

# Detecting and Imaging Historical Graves by Using Visual Inspection and Ground Penetrating Radar Investigation

Dr Ibrahim E. Ahmed Amari<sup>1</sup>, Ghassan S. Alsulaimani<sup>2</sup>

<sup>1</sup>Department of Geology & Geography, Georgia Southern University, Statesboro, GA 30458 USA

<sup>2</sup>Department of Geosciences, Missouri University of Science & Technology, Rolla, MO 65401 USA

**Abstract:** This is a comprehensive summary of the geotechnical investigation of the Historical Pulaski County Poor Farm Cemetery, southeast Waynesville, Missouri. The study demonstrates that unmarked graves in an abandoned historical cemetery can be located using visual site inspection and ground penetrating radar techniques. During the course of these investigations, multiple visual site inspections of Pulaski County Poor Farm Cemetery were conducted and ground penetrating radar data were acquired. Based on the visual site inspections and the interpretation of ground penetrating radar data, a total of one-hundred and fifty-one (151) graves were identified; eighty-seven (87) of the graves were mapped using visual site inspection techniques; sixty-four (64) were identified based on the analysis of the ground penetrating radar data. A report was submitted to the Pulaski County Historical Society, recommending that markers (wooden crosses) be placed on each identified grave. The visual site inspections and ground penetrating radar investigation were successful and proved to be useful methods for detecting abandoned graves.

## I. INTRODUCTION

### 1.1 Background

The study site, the Pulaski County Poor Farm Cemetery, is located on the Pulaski County Poor Farm. The "Pulaski County Poor Farm" was originally owned by Pulaski County; the property is now privately owned. The Pulaski County Poor Farm was established around 1874, and used for the care of those in the County who were not mentally, physically, or financially able to care for themselves. Some were old and weak and senile. Some were crippled physically and other were blind (Pulaski County Historical Society, 1987). A few children were taken from their parents and placed there because of neglect. Many poor Pulaski County residents were buried in the Pulaski County Poor Farm Cemetery. According to an article in the Waynesville Daily Guide posted on August 17, 2010, the Pulaski County Poor Farm Cemetery was established around 1874 and closed in 1957. The Pulaski County Poor Farm Cemetery is located in southeast Waynesville Missouri beside the Spring/Superior road about 22 miles west of Rolla, Missouri (Figure 1). More than one hundred people are reported to have been buried in the Pulaski County Poor Farm Cemetery. There are few headstones (only one still stands) on the Pulaski County Poor Farm Cemetery site, probably because it was too expensive to place stone markers on the graves. As a consequence, no one knows either the exact number of graves or the locations of the graves. The cemetery is located on private property and is unmarked except for few headstones and an old wire fence that is still standing in places. The Pulaski County Poor Farm Cemetery was farmland. The cemetery, as it stands, September 12th, 2010 is located on private properties and is completely unmarked. The Pulaski County Poor Farm Cemetery site located about 800ft far from the Rubidoux River. The cemetery is now being maintained by Pulaski County Historical Society. The Pulaski County Historical Society asked Missouri S&T to help locate graves on the site so that markers could be placed at appropriate locations.

There is not much information about coffins used by the persons who ran the Pulaski County Poor Farm Cemetery. However, the Pulaski County Historical Society told the author the dead were almost certainly buried in inexpensive wooden coffins. During the site inspections, the author determined that the graves in the Pulaski County Poor Farm Cemetery are oriented almost east-west, with the head facing to the east to greet the rising sun on Judgment Day. The depths to the top of the coffins probably vary, but are thought to be typically about 2ft (based on analyses of the acquired GPR data). The length of atypical coffins appears to be about 6ft; the width appears to be about 2ft. The space between adjacent graves is typically 5ft. In places, the soil overlying the graves is sunken (by up to 1 ft.), probably as a result of decay and collapse of the wooden coffins. Visually identifiable sunken grave sites account almost 60% (87 of 151) of the unmarked graves identified by the author.

