenal at Augusta, ca. 1816-1826. Other than the vague locational description, “while digging for the foundation of the [Sibley] mills”, the precise location of these finds on the modern day landscape remains undetermined (Columbus Daily Enquirer 1880; Macon Weekly Telegraph 1880a-b).

While operation of Sibley Mill ended in 2006, national recognition of the historic character of the Sibley Mill vicinity escalated –as early as the 1970s. Sibley Mill was listed by the National Park Service in the National Register of Historic Places in 1975; registered as a National Historic Landmark in 1978, and elevated to be part of the first National Heritage Area in 1996. The architecture of Sibley Mill was documented by the Historic American Building Survey. The Sibley Mill property was purchased from Avondale Mills by the Augusta Canal Authority in 2010. Sibley Mill and its surrounding landscape, however, has received no formal archaeological study with the exception of limited excavations within
the powder works tower itself by archaeologist Mark Newell, which remains unreported (Tammy Herron personal communication May 29, 2014).

**Previous GPR Survey**

On May 22 and 23, 2014 the LAMAR Institute’s Ground Penetrating Radar (GPR) survey team examined four areas of the Sibley Mill complex. The project began with a meeting with Cardno Entrix Senior Staff Archaeologist Garrett Silliman, Augusta Canal Authority staff Dayton Sherrouse and Billy Power, and LAMAR Institute researchers Daniel Elliott and Rita Folse Elliott. Mr. Sherrouse led the group on a tour of the building grounds and emphasized areas of concern for future development. Mr. Power provided key information on the location of buried utilities. Both men advised that no master plan of the underground utilities for the Sibley Mill complex exists. Mr. Power provided an early fire insurance map that depicted the location of buried water lines for fire protection services. The 2014 GPR Survey at Sibley Mill mapped 2535.5 m² (0.63 acres or 0.25 hectares) within four GPR sample blocks (A, D, E and F) (Figure 3). The results of the 2014 GPR study are detailed in a LAMAR Institute technical report that was submitted to Cardno Entrix and the Augusta Canal National Heritage Area (Elliott 2014).

![Figure 3. Sibley Mill, 2014 GPR Study Locations (Google Earth 2014).](image)

The LAMAR Institute’s 2014 GPR survey at Sibley Mill is the first documented archaeological investigation of the Sibley Mill property (Elliott 2014). Cardno Entrix monitored the brownfield soil removal phase for cultural resources later in 2014 (Dayton Sherrouse personal communication march 18, 2015). Potential subsurface features in the project vicinity that might be located by GPR surveys include the following:
• Prehistoric features and occupational layers (The banks of the Savannah River at Augusta are rich with evidence of prehistoric life and the study area is highly likely to contain evidence of this occupation if any of those soil zones remain intact.)
• Human burials, including 19th century military graves
• Architectural remnants from the ca. 1816-1826 United States Arsenal
• Architectural remnants from the ca. 1861-1865 Confederate Powder Works
• Debris fields from after 1880 and the construction of Sibley Mill
• Modern (1880 and later) utility lines servicing the mill
• Soil deposits associated with the initial construction of the Augusta Canal in 1845 and its 1872 upgrade.
Research Methods for the 2015 GPR Survey

The same RAMAC X3M GPR system as that used in the 2015 GPR study has been used successfully by the author on numerous archaeological sites in the southeastern United States. The methods employed for the GPR survey were consistent with similar projects conducted by the LAMAR Institute. The equipment used for the GPR survey consisted of a RAMAC/X3M Integrated Radar Control Unit, mounted on a wheeled-cart and linked to a RAMAC XV11 Monitor (Firmware, Version 3.2.36). Both 500 and 800 megahertz (MHz) shielded antenna were used for the data gathering. MALÅ GeoScience’s Ground Vision software (Version 1.4.6) was used to acquire and record the radar data (MALÅ GeoScience USA 2006). The radar information was displayed as a series of radargrams. Output from the survey was first viewed using GroundVision. This provided immediate feedback about the suitability of GPR survey in the area and the effective operation of the equipment. GPR-Slice software (Version 7.0) was used in post-processing the data (Goodman 2014).

Ground Penetrating Radar (GPR) is an important remote-sensing tool used by archaeologists (Conyers and Goodman 1997; Conyers 2012). The technology is particularly effective in mapping historic cemeteries. The technology uses high frequency electromagnetic waves (microwaves) to acquire subsurface data. 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 are shielded to eliminate interference from sources other than directly beneath the device. The transmitting antenna emits a series of electromagnetic microwaves, which are distorted by differences in soil conductivity, dielectric permittivity 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.

