**United States Department of Agriculture** | **Natural Resources Conservation Service Service** | **344 Merrow Road Suite A Tolland, CT 06084**

**SUBJECT**: Archaeology – Geophysical Field Assistance November 22, 2011

**TO**: Dr. Nicholas F. Bellantoni
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**Purpose:**
At the request of the Connecticut State Archaeologist, soil scientists conducted ground-penetrating radar surveys at a historical site located in Pomfret, Connecticut, and at two cemeteries in Canterbury and Norwich, Connecticut.

**Principal Participants:**
Nicholas Bellantoni, Connecticut State Archaeologist, Connecticut Archaeology Center, Univ. of Connecticut, Storrs, CT
Debbie Surabian, MLRA Soil Survey Office Leader, USDA-NRCS, Tolland, CT
Maribeth Holer, Earth Team Volunteer, USDA-NRCS, Tolland, CT

**Activities:**
All activities were completed on 9 November 2011.

**Summary:**

1. At the Fox Run Vineyard in Pomfret, the use of geophysical techniques provided added insight into subsurface conditions and the presence of archaeological features. The data revealed anomalous features attributed to what may be the foundation of Israel Putnam's first home.

2. At the cemeteries in Canterbury and Norwich, the use of geophysical techniques provided added insight into subsurface conditions and the presence or absence of unmarked graves. In Norwich, a group of people are working together to have the Ruggles Family plot designated as a location along the Freedom Trail and the Yantic Cemetery on the National Registry of Historic Places

Regards,

Deborah Surabian
MLRA Soil Survey 12-6 Leader

cc:
James Doolittle, Research Soil Scientist, USDA-NRCS-NSSC, Newtown Square, PA
Kipen Kolesinskas, State Soil Scientist, USDA-NRCS, Tolland, CT
Joyce Purcell, Assistant State Conservationist & CT Cultural Resources Liaison, USDA-NRCS, Tolland, CT
Jay T. Mar, State Conservationist, USDA-NRCS, Tolland, CT

**Equipment:**
The radar unit is the TerraSIRch Subsurface Interface Radar (SIR) System-3000 (SIR-3000); manufactured by Geophysical Survey Systems, Inc.[1] The SIR-3000 consists of a digital control unit (DC-3000) with keypad, SVGA video screen, and connector panel. One 10.8-volt lithium-ion rechargeable battery powers the system. The SIR-3000 weighs about 9 lbs (4.1 kg) and is backpack portable.

GPR transmitting antennae operate in the megahertz range and must be chosen based on expected project goals. Higher frequencies do not penetrate as deeply as lower frequencies, but give better resolution and "see" smaller objects at shallower depths. Once a source antenna is chosen for a particular survey, GPR data can be collected fairly rapidly by using the unit over an area of interest. The data can be collected in simple line scans like a wildcat survey to locate an anomaly or in a grid format for a more detailed study. For this survey, a 400 MHz antenna was used to conduct a wildcat survey with scanning rates of 64 scans/sec and a scanning time of 50 ns. With a scanning time of 50 ns, the maximum penetration depth is about 3 m.

The RADAN for Windows (version 6.6) software program developed by Geophysical Survey Systems, Inc (GSSI) was used to process the radar records. [1] Processing included setting the initial pulse to time zero, color table, transformation selection, and marker editing. For these sites, radar records were processed into two-dimensional images or three-dimensional images using the 3D QuickDraw for RADAN. Once processed, arbitrary cross sections and three-dimensional images were viewed and attached to this report.

**Ground-Penetrating Radar and Archaeological Investigations:**
GPR is a non-invasive geophysical method that uses radar pulses to produce an image or record of subsurface features. The GPR antenna transmits high to ultra high frequency (center frequencies from 12.5 MHz to 2.6 MHz) electromagnetic energy into the ground as the unit is pulled along, in contact with the surface of the ground. As the radar wave hits a buried object or a boundary with different dielectric properties, the receiving antenna records variations in the reflected return signal. The amount of energy reflected back to an antenna by a buried object is a function of the contrast in dielectric properties that exists between an object and the surrounding soil. The greater and more abrupt the difference in dielectric properties, the greater the amount of energy that is reflected back to the antenna, and the more intense amplitude reflections on the radar record. In addition, certain GPR signatures can relate to specific underground targets such as attenuation losses or absorbed GPR signals related to highly conductive materials (clays and dissolved salts); complete reflection related to metals that do not allow any amount of signal to pass through; and distinct natural layering versus chaotic in-filled trenches or excavation areas (Cardimona et al., 2002).

