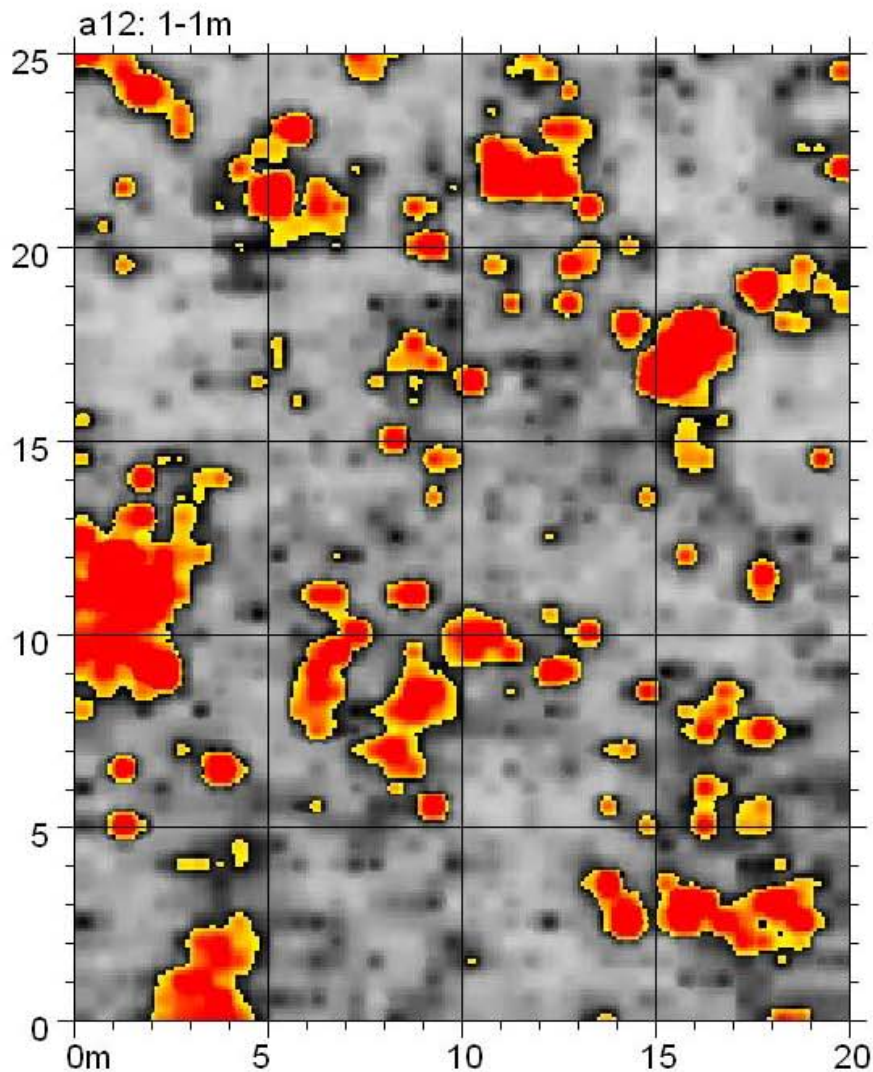


# Ground Penetrating Radar Survey on Portions of Chocolate Plantation, Sapelo Island, Georgia

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*The LAMAR Institute, Inc.*  
*Savannah, Georgia*  
*2007*

**Ground Penetrating Radar Survey on  
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**2007**

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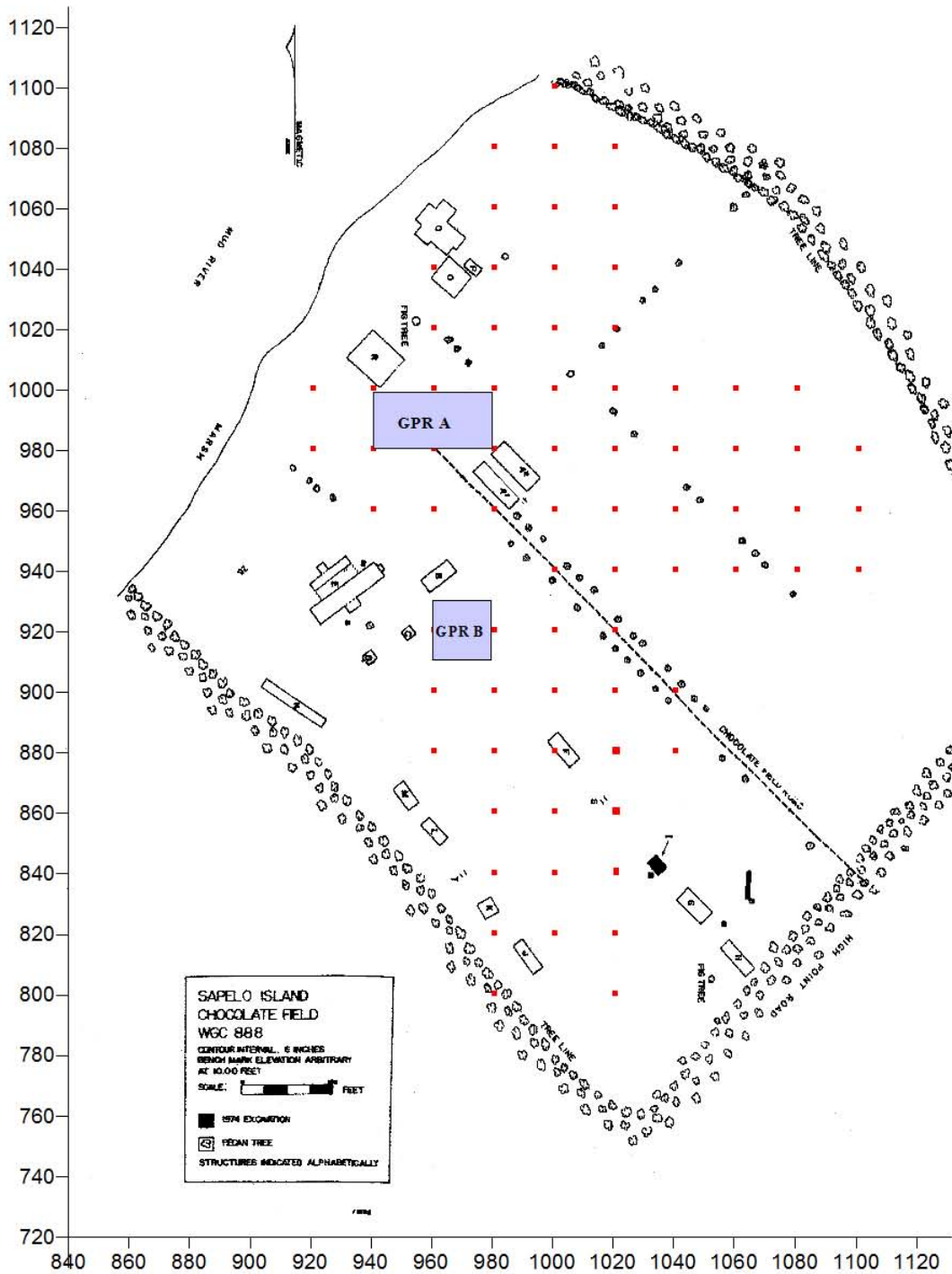
## I. Introduction