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 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, 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.

The GPR samples 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 termed 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.
The GPR signals that are captured by the receiving antenna are recorded as an 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 computer monitor, mounted on the GPR cart.

GPR 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 cast iron 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.

Upon arrival at the site on March 18, 2015 the RAMAC X3M Radar Unit was set up and calibrated. Several trial runs were made on parts of the site to test the machine’s effectiveness in the site’s soils. The time window that was selected allowed data gathering to focus in the soil 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.

LAMAR Institute surveyors mapped GPR Block G, which covered 2,524.8 linear meters and encompassed an irregular polygon that measured 53 meters north-south and from 15 to 35 meters east-west. UTM coordinates for the southwestern corner of Block G (0, 0) are Zone 17, 407961E, 3705784N (WGS84) (Figure 4). Grid North was oriented at a bearing of 232 degrees. The 0 North baseline was located one meter from the concrete wall that follows the edge of the building complex. One hundred and fifteen (115) radargrams were collected within this block. Figure 5 shows a plan of the radargram coverage in Block G. Radar equipment settings and configurations for all four blocks were as follows:

- 50 cm spacing of radargrams
- Collection from grid south to grid north and progressing from west to east
- Collection of 512 samples per trace
- 500 MHz shielded antenna
- Sampling frequency—7462.13
- Time window—68.6 ns
- Antenna separation—0.18 m
- Trigger, ping interval—0.02 m
- Stacks—4
- Estimated soil velocity—75
Figure 4. Sibley Mill, 2015 GPR Study Location with GPR Block G, 0,0 Point Indicated by Purple Symbol (Google Earth 2015).
Figure 5. Radargram Coverage Plan of GPR Block G, Sibley Mill (Grid North is to left, Riverwatch Parkway ROW is to right).
Results of the GPR Survey

Figures 6 through 9 illustrate the surface conditions of that portion of the Sibley Mill grounds that were surveyed in GPR Block G. The first image shows the grid Southwest corner of GPR Block G. The following image shows the study area toward grid East. The next image shows the grid South portion, including a view of the concrete wall located one meter from the 0 North baseline. The last image shows GPR Block G facing grid North (with the radargram collection in progress).

Figures 10 through 18 present a variety of plan and profile views of the GPR data from Block G. Figure 10 is a plan view at approximately 127-144 cm depth. Figure 11 is a composite view of the radar data, where reflections from several layers have been combined. Figure 12 is an Iso-surface view, which is another way to view the data in three dimensions. Figure 13 shows several known modern features that have created strong radar reflections. Figure 14 identifies two areas within Block G that are of possible cultural interest. Figure 15 shows one interpretation of a potential building architectural footprint. Figures 16 and 17 are radargram (profile) views of that same radar anomaly. Figure 18 shows a radargram displaying a strong radar reflection that may be a significant cultural resource.

Numerous modern disturbances were noted by the survey team on the ground surface within or near GPR Block G. These included sewer drains, test wells, unidentified utility access points and a well-used access road (Figure 13). Two of these features appear in the GPR data as strong anomalies. Sewer manhole covers and grates were located at: 407948E, 3705762N [outside of GPR coverage area]; 407942E, 3705777N [strong oval GPR anomaly indicated]; 407930E, 3705780N [strong circular GPR anomaly indicated]; 407919E, 3705812N; and 407915E, 3705818N. Other, unidentified utility access points with metal covers were located at 407950E, 3705758N [outside of GPR coverage area] and 407927E, 3705807N. A monitoring well, covered with a metal plate, was located at 407932E, 3705792N.

Many smaller radar anomalies appear in GPR Block G whose significance remains undetermined. These form no apparent patterning and many may represent modern disturbances. Most of these are smaller than one meter in diameter and most appear as point reflections and not linear trenches. Some of these may represent cultural features predating the textile mill but this could not be determined by the GPR survey alone. One strong linear cluster of anomalies on the eastern portion of Block G is likely a modern utility line, as the pipe end protrudes from the ground, as revealed in Figure 13.

GPR Block G revealed two areas of interest that may relate to important cultural features. These areas are outlined in Figure 14. These areas should be monitored by an archaeologist during soil removal to determine their age, content and integrity. The larger of the two is a cluster of radar anomalies that measures about 18 meters by 10 meters (Figure 15). It is located immediately south of the access road. It is unclear if this anomaly grouping is associated with the textile mill complex, or if it follows a different orientation. It possibly represents an earlier building that was not aligned on the textile mill grid. This
cluster of radar reflections originate near the ground surface, as shown in Radargrams 10 and 15 (Figures 15, 16 and 17).