Typically, reflections are identified and correlated on two-dimensional (2-D) radar records. These 2-D profiles present the returned signal as a function of time (associated with depth) and survey position (horizontal coordinate). Today, three-dimensional imaging techniques can be used to distinguish coherent noise components, reduce interpretation uncertainties, and aid identification of potential targets (Pipan et al., 1999).

A favorable feature of GPR for archaeological investigations is its ability to detect disturbances and the intrusion of foreign materials in soils. On radar records, the depth, shape, size, and location of subsurface features may be used as clues to infer buried cultural features. GPR offers the horizontal and vertical resolution necessary for this type of application. The GPR data images do require someone with field experience to accurately determine the findings. The collection of ground truth data is important for correlating GPR signatures with specific underground targets in a given survey.

**General Israel Putnam**
Israel Putnam was an American army general and Freemason whose reckless courage and fighting spirit was well known far beyond Connecticut. He fought in the French and Indian Wars, at the Battle of Bunker Hill during the American Revolution, and was known to have killed the last wolf in Connecticut (Wikipedia, 2011). At the age of 22, he moved to Mortlake (now Pomfret) in northeastern Connecticut to what is now home of Fox Run Vineyard. A plaque (shown in Figure 4) stands on Route 169 indicating the approximate distance to where Israel Putnam's first house once stood.

[1] Manufacturer's names are provided for specific information; use does not constitute endorsement.

*Figure 1. Some people believe Col. William Prescott said "Don't fire until you see the whites of their eyes." It is believed the most likely scenario was Putnam spoke the words first, and then Prescott repeated them to his men (Compmast, 2011).*

*Figure 2. In 1888, General Putnam's remains were reburied under a bronze equestrian statue in Brooklyn, CT. A popular belief in the United States is that if the horse is rampant (both front legs in the air), the rider died in battle; one front leg up means the rider was wounded in battle or died of battle wounds; and if all four hooves are on the ground, the rider died outside the battle. However, there is little evidence to support this belief (Wikipedia, 2011).*

*Figure 3. A road sign entrance to Wolf Den Road, the Wolf Den, and the plaque at the entrance of Wolf Den Park (Compmast, 2011).*

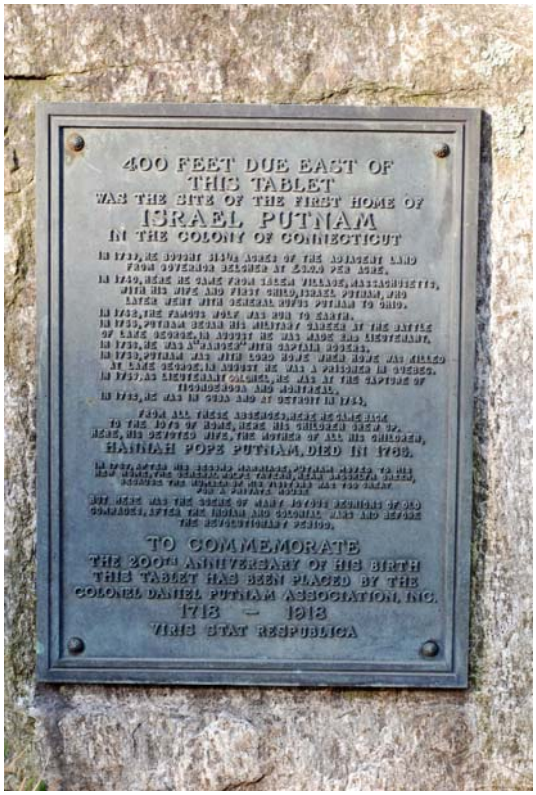


*Figure 4. The tablet placed on the Route 169 in 1918 (photograph courtesy of Maribeth Holer, Earth Team Volunteer).*

**Survey Procedures:**
Based on the roadside plaque in Figure 4, the location of the foundation of General Israel Putnam's first house is believed to be located near or within the vineyard of Fox Run Vineyard. Using the 400 MHz antenna, random radar traverses were conducted across the area in essentially an east-west direction alongside the vineyard as well as in a north-south direction in between the rows of grape vines. Wildcat surveys were completed in both of these areas in an attempt to locate a buried foundation.