This report presents the findings of a Ground Penetrating Radar (GPR) survey by the LAMAR Institute on two portions of the Chocolate Plantation (9MC96) on Sapelo Island, McIntosh County, Georgia (Figures 1 and 2). Chocolate Plantation has been the scene of several archaeology field schools in recent years and the results of that work are described by Honerkamp and others (Honerkamp et al. 2007; Honerkamp and DeVan 2008; Simmons 2004). The present report is the results of a brief GPR survey of two locations at Chocolate, which was accomplished on May 27, 2006 during the University of Tennessee at Chattanooga archaeology field school. The course was taught by Nick Honerkamp. Norma Harris, University of West Florida, as well as Nick and his field school students assisted in the field work phase of the GPR survey.

GPR data was collected from two sample areas of the Chocolate Plantation site and these data represent the basis of this report. These study areas are shown in Figure 1. The two samples selected for survey were areas of interest to Honerkamp. Existing tabby ruins flank both of these study sites. UTC's systematic shovel testing program revealed areas of artifact concentration at these locations.

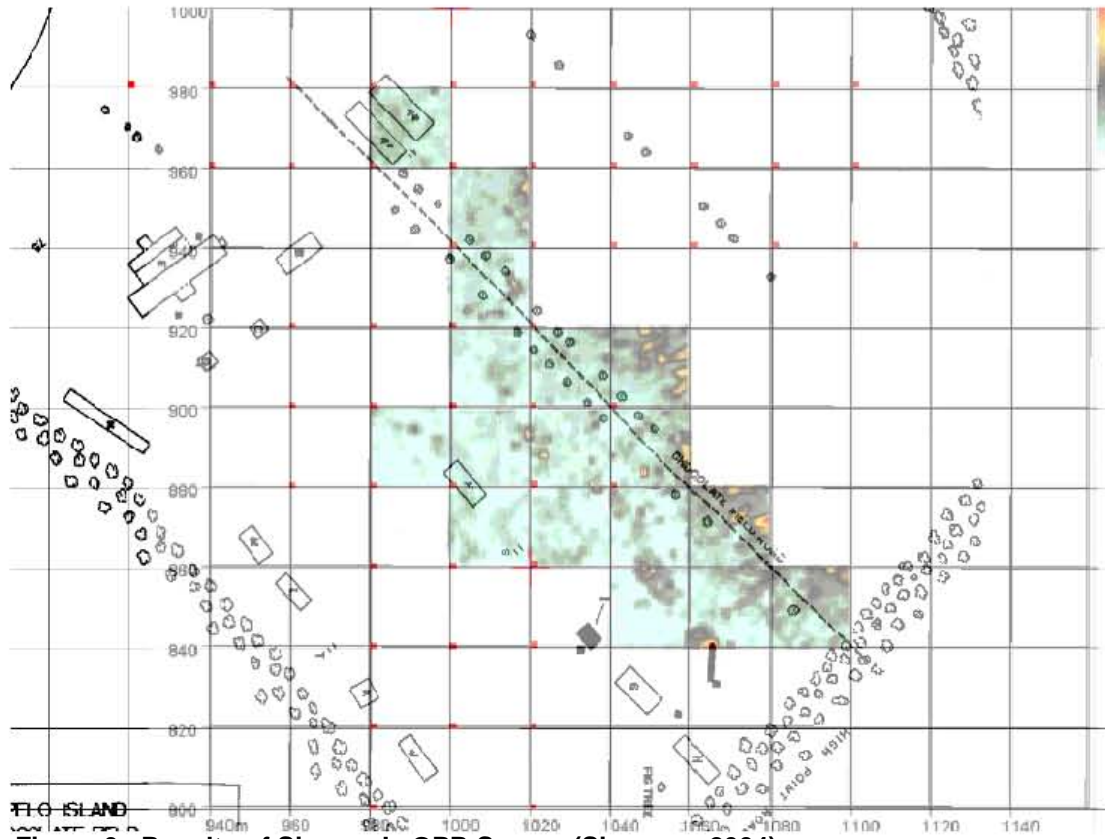


Figure 1. Chocolate Plantation, Sapelo Island, Georgia.



**Figure 2. Chocolate Plantation Base Map with GPR Blocks A and B Locations Indicated.**

Previous GPR survey was completed on a large portion of Chocolate Plantation by Simmons (2004), as part of his M.A. thesis at the University of Mississippi. This coverage did not extend to the present study sites (Figure 3). The present study also used different GPR equipment and software than that used by Simmons.



**Figure 3. Results of Simmon's GPR Survey (Simmons 2004).**

This report should be considered supplemental information to the larger report on historical archaeology at Chocolate Plantation by Honerkamp and his colleagues (Honerkamp et al. 2007; Honerkamp and DeVan 2008). Readers should consult those reports for background information on the history and environment of the study site, as well as more comprehensive discussion of the previous survey and testing work.