### 1.2 The Pulaski County Poor Farm Cemetery Restoration Project

The Pulaski County Poor Farm Cemetery restoration project is headed by the Pulaski County Historical Society. The main goal of Pulaski County Historical Society is to clean up, preserve and restore the Pulaski County Poor Farm Cemetery, to honor those buried there and allow a place for family members to gather and

pay respects, and to Pulaski County Poor Farm Cemetery provide a place for the community to have a visible reminder of an overlooked part of Pulaski County history. The Pulaski County Poor Farm Cemetery has been neglected and ignored for decades since being abandoned in 1957. On August 14, 2010 the US Navy Seabee's detachment at Fort Leonard Wood volunteered for a massive cleanup at the Pulaski County Poor Farm Cemetery. Their hard work and effort have put the Pulaski County Historical Society a lot closer to their vision on the finalized product of this restoration project.

The Pulaski County Historical Society approached to Missouri S&T and asked if we could help identify unmarked graves at the Pulaski County Poor Farm Cemetery. The author took charge of this project and he and his team (graduate and undergraduate students) did their investigations using visual inspection and GPR techniques on the site.

### **1.3 Objective of Missouri S&T Team**

The objective of the Missouri S&T team was to accurately identify as many unmarked graves as possible on Pulaski County Poor Farm Cemetery site in southeast Waynesville, Missouri, so that the Pulaski County Historical Society could place markers (crosses) on each grave.



**Figure 1:** Google Earth Map of the Pulaski County Poor Farm Cemetery

## **II. METHODS AND RESULTS**

### **2.1 Visual Site Inspection**

Figure 2 shows the Pulaski County Poor Farm Cemetery site before the initial clean up (brush cleaning; August 14th, 2010). The site was covered by trees, bushes, rocks and a few headstones. The Pulaski County Historical Society asked the United States Navy Seabees volunteers to clean up Pulaski County Poor Farm Cemetery site as part of their restoration effort.



**Figure 2** Main Gate at Front of Cemetery

On August 14, 2010, about one month prior the first Missouri S&T crew visit, a group of volunteers from United States Navy Seabees cleared vegetation from the Pulaski County Poor Farm Cemetery site in support of restoration efforts headed by the Pulaski County Historical Society. Figure 3 is photograph of United States Navy Seabees clearing trees and vegetation from the cemetery site. After the Navy group completed their work, the site was suitable for visual site inspection and ground penetrating radar investigations with the objective of detecting and mapping old historical graves within the Pulaski County Poor Farm Cemetery site.

The photograph in Figure 4 illustrates conditions when the Missouri S&T crew first visited the site. The Pulaski County Poor Farm Cemetery had mostly been cleared of trees and brush prior to our arrival on the first day of the GPR survey (September 12, 2010), but many obstacles such as trees, shallow roots, rocks, and sunken ground remained, making it difficult to perform a proper GPR survey. As part of the initial visual site assessment, a base map was made of all the obstacles (trees, tree roots, sunken ground) that could adversely affect GPR data acquisition (Figure 6).



**Figure 3:** United States Navy Seabees Clearing the Site



**Figure 4:** Uneven Ground, Trees, Tree Roots and Branches

**2.1.1 Visual Inspection of the Pulaski County Poor Farm Cemetery Site** Since September, 12, 2010 the author has visited the Pulaski County Poor Farm Cemetery site five times in an effort to fully inspect the site. During the first visit, three important things came to the author's attention: soil type, the fence and the significance and nature of the "sunken" ground (subsidence above graves).

**2.1.1.1 Soil Type.** The soil on the Pulaski County Poor Farm Cemetery site is a mixture of sand and silt. These soils presumably were deposited as the result of the flooding of Rubidoux River and movement of the river back and forth across the valley. The site located just immediately outer edge of the floodplain. Houses nearby are at the same elevation, suggesting that the river does not flood regularly, and the site about 800ft away from the river (Figure 1). The type of the soil is very important from the perspective of GPR surveying. More specifically, GPR does not work well in clayey soil, but usually does work well where the soils are sandy and/or silty.