*Figure 5.A GPR survey being conducted at the Fox Run Vineyard (photograph courtesy of Maribeth Holer, Earth Team Volunteer).*

The main area of interest was located within the vineyard between rows 5 and 8 (shown in Figure 6). The soil in this area is mapped as Woodbridge fine sandy loam, 3 to 8 percent slopes. Woodbridge soils are formed in glacial till, more specifically, lodgment till derived mostly from schist, gneiss, and granite. Glacial till is material that has been transported and deposited directly by ice. Till typically has unsorted sediments varying in texture, mineralogy, and degree of consolidation. Material carried in different parts of the glacier produces till with different characteristics. Lodgment till is compact and contains a greater amount of fine-grained sediment. The depth to the compacted layer (Cd horizon) ranges from 46 to 100 centimeters. Woodbridge soils formed in a loamy mantle underlain by loamy dense till and are classified as coarse-loamy, mixed, active, mesic Aquic Dystrudepts. Woodbridge soils are considered well suited to GPR applications.

*Figure 6. A soil map from the Soil Survey of the State of Connecticut. The orange box indicates the area of interest and the red dot indicates the roadside plaque. The soil mapped across this area is 45B Woodbridge fine sandy loam, 3 to 8 percent slopes.*

**Results:**

Overall the radar records showed widely dispersed and chaotic patterns of high-amplitude reflections that are typically associated with the underlying till soil. In Figure 7, the radar record shows an area of high amplitude reflections near the soil surface. This area continued into several more rows in the same area heading to the west from row 5 and then subsequently was lost. The anomaly is approximately 0.5 meter to 1.5 meters below the soil surface and 15 meters wide. While no subsurface feature such as a house foundation can be unambiguously indentified on these images, the concentration and contrasts of graphic signatures within the defined area may merit the attention of archaeologists.

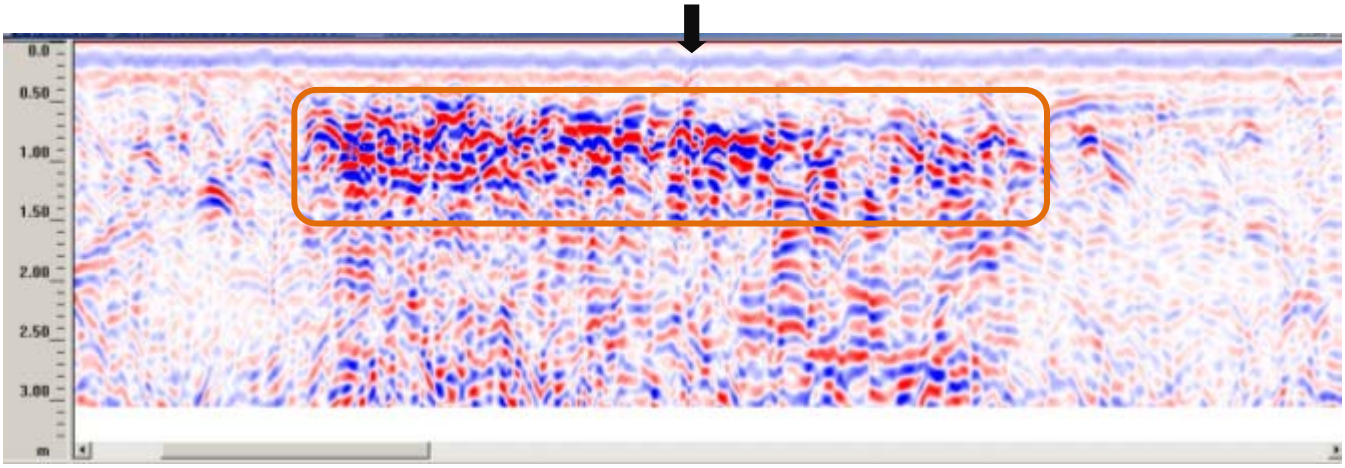


*Figure 7. A two-dimensional radar record heading south in row 5 running in between the grapevine rows. The double tick (black arrow) is where the GPR crossed the starting main pole of row 5. As the transect moves from the dirt road towards the vineyard in a north to south direction (from left to right in the radar record), an area of high amplitude reflections appears on the radar record. This area, which is included in the orange box shown in Figure 6, may merit the attention of archaeologists.*