## II. Research Methods

Ground Penetrating Radar, or GPR, uses high frequency electromagnetic waves 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 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 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.

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 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. 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 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 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, or ns), 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.

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.

Using the same RAMAC X3M GPR system as that used in the present study, Elliott has conducted several GPR studies of 18<sup>th</sup> and 19<sup>th</sup> 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). 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 [Waldburg Street, Savannah] (Chatham County), the Gould-Bethel Cemetery (Chatham County), Bullhead Bluff Cemetery (Camden County), Fort Saint Andrews (Camden County) and numerous other sites with satisfactory results (Elliott 2003b; 2004; 2006). The same equipment has been used successfully for GPR surveys on several of Georgia's barrier islands, including Cumberland, Jekyll, Ossabaw, St. Catherines and Tybee islands.

The LAMAR Institute was invited to test their GPR equipment and technology and previously surveyed portions of Chocolate Plantation. This work was integrated into the University of Tennessee at Chattanooga's 2006 archaeological field school, which was directed by Nicholas Honerkamp. Dr. Honerkamp's assistants and students participated in the GPR data collection.

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 XV11 Monitor (Firmware, Version 3.2.36). 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. 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.

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. The crew consisted of: Daniel Elliott, Rita Elliott, Nick Honerkamp, and Norma Harris. Several trial runs were made on parts of the site to test the machine's effectiveness in the site's soils. Machinery settings and other pertinent logistical attributes included the following:

**Machine Settling Block A**

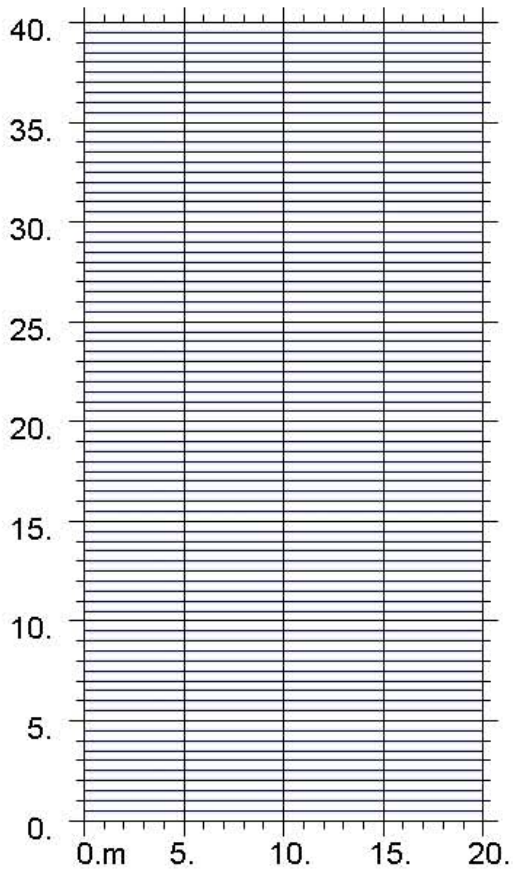
Time Window: 75 ns  
Number of Stacks: 4  
Number of Samples: 721  
Sampling Frequency: 9605 MHz  
Antenna: 500 MHz shielded  
Antenna Separation: 0.18 m  
Trigger: 0.02 m  
Radargram orientation: Odd number lines to North, Even number lines to South  
Radargram progress: East to West  
Radargram Spacing: 50 cm  
Total Radargrams: 81  
Dimensions: 40 m E-W by 20 m N-S

**Machine Settling Block B**

Time Window: 75 ns  
Number of Stacks: 4  
Number of Samples: 721  
Sampling Frequency: 9605 MHz  
Antenna: 500 MHz shielded  
Antenna Separation: 0.18 m  
Trigger: 0.02 m  
Radargram orientation: Odd number lines to East, Even number lines to West  
Radargram progress: South to North  
Radargram Spacing: 50 cm  
Total Radargrams: 51  
Dimensions: 25 m N-S by 20 m E-W

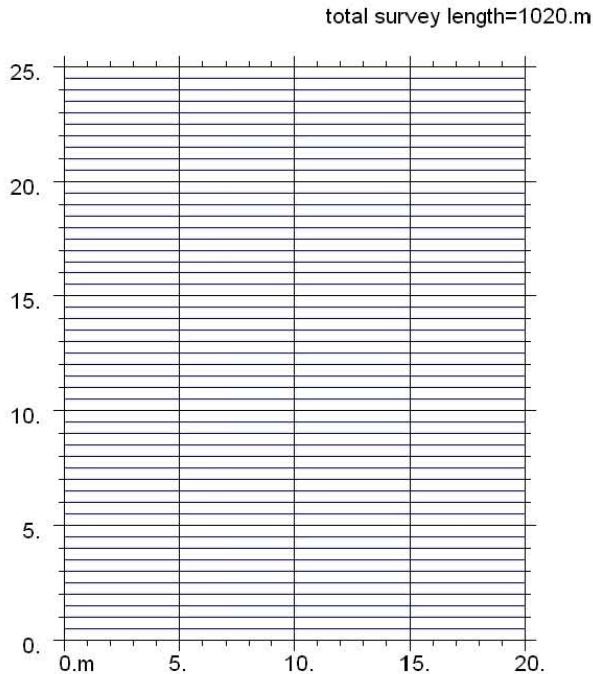
GPR Block A consisted of 1,620 m of radargram collection. The grid arrangement of these radargrams is shown in Figure 4. The block examined an area measuring 40 meters by 20 meters, or 800 m<sup>2</sup>. The site grid coordinates for Block A were: Southeast corner, 980N, 980E; Northeast corner, 1000N, 980E; Southwest corner, 980N, 940E; and Northwest corner, 1000N, 940E.

total survey length=1620.m



**Figure 4. GPR Block A Collection Grid (Grid North is to the Right).**

GPR Block B consisted of 1020 m of radargram collection. The grid arrangement of these radargrams is shown in Figure 5. The block examined an area measuring 25 meters by 20 meters, or 500 m<sup>2</sup>. The site grid coordinates for Block A were: Southeast corner, 910N, 980E; Northeast corner, 935N, 980E; Southwest corner, 910N, 960E; and Northwest corner, 935N, 960E.