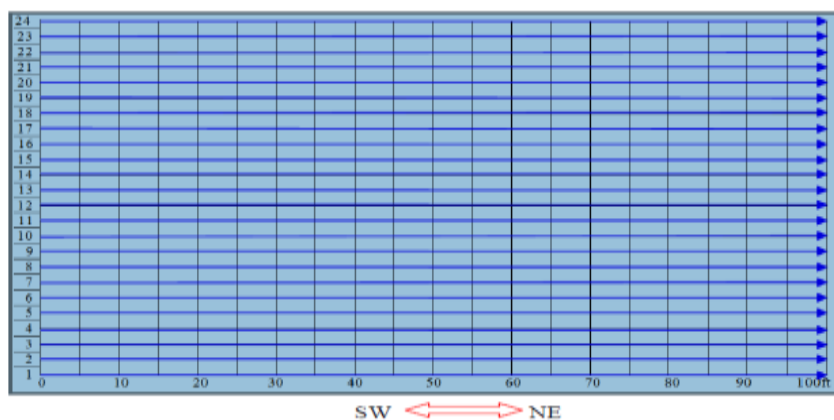
**2.1.1.2 A Fence.** The Pulaski County Poor Farm Cemetery site is more-or-less surrounded by a rusted wire fence that has collapsed in places. Laura Huffman (Pulaski County Historical Society), who is in charge of the restoration project, said “The fence almost certainly represented the outer edge of the cemetery” (as all markers and sunken ground lie within the boundaries of the old fence). When the author and Laura walked around the outer side area of the fence, there was no evidence of occurrence of the graves like sunken ground (subsidence above graves) or headstone markers. This indicated that all the graves of the Pulaski County Poor Farm Cemetery are probably located within the fenced area.

**2.1.1.3 Depressions or Sunken Ground.** The most important features discovered on the Pulaski County Poor Farm Cemetery site were the many depressions (sunken ground) on the site. These depressions do vary slightly in terms of size, but are arranged in rows and are oriented parallel to one another. What make these depressions important in this research is that each of these depressions is almost certainly indicative of the presence of a grave.

**2.1.1.4 GPR Traverses.** The author used a measuring tape and laid out 48 traverses on the Pulaski County Poor Farm Cemetery site (Figure 5 shows example of 24 traverses). Starting from southwest corner of the site to the northeast, the length of each traverse is about 100ft, depending on accessibility. The interval spacing between each adjacent traverse was 2ft apart. Figures 5 shows the 24/48 GPR traverses which were laid out across the Pulaski County Poor Farm Cemetery site, these traverses run from Southwest to Northeast with 2ft intervals between adjacent traverses. Collectively these traverses cover the entire Pulaski County Poor Farm Cemetery. Starting from station “0”, the author walked along each traverse and mapped all indentations (depressions; sunken ground), trees, tree roots, headstones, etc., Figure 6.

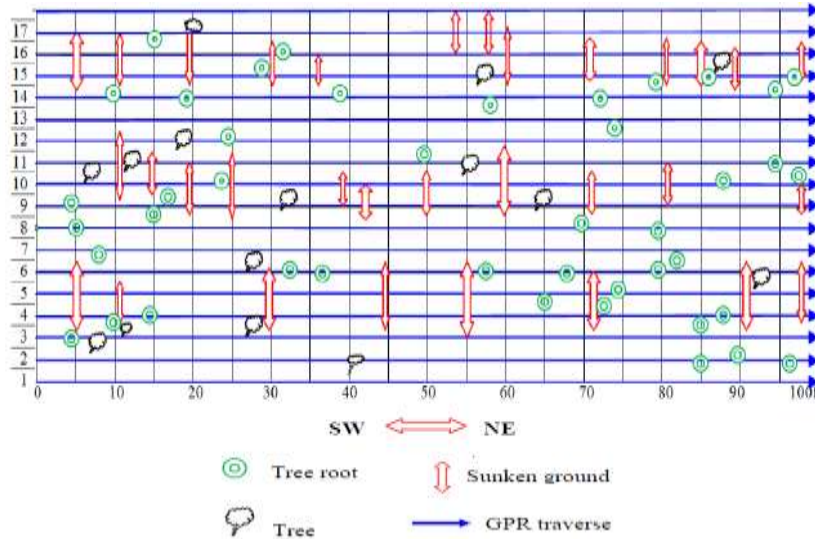
**2.1.1.5 The Significance and Nature of the “Sunken” Ground (Subsidence above Graves).** The expression “sunken ground”, as used herein, refers to the visible depressions that are observed at many locations within the confines of the cemetery. These depressions were almost certainly caused by the degradation of the wooden coffins and human remains, and the collapse of the overlying soil. On the Pulaski County Poor Farm Cemetery site the depression of the sunken ground varies typically between 0.5ft and 1ft in depth. The centers of many of the depressions are about five feet apart indicating most the graves were spaced at about five-foot intervals. In many of the sunken grave sites, small trees have taken root. Typically, the depressions are about 6ft in length and 2ft in width (consistent with burial practices as described by the Pulaski County Historical Society). Figures 7, 8 and 9 show three examples of depressions (subsidence above graves) on the Pulaski County Poor Farm Cemetery site. Figure 6 shows that the length of depression is about 6ft, the width is about 2ft and depth is about 1ft. The volume of this depression is approximately 12ft<sup>3</sup>.