**Calvary Chapel Cemetery**

Calvary Chapel Cemetery is a small cemetery located in Canterbury, CT. We were asked to provide information to the sexton as to whether several areas within the cemetery were still vacant, meaning there were no unmarked graves. The cemetery is most noted for the burial of Izola Martha Mills (1836-1887). The heirs of Izola Martha Mills claim she was secretly married to John Wilkes Booth on January 9, 1859 in Cos Cob, Connecticut and never divorced. With Booth, she had one child named Ogarita Rosarita Elizabeth Booth born on October, 23 1859 in Providence, Rhode Island. Once Booth was legally declared dead in 1865, his 'widow' was free to remarry. She was to remarry three more times: first to Charles Still Bellows, then to John H. Stevenson, and finally to Edwin Sylvanus Bates.

*Figure 8. Izola Martha Mills' gravestone in the Calvary Chapel Cemetery (photograph courtesy of Maribeth Holer, Earth Team Volunteer).*

**Survey Procedures:**

To collect the data required for the construction of 3D GPR pseudo-images, small survey grids were established across selected areas of interest. The sizes and dimensions of the grids varied and are listed in Table 1. For each grid, two parallel lines were established across the selected sites. Along each of these parallel lines, survey flags were inserted into the ground at a spacing of 50 cm. A reference line was extended between matching survey flags on opposing sides of the grid using a distance-graduated rope. GPR traverses were conducted along the distance-graduated rope to assure accuracy. Following data collection, the reference line was sequentially moved to the next pair of survey flags to repeat the process. For each grid, the 400 MHz antenna was towed along the graduated rope, and as it passed each 1 meter graduation, a mark was impressed on the radar record. The parallel radar traverses were conducted across the grid area in essentially a north-south direction. Traversing in a north-south direction with the radar in this cemetery is important in establishing patterns of unmarked graves since most graves in early New England cemeteries are orientated in an east-west direction. This traditional Christian method of positioning bodies face up and facing east in the direction of the rising sun was to allow the dead to see the Second Coming of Jesus.

**Table 1. Basic features of the GPR Grid Sites**

| Site | Grid Dimensions | Line Spacing |
|---|---|---|
| Calvary Cemetery Grid 1 | 5.5 x 3 m | 50 cm |
| Calvary Cemetery Grid 2 | 8.5 x 24 m | 50 cm |

The cemetery is open with large trees around the boundary. The area is mapped as Merrimac sandy loam, 3 to 8 percent slopes. The Merrimac soils are formed in glacial outwash, more specifically, well sorted sands and gravels derived mainly from granite, gneiss, and schist. Merrimac soils have very high air and water movement throughout, but low available water making it very droughty. Merrimac soils are considered well suited to GPR applications.

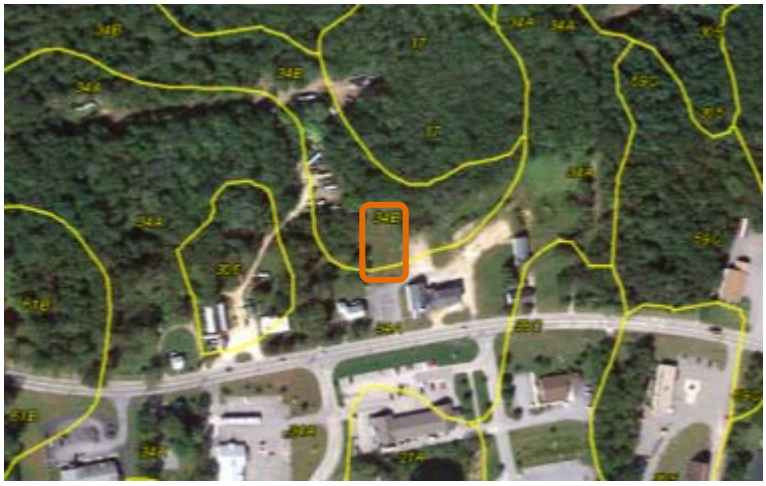

*Figure 9. A soil map from the Soil Survey of the State of Connecticut. The soil mapped is 34B Merrimac sandy loam, 3 to 8 percent slopes. The orange box indicates the area of interest.*

*Figure 10. The GPR survey being completed at the Calvary Chapel Cemetery (photograph courtesy of Maribeth Holer, Earth Team Volunteer).*

**Results:**
Overall, the three-dimensional images revealed no subsurface reflectors or spatial patterns that could be associated with unmarked graves or buried headstones within the first grid and the wildcat survey done in the far left-hand corner of the Calvary Chapel Cemetery. In the second grid, high amplitude reflectors indicate several known gravesites and one cremation, as well as one anomaly.