**Figure 5. GPR Block B Collection Grid (Grid North is Up).**

*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.

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). The output from his software, which is superior to that generated by Easy 3D, forms the results presented in this report.

### III. Results and Interpretation

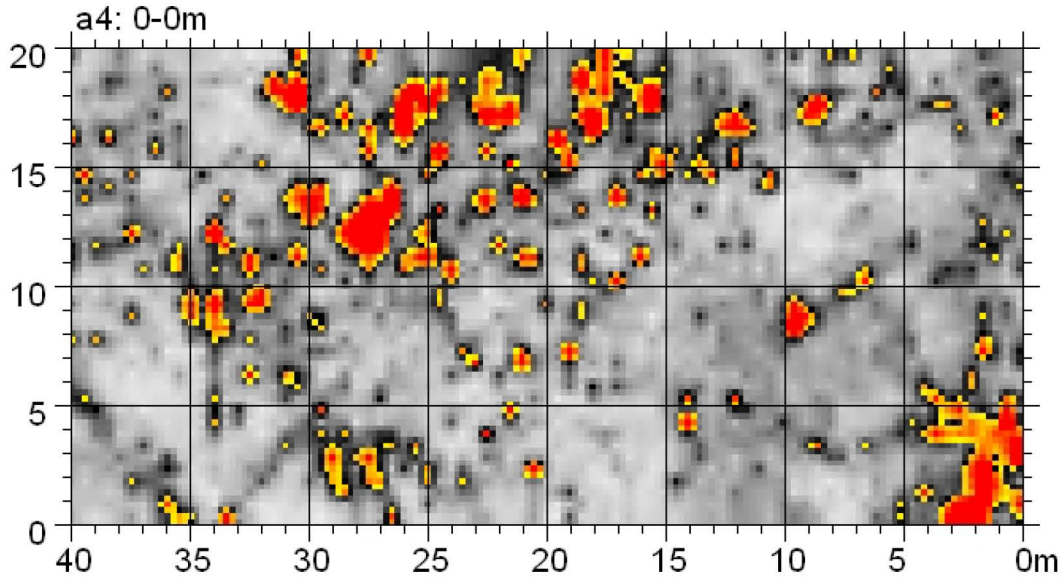
Two sample GPR blocks were surveyed at Chocolate Plantation in the present study. GPR Block A examined an area measuring 40 meters east-west by 20 meters north-south, or 800 m<sup>2</sup>. The site boundaries for Block A were: 980-1000N, 940-980E. GPR Block B consisted of 1020 m of radargram collection. The block examined an area measuring 25 meters north-south by 20 meters east-west, or 500 m<sup>2</sup>. The grid boundaries for Block B are 910-935N, 960-980E. Figure 5 shows the GPR Survey of Block B in progress. The findings from each block are described in the following section.



Figure 5. GPR Survey in Progress, Chocolate Plantation.

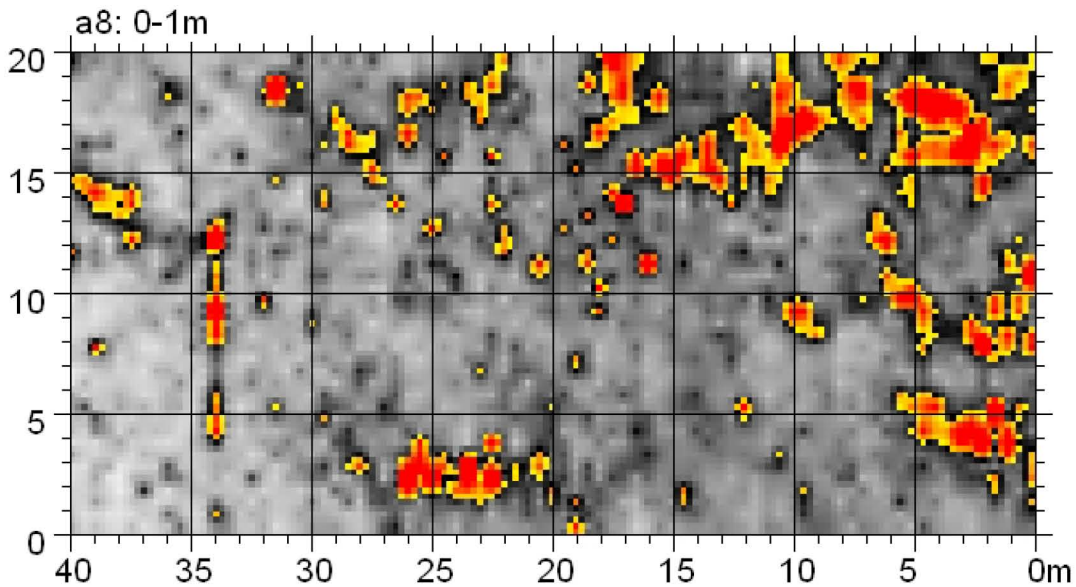
#### *GPR Block A*

Figure 6 shows an aerial view of Block A at approximately 50 cm below ground. At this depth most of the near-surface clutter is removed and the radar reflections that are displayed probably represent meaningful anomalies. The greatest concentration of these is located in the north central portion of the block. A large, strong reflection also is located in the southeastern corner of the block.



**Figure 6. GPR Block A Aerial View at 50 cm Depth.**

Figure 7 shows an aerial view of Block A at approximately 75 cm below ground. At this depth the eastern portion of the block displays more pronounced radar reflections and those near the northern center of the block are diminished. A strong area of reflection, possibly a cellar, is visible in the south-central portion of the block.