**2.1.1.6 The Base Map.** After all the sunken ground, trees and tree roots on the Pulaski County Poor Farm Cemetery site were mapped, a final base map was created to show all these natural features on the site. The trees and tree roots were mapped, because the author did not want to misinterpret the GPR signatures of tree roots as graves. Figures 5 shows one example of the base map of the Pulaski County Poor Farm Cemetery site. One of the good result of visual inspection is creation of the base map that shown the location of the trees, tree roots and sunken ground (Figure 6). The depressions (sunken ground) are oriented almost east to west.



**Figure 5:** Map [1/2] of GPR Traverses (1-24)

All of the visually identifiable depressions (sunken ground) on the Pulaski County Poor Farm Cemetery site were mapped. Each indentation is presumed to correspond to a grave. The sunken ground is believed to be caused by the deterioration of the bodies and the coffins. The depressions are oriented almost east to west (Figures 7, and 8).



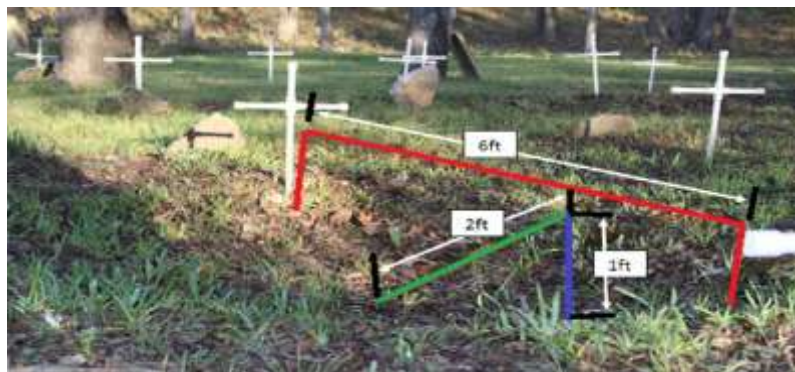
**Figure 6:** Base Maps [1/3] of Pulaski County Poor Farm Cemetery

**2.1.2 The Few Remaining Grave Markers and Unmarked Graves on the Site**

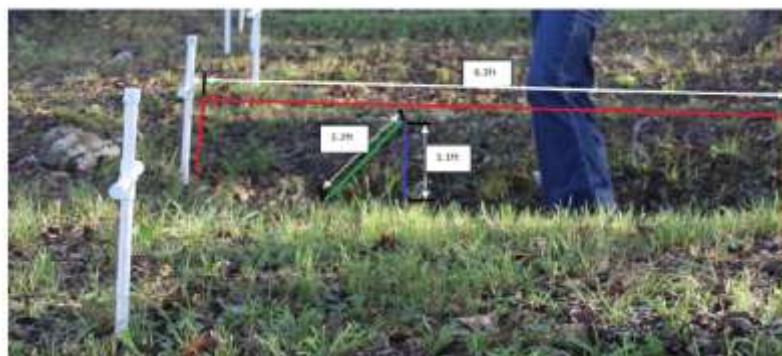
On the Pulaski County Poor Farm Cemetery many of the graves are difficult to identify, either because they were never marked, or because the grave markers have decayed, been removed, or been destroyed. Some graves were definitely marked headstones, as a few were found randomly dispersed on the site. Figures 10 and 11 show the only still-stand headstone marker and a non-standing headstone marker, respectively.