Figure 11 contains a three-dimensional image of the second grid completed at the Calvary Chapel Cemetery. The image reveals greater amplitude patterns and abrupt differences in dielectric properties (seen in the green cylinders), which may be associated with slight differences in soil moisture and/or soil density. Due to the fact that burial plots are backfilled immediately with excavated materials, it is speculated that soils within a burial shaft would be more mixed than the surrounding soils. This lack of uniformity between the natural soils and disturbed burial shafts is expected to produce differences in soil moisture and/or soil density and a contrast in dielectric properties. The greater and more abrupt the difference in dielectric properties, the greater the amount of energy that is reflected back to an antenna, and the more intense will be the amplitude of the reflected signals on the radar record. The plain green cylinders represent gravesites and a cremation that are already marked with headstones or a marker. The other green cylinder with a white star represents an anomaly with similar high amplitude

reflectors. The anomaly is approximately 3 meters east and 16 meters north from the southwest corner of the grid (0, 0). It is also in line with and about 4 meters north of the known cremation. This anomaly may be deemed worthy of further attention by the sexton and archaeologist. The dominance of planar reflections of different amplitudes in the lower portion of the radar records at approximately 2 meters from the soil surface (indicated by the white arrows) supports glacial outwash and the presence of Agawam soil.

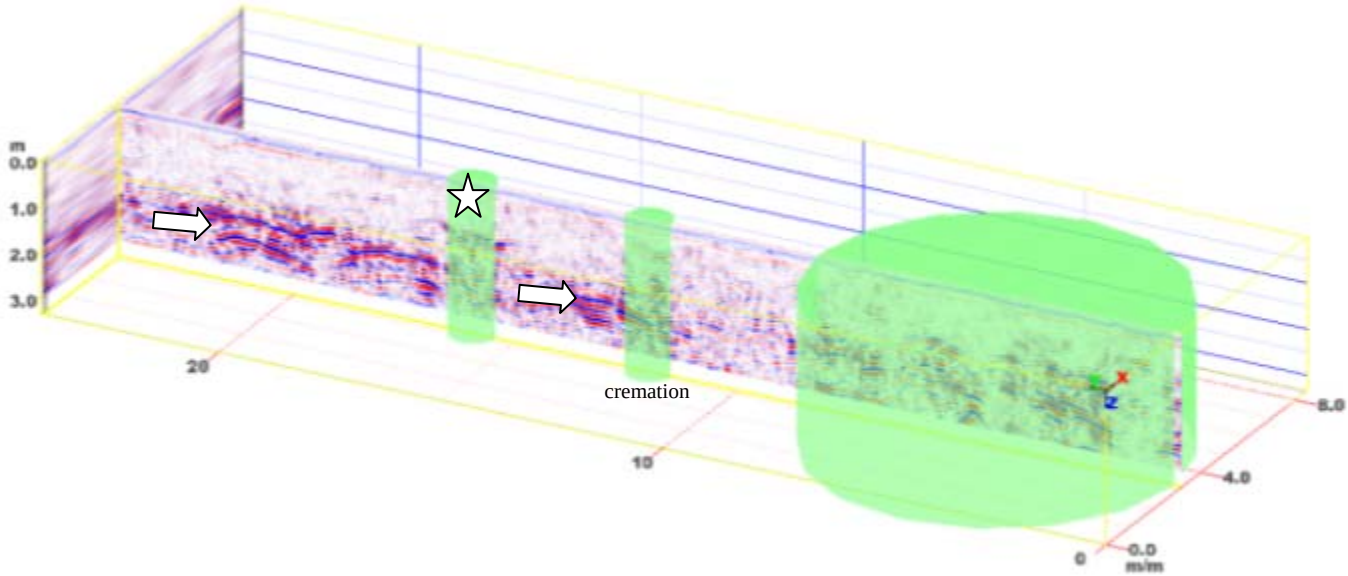


*Figure 11. A three-dimensional image showing grid 2 at the Calvary Chapel Cemetery. All of the green cylinders indicate areas of high amplitude reflectors in the survey area. The plain green cylinders represent known gravesites and one cremation. One green cylinder with a white star represents an anomaly with similar high amplitude reflectors. The anomaly is approximately 3 meters east and 16 meters north of the southwest corner of the grid (0,0). It is also in line with and about 4 meters north of the known cremation. This anomaly may be deemed worthy of further attention by the sexton and archaeologist. The dominance of planar reflections of different amplitudes in the lower portion of the radar records at about 2 meters from the soil surface (indicated by the white arrows) supports glacial outwash and the presence of Agawam soil.*