The other anomaly of interest is an irregular, rounded anomaly near the center of the survey area. It measures about 3 meters in diameter. Given that this radar reflection originates near the ground surface, it is likely associated with the textile mill. This anomaly is clearly shown in profile in Radargram 52 (Figure 18). It may represent a large well shaft, although the age of this feature is not known.
Figure 7. General View of GPR Study Area, Sibley Mill, Facing Grid East.

Figure 8. General View of Study Area, Sibley Mill, Facing Grid West Along 0 Baseline (0, 0 point indicated by red symbol).
Figure 9. General View of Study Area, Sibley Mill, Facing Grid North with GPR Collection in Progress.
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Figure 17. Radargram 15, Exhibiting Strong Radar Anomaly Cluster and Modern Road.
Figure 18. Radargram 52 Showing Strong Reflection (at 5-7 meters), Which May Indicate an Important Cultural Feature.
Interpretive Summary
Ground Penetrating Radar (GPR) survey was conducted by the LAMAR Institute on portions of the Sibley Mill historic site. The goal of this study, requested by the Augusta Canal National Heritage Area, was to document soil anomalies that may have cultural resource potential, prior to the removal of soil from a brownfield site. The GPR survey located numerous modern radar anomalies that are not considered important cultural resources. It also identified two areas of the sample block where important cultural resources may be present. Collectively, the LAMAR Institute research team examined a total of 2535.5 m² within four GPR sample blocks in 2014 and 2524.8 m² in the 2015 study. This represents approximately one-half hectare of GPR coverage. This GPR mapping coverage represents a substantial sample of the available exterior space on the Sibley Mill context from which one may derive conclusions about the suitability and effectiveness of GPR survey for mapping cultural resources in this environment. These survey data also may serve a useful purpose for other engineering concerns, including soil removal of contaminated (or brownfield) areas of the study property.

Past human activity in the study area resulted in a vast number of ground disturbing activities. The study property is located on ancient piedmont soils (primarily clay and decomposed bedrock), which are elevated well above the elevation of historic floods on the Savannah River. Radar propagation characteristics of piedmont clay soils are considered to be poor as the radar energy is absorbed and the return signals are attenuated. Consequently, GPR is not very effective for mapping these clay soils. Over most of the project area, GPR mapping of the clay soil matrix was ineffective below a depth of two meters. Where the clay has been intruded and the holes filled with other types of soil, however, GPR mapping was more effective.

The extent of the soil disturbance is quite apparent in the GPR mapping information. Major areas of the study property have been used for buried utilities, including water, electric and sewer. Despite these widespread disturbances, most of which likely date after 1879, the GPR data reveals some areas of interest.

Demand for water was intense, at both the Confederate Powder Works and the Sibley Cotton Mill. Wells and cisterns likely provided part of their pure water needs. Large ring-shaped radar anomalies in Blocks E and F may represent large cisterns (Elliott 2014). A large supply of water for fire suppression also was necessary and several water mains dating to the post-1880 period met these needs. Over the more than 125 years that Sibley Mill was in operation the mill owners made many additions, changes and repairs to the utility infrastructure. One strong radar reflection in Block G may represent a well feature. The LAMAR Institute recommends monitoring of this feature during soil removal.

GPR Block G contains a cluster of radar reflections suggestive of a rectangular pattern that may represent the footprint of a former building on the grounds. If so, this building does not conform to the grid orientation of most buildings associated with the Sibley textile mill and this may indicate that it predates the textile mill. The LAMAR Institute recommends monitoring of this locale during soil removal.
Ground Penetrating Radar (GPR) is one remote sensing method for identifying and imaging buried cultural deposits. It has a marked advantage over other remote sensing methods by providing information in three dimensions. In many situations, however, other methods are superior for mapping deposits with concentrations of metal or in clay soils. At Sibley Mill, GPR appeared to perform effectively for imaging radar anomalies in the soil. The problem, however, was in isolating the meaningful cultural information from the massive amount of ground disturbance related to the recent historic period. This more recent ground disturbing activity created strong radar reflections that likely masked the deeper, more subtle radar reflections. In many areas, it is nearly impossible to determine if important cultural deposits exist because of this masking effect. In other areas GPR imagery reveals a number of potentially important cultural features. These radar targets may be areas of interest for future investigators. No excavation was included in the current effort, so the validation and confirmation of the tentative conclusions in this report must await future investigations.
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