**2.1.3 Headstones**

When the S&T crew walked across the Pulaski County Poor Farm Cemetery site looking for clues about the locations of unmarked graves, it did find two old headstones. One was dated 2/12/1905 (Figure 10); and other one was dated 6/5/1871 (Figure 11). This indicates that the Pulaski County Poor Farm Cemetery is at least 139 years old. One of significant result is measuring the length, width, and depth of the sunken grave and the result shown consistent with buried practice of other cemeteries in other places in Missouri, (Figures 7, and 8).



**Figure 7:** Typical Depression on the Site



**Figure 8:** Typical Depression on the Site



**Figure 9:** Rocks and Sunken Ground

In above photo, a few rocks can be seen. These may have been used as grave markers at one time. Also, sunken ground is imaged on the photograph.



**Figure 10:** Still-Standing Headstone



**Figure 11:** Non-Standing Headstone Dated Dated 2/12/1905 Dated 6/5/1871

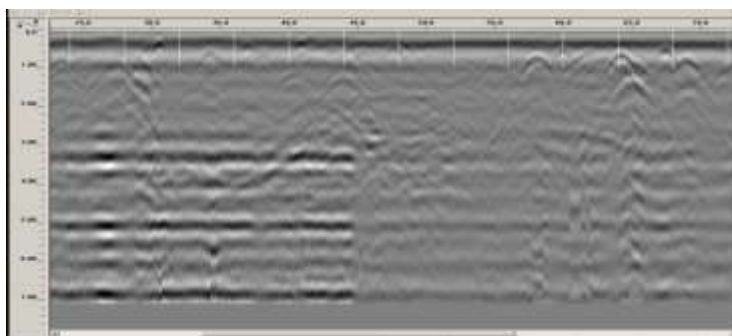
## **2.2 Ground Penetrating Radar (GPR)**

### **2.2.1 Background**

A typical GPR system has three main components: a transmitter, a receiver and a control unit. Both transmitter and receiver serve as the GPR single antenna (monostatic) of the GPR system. Conceptually the GPR tool is relatively simple, and very easy to work with. (Geophysical Survey System, Inc., 2005), (Maierhofer, C., 2008), (Davis, J.L., and Annan, A. P., 1989), and Federal Highway Administration (FHWA). 2007), (Baker, G., Jordan, T., and Pardy, J., 2007).

### **2.2.2 GPR Data Acquisition**

Ground penetrating radar (GPR) data were acquired on the Pulaski County Poor Farm Cemetery using a 400 MHz antenna. The locations of the traverses along which ground penetrating radar data were acquired are shown as Figure 12. The ground penetrating radar profiles were collected along traverses spaced at 2ft intervals beginning in the southwest corner of the study area running to the northeast corner of the Pulaski County Poor Farm Cemetery site. The ground penetrating radar data were collected in the parallel or unidirectional mode with the operator returning to the same zero (0) ft. mark to start the next traverse profile. The ground penetrating radar data were collected from Southwest to Northeast. A total of 48 ground penetrating radar profiles were collected across the Pulaski County Poor Farm cemetery. Measuring tape was used to measure all 48 ground penetrating radar traverses. The tape was stretched from zero (0) ft. mark to 100 ft.



**Figure 12:** Shows Ground Penetrating Radar 2D Data Acquisition Across the Pulaski County Poor Farm Cemetery.

### **2.2.3 GPR Data Processing**

According to the manufacturer of the Missouri S&T GPR system (GSSI SIR-3000 User's Manual, 2007), the Radan software was created to fill a GPR data processing need, and to provide both novice and experienced GPR users with processing capabilities using a windows XP Pro or Vista format, making the processing radar images easy. The Radan software package consists of a main module and add-on modules. The main Radan module (henceforth called Radan) provides all of the tools necessary to display, process, analyze, interpret and present ground penetrating radar data for most applications. (Geophysical Survey System, Incorporated, 1995, RADAN for Windows Manual), (Annan, A., and Cosway, S., 1994). Total of 48 GPR data were processed using Radan software. The quality of GPR data was excellent. Figure 13 shows one example of GPR data profile processed by Radan using 400 MHz antenna. You can clear see the GPR image shows well-defined reflection/diffraction hyperbola from the top of the coffins appears to be at a depth 1ft to 2ft.