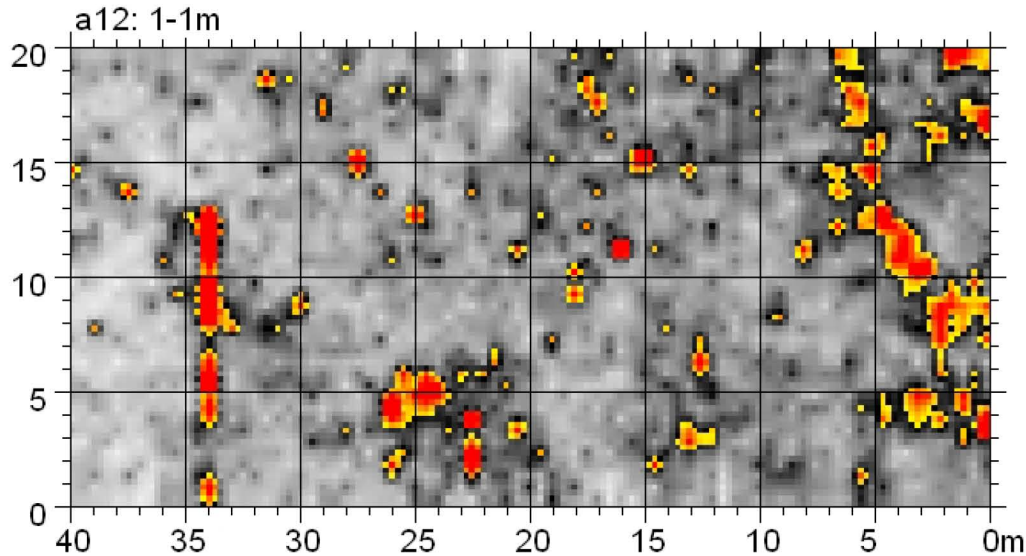


**Figure 7. GPR Block A Aerial View at 75 cm Depth.**

Figure 8 shows an aerial view of Block A at approximately 1 m below ground. At this depth many of the radar reflections observed at shallower depths are no longer visible. A series of strong reflections remain along the eastern end of the block and these now have more linear characteristics. The possible cellar, observed at the higher depth in the south-central portion of the block has morphed and shifted slightly to the northwest. The strong

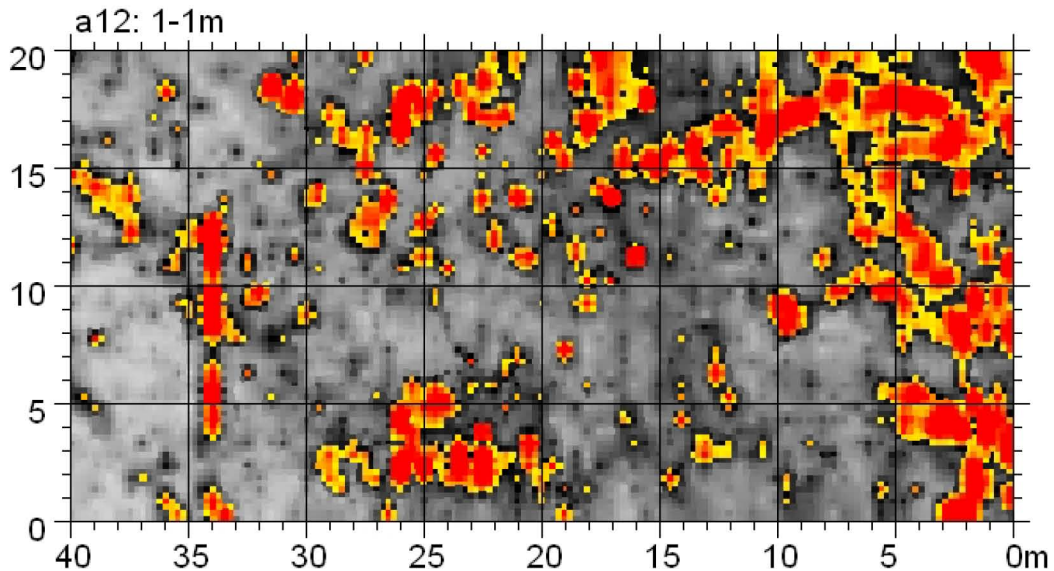


north-south linear reflection in the western part of the block may represent machine noise (given its orientation in alignment with the collection grid), or possibly a ditch.



**Figure 8. GPR Block A Aerial View at 1 m Depth.**

Figure 9 shows a GPR overlay plan map (time slice) of Block A at approximately 1 m depth. This graphic reveals a composite view of strong radar reflections within the zone of “cultural interest”. Strong radar reflections are widespread in this view, although the greatest concentration is in the eastern portion of the block. Many of the smaller, isolated radar reflections may represent large features, such as privys or wells, or possibly trees stumps. Areas shown in gray on this map had weak radar reflections and are less likely to contain cultural features.



**Figure 9. GPR Block A Composite Aerial View at 1 m Depth.**

### ***GPR Block B***

Figure 10 shows an aerial view of Block B at approximately 50 cm below ground. Figure 11 shows an aerial view of Block B at approximately 75 cm below ground. Figure 12 shows an aerial view of Block B at approximately 1 m below ground.