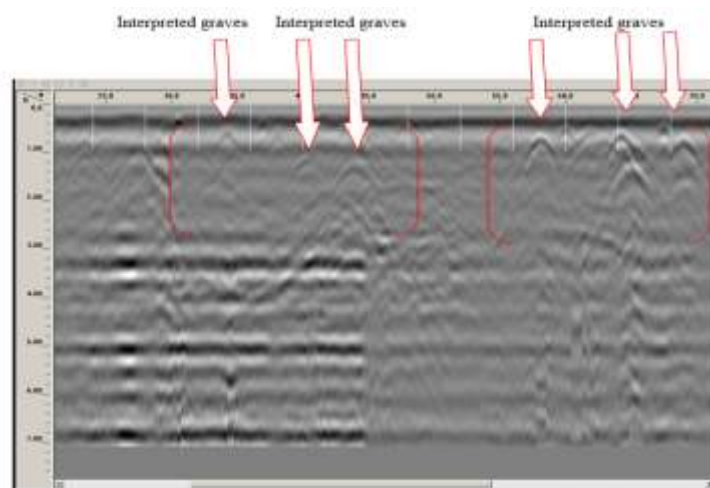


Figure 13 Shows Ground Penetrating Radar 2D Data Processed Across Pulaski County Poor Farm Cemetery, with Clear Locations of the Interpreted Graves. [2D traverse # 10]

### **2.2.4 GPR data Interpretation**

#### **2.2.4.1 Interpretation of One GPR Image from Veterans Cemetery in St. James**

GPR image collected at the Veterans Cemetery in St. James, Missouri is shown on Figure 14. This site is more nearly ideal for GPR data collection since fewer limiting factors exist at this site. The data is included here for comparison purposes and also collected using a 400 MHz antenna. On Figure 14, the GPR image shows well-defined reflection/diffraction hyperbola from the top of the coffins appears to be at a depth between 1ft and 2ft. The spacing between these coffins is about 5ft, consistent with the burial practices at the Pulaski County Poor Farm Cemetery.

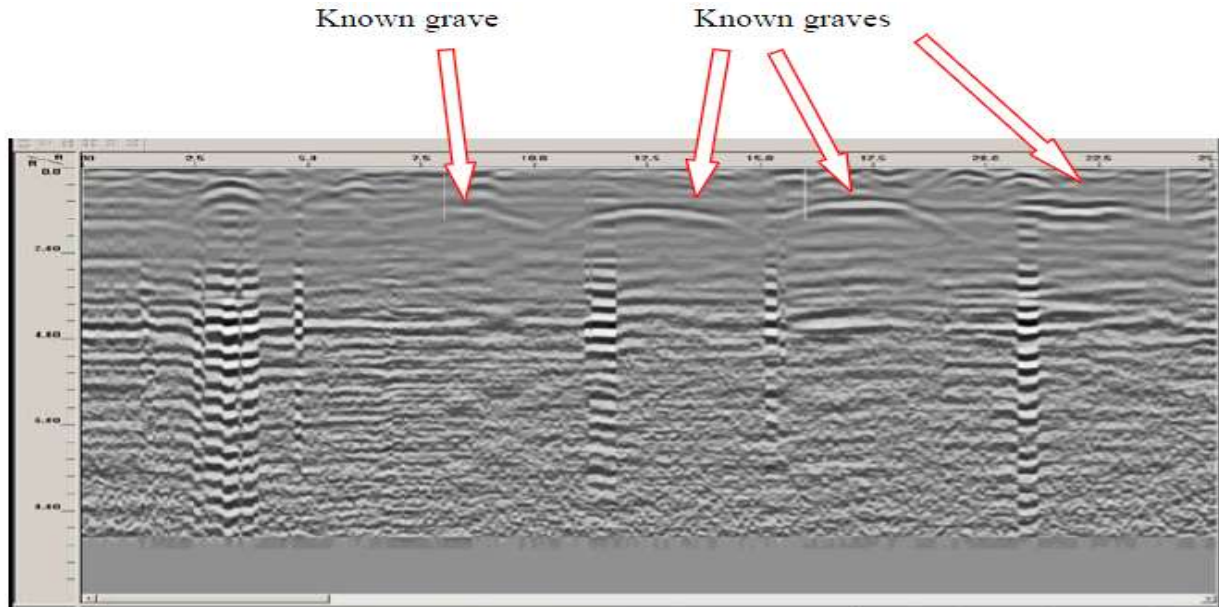


Figure 14: Ground Penetrating Radar (GPR) 2D Data Acquired Across Veterans Cemetery in St James, Missouri.