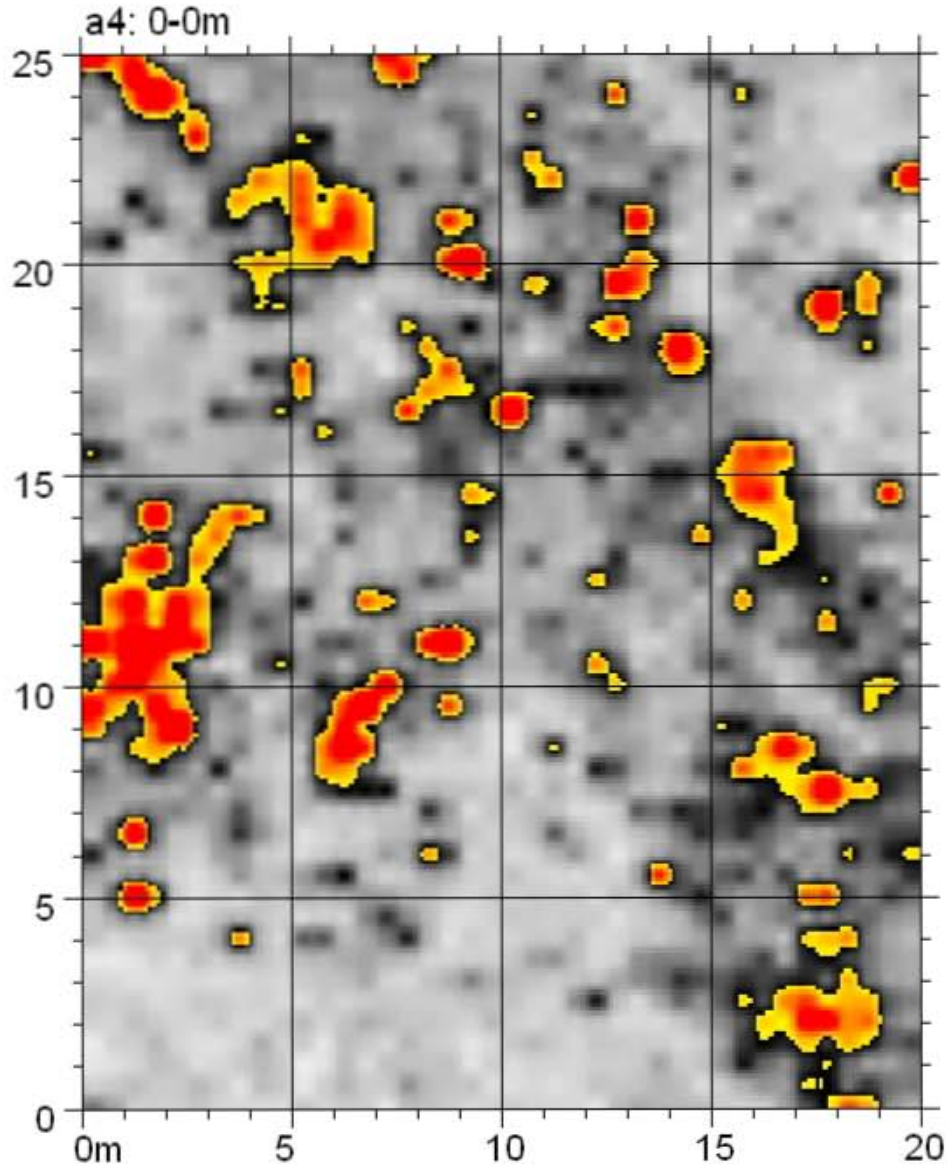
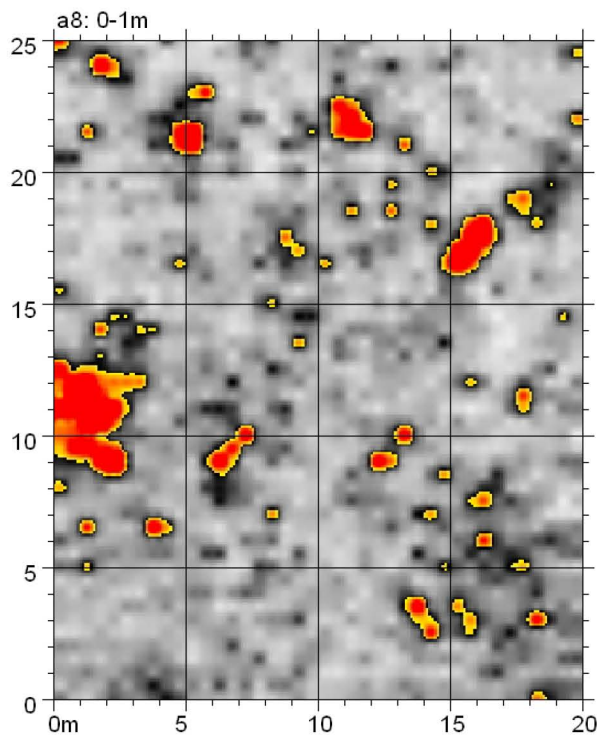
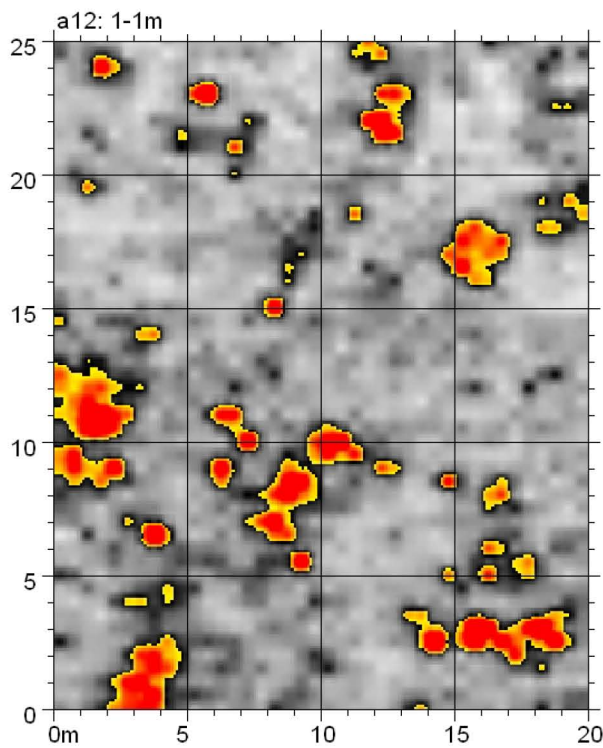


Figure 10. GPR Block B Aerial View at 50 cm Depth.



**Figure 11. GPR Block B Aerial View at 75 cm Depth.**



**Figure 12. GPR Block B Aerial View at 1 m Depth.**



Figure 13 shows a GPR overlay plan map (time slice) of Block B at approximately 1 m depth. Figure 14 shows the two GPR blocks superimposed on the map of Chocolate Plantation.