### III. DISCUSSION

**3.1 2D GPR Profile #10.** The 2D GPR profile #10, which acquired across traverse # 10, shows six (6) anomalies. The presence of those hyperbolic anomalies as the results of the reflected EM pulses from the top of the coffins. This six graves are located at 35ft, 40ft, 45ft, 57ft., 64ft., and 69ft mark of profile #10. Hyperbolic reflections in GPR traverses are originated from localized sources and can correspond to archaeological targets (Daniels, 1996; Conyers, 2004). The shape, depth and the length of those a hyperbolic reflector are vary and this may be as the results of the collapse of the coffins or due to deterioration of the bodies. There is no direct evidence of multiple and/or overlapping graves in this GPR profile. On traverse #10, the depth to the top of the most coffins about 1ft (Figure 13).

**3.2 Location of the Graves.** Based on the a comprehensive visual inspection of the site, based on the interpretation of the ground penetrating radar data and based on the pattern of identifying graves on the site generated a map showing what believed the locations of all graves on the site. Understanding this interpretation it consistent with everything we could do with the site. Accordingly there are 151 graves were found on the (Figure 15 one example of five maps have total of 87 graves).

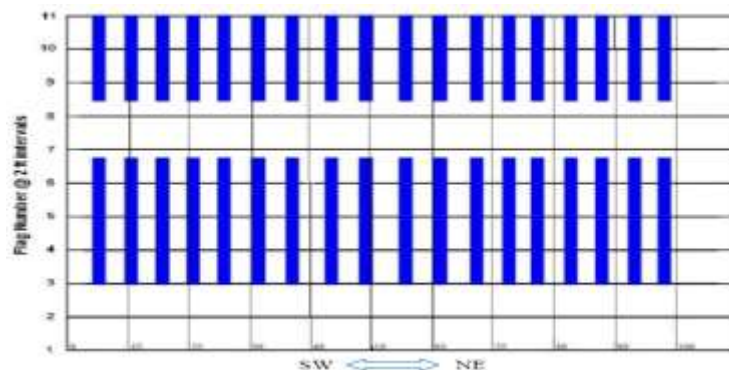


Figure 15: Maps [1/5] Approximate Locations of Interpreted Graves (Blue Areas)

### IV. CONCLUSIONS AND RECOMMENDATIONS

Two techniques were used to investigate the Pulaski County Poor Farm Cemetery site: visual site inspection, and ground penetrating radar (GPR). The author visited the site a total of the five times since September 12, 2010. Each time the author took additional photographs, re-mapped some of the indentations and inspected the indentations (with the expectation of each the indentation represented a grave). During the visual site inspection of the site, the land surface was examined for features indicative of burial sites. Two marked headstones were found one dated 1905, the other dated 1871. Apparently the Pulaski County Poor Farm



Cemetery is at least 139 years old. In total, eighty seven (87) surface indentations were mapped and plotted on a base map. In areas with no visible indentations, we acquired ground penetrating radar and some electrical resistivity data. Interpretation of ground penetrating radar data identified an additional sixty four (64) possible grave sites. We are very confident that each of the mapped indentations represents a grave, but are less confident of our interpretation of ground penetrating radar data, and least confident of the electrical resistivity data. Based on visual site inspections and the interpretation of the ground penetrating radar data, the recommendation to the Pulaski County Historical Society is to place markers on each of the 151 identified potential grave sites. It is possible that a couple of these identified anomalies may be not graves. If additional data is acquired on the Pulaski County Poor Farm Cemetery site, the Society is encouraged to use a GPR with 400 MHz antenna and to remove as many obstacles like trees, tree roots and rocks as possible to improve the quality of the acquired ground penetrating radar data.

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