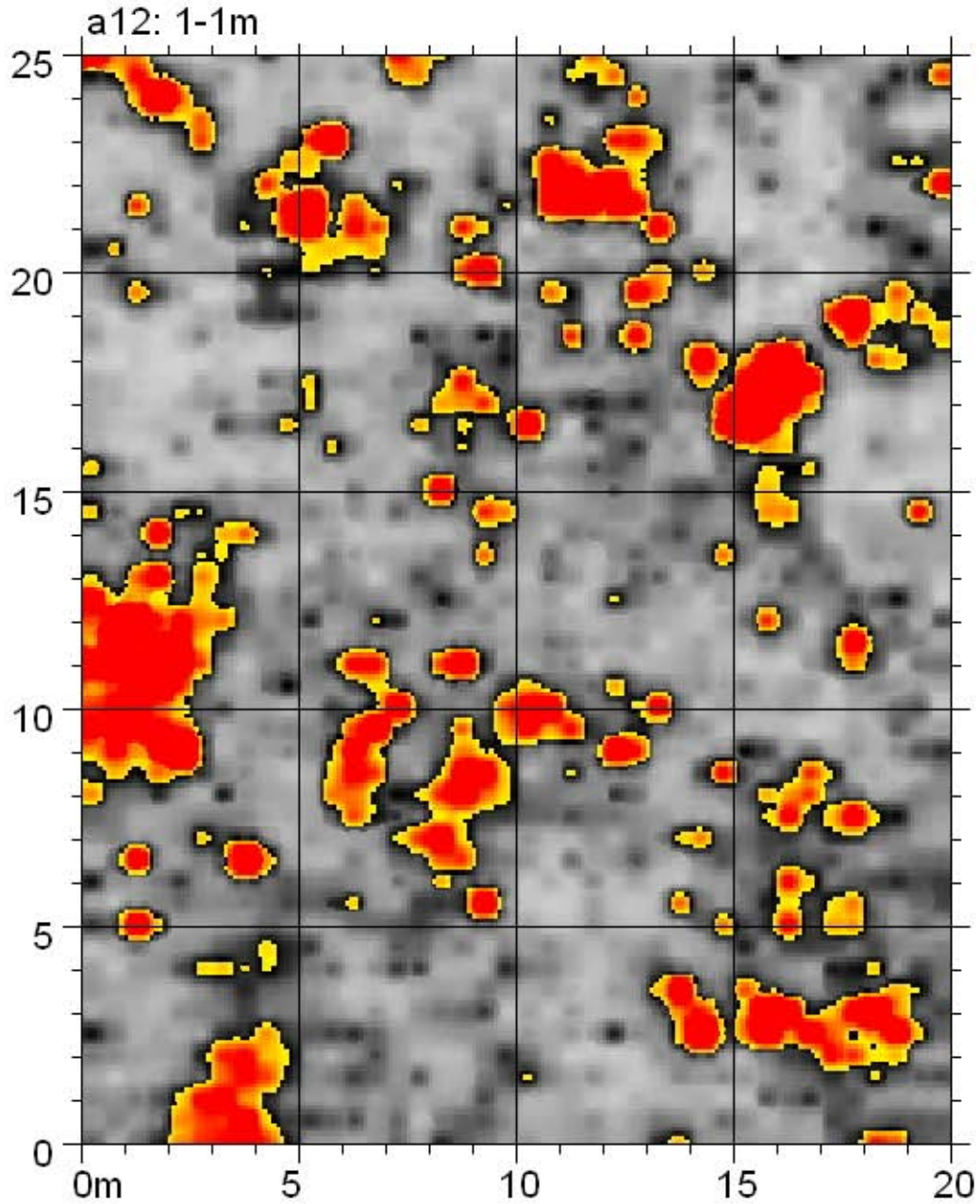


Figure 13. GPR Block B Composite Aerial View at 1 m Depth.

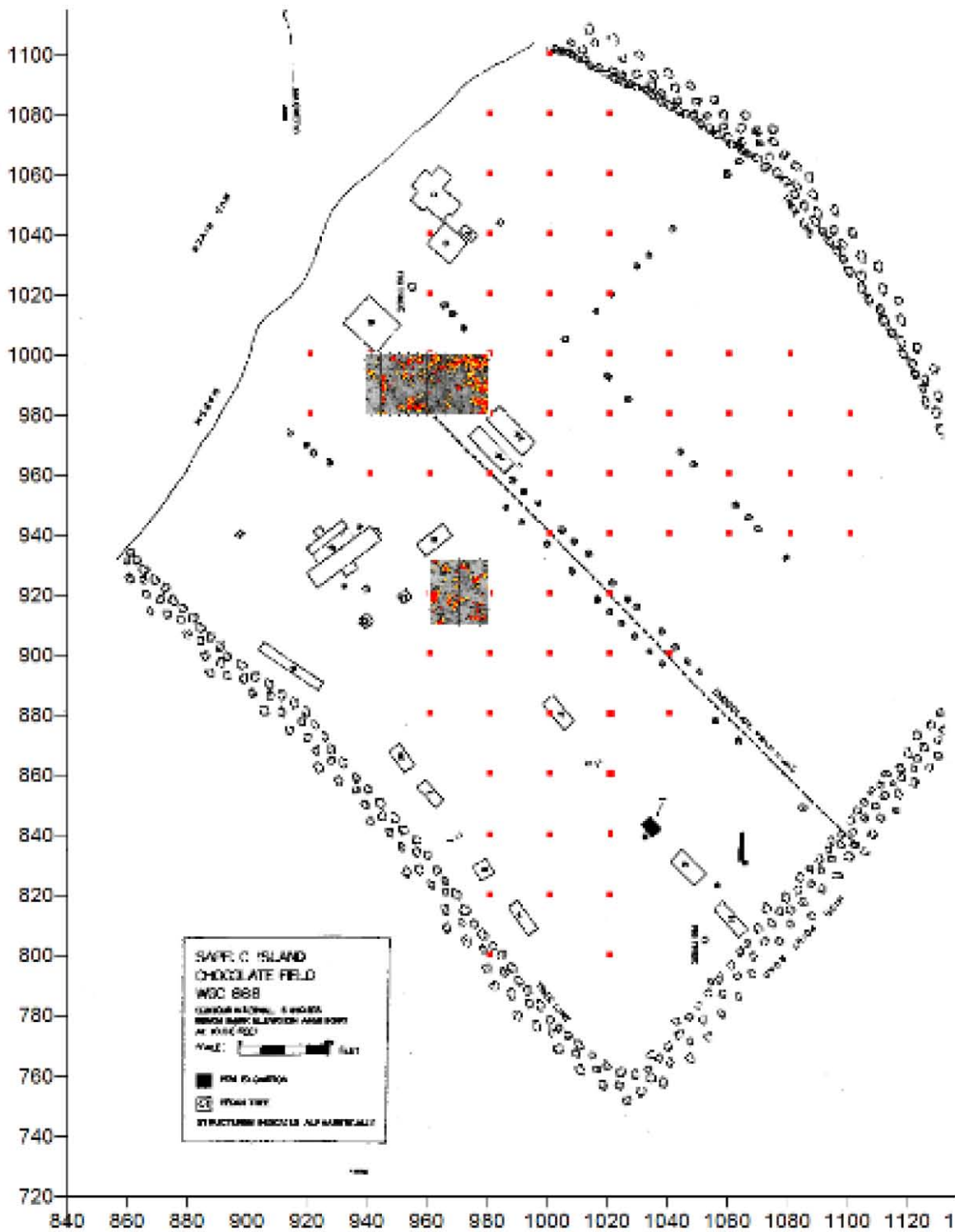


Figure 14. GPR Blocks A and B Superimposed on Chocolate Plantation Plan.

UTC's shovel testing program at Chocolate Plantation yielded excellent artifact distributional data that revealed high intensity activity loci. Their map of the distribution

of tabby fragments is shown in Figure 15 with the two GPR maps superimposed (Honerkamp and DeVan 2008:21, Figure 13). As will be noted, the area of strongest radar reflections in GPR Block A, which are on the eastern end of the block, correspond to the high frequency of tabby in this vicinity. The relationship between the high frequency of tabby in the vicinity of GPR Block B is less pronounced.

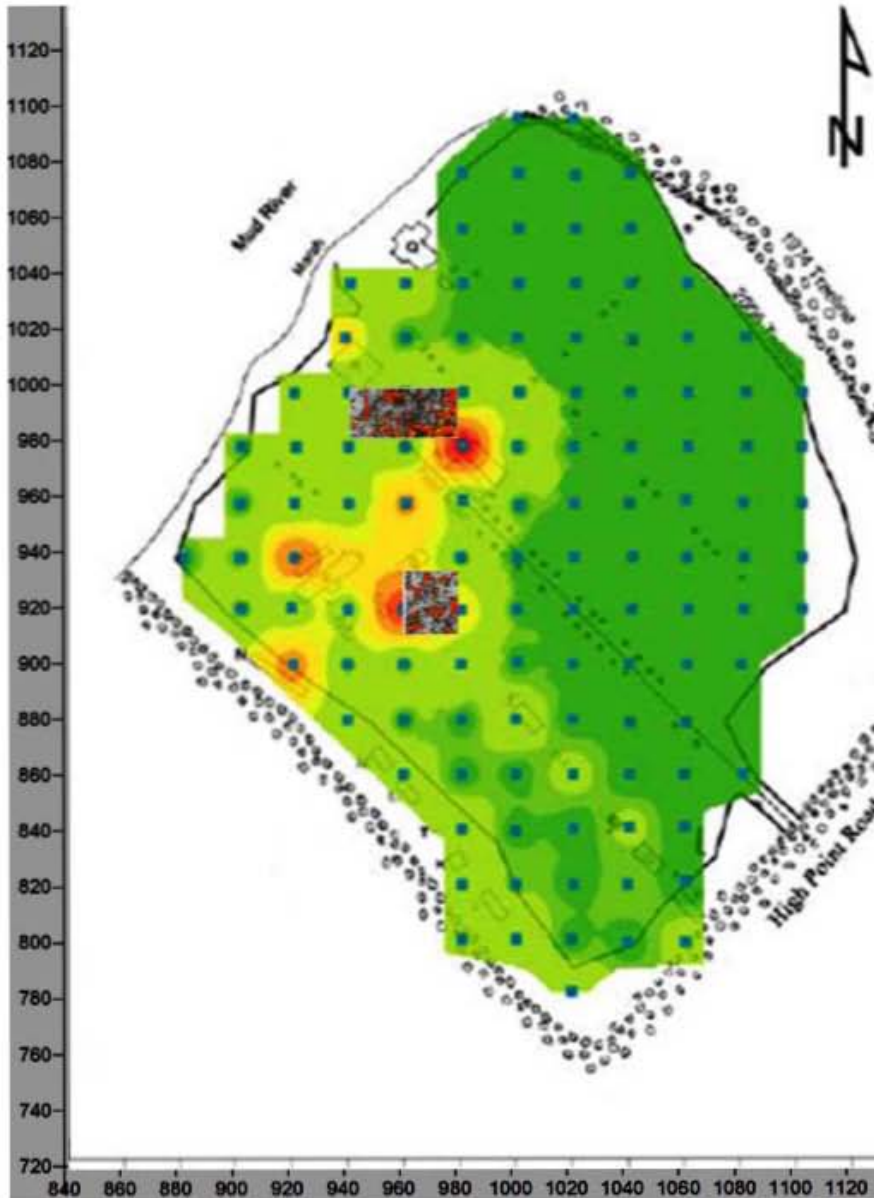


Figure 15. GPR Blocks A and B Superimposed on Tabby Distribution Map, Chocolate Plantation.

## **IV. Summary**

The LAMAR Institute's GPR Survey at Chocolate Plantation collected 2.64 kilometers of radargram data, of complete coverage of approximate 1,300 m<sup>2</sup> of the site. This represents a small sample of the entire site, and substantially less than that gathered previously by Simmons. Nevertheless, this sample yielded promising results. Both the previous work by Simmons and that in the present study indicate that strong radar reflections, which are likely related to cultural activity on the site, display intriguing spatial distributions. A full understanding of the meaning of these reflections will require additional "ground truthing" excavations. The shovel test excavations already completed by the UTC field school provide an element of validation for the GPR data. The present study was intended as a demonstration of the RAMAC X3M radar system, and as a discovery aid to Honerkamp in his field research. The radar equipment and software used in this study produced very useful information and additional GPR survey of currently unexplored portions of Chocolate Plantation is recommended.

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