**David Ruggles**

David Ruggles was born in 1810 to free black parents in Norwich, CT and became an important figure in the abolition movement. Trained as a hydropathical physician, David Ruggles still maintained a lifelong battle against slavery by operating the first black press in the nation and using it to advocate for antislavery. Ruggles was also an Underground Railroad conductor, secretary of the New York Committee of Vigilance, journalist for the *Freedom Reporter* (the country's first black newspaper), and the first African American to be published in the *Mirror of Liberty*. He claimed to have led over 600 people to freedom, including his friend and fellow abolitionist Fredrick Douglass (CT Freedom Trail, 2011). He also helped protect runaway slaves and confronted slave catchers called "blackbirders" (MAAP, 2011). His activism earned him many enemies, as he was physically assaulted and had survived several attempted kidnappings for the purpose of selling him into slavery. Ruggles died in 1849 and was buried in his family plot in an unmarked grave at the Yantic Cemetery in Norwich, CT. Today, the Ruggles Family plot is part of the CT Freedom Trail. The CT Freedom Trail documents and designates sites that represent the struggle towards freedom and celebrate the accomplishments of the African American community. At the Ruggles family plot, we were asked to provide information on if the plot contained any unmarked graves.

*Figure 12. A picture of David Ruggles (MAAP, 2011).*

**Survey Procedures:**
To collect the data required for the construction of 3D GPR pseudo-images, a small survey grid was established across the Ruggles Family plot. The grid measured 6 meters by 8 meters. Two parallel lines were established across the site. Along each of these parallel lines, survey flags were inserted into the ground at a spacing of 50 cm. A reference line was extended between matching survey flags on opposing sides of the grid using a distance-graduated rope. GPR traverses were conducted along the distance-graduated rope. Following data collection, the reference line was sequentially moved to the next pair of survey flags to repeat the process. For each grid, the 400 MHz antenna was towed along the graduated rope, and as it passed each 1 meter graduation, a mark was impressed on the radar record. The parallel radar traverses were conducted across the grid area in essentially an east to west direction. Since this cemetery is orientated in a north-south direction, traversing took place in an east-west direction with the radar in this cemetery. This direction is important in establishing patterns of unmarked graves.

The survey area is a flat grassed area containing three headstones. The area is mapped as Merrimac sandy loam, 0 to 3 percent slopes. The Merrimac soils are formed in glacial outwash, more specifically, well sorted sands and gravels derived mainly from granite, gneiss, and schist. Merrimac soils have very high air and water movement throughout, but low available water making it very droughty. Merrimac soils are considered well suited to GPR applications.

*Figure 13. GPR work being discussed at the Ruggles Family plot in the Yantic Cemetery in Norwich, CT (photograph courtesy of Maribeth Holer, Earth Team Volunteer).*

*Figure 14. A group of people working to have the Ruggles Family plot designated as a location along the Freedom Trail and the Yantic Cemetery on the National Registry of Historic Places (photograph courtesy of Maribeth Holer, Earth Team Volunteer).*

**Results:**

Overall, the three-dimensional image reveals subsurface reflectors or spatial patterns that are associated with marked graves and may be associated with unmarked graves. Figure 15 contains a three-dimensional image of the grid completed at the Yantic Cemetery in the Ruggles Family plot. The image reveals greater amplitude patterns and abrupt differences in dielectric properties (indicated by the green cylinders), which may be associated with slight differences in soil moisture and/or soil density. Due to the fact that burial plots are backfilled immediately with excavated materials, it is speculated that soils within a burial shaft would be more mixed than the surrounding soils. This lack of uniformity between the natural soils and disturbed burial shafts is expected to produce differences in soil moisture and/or soil density and a contrast in dielectric properties. The greater and more abrupt the difference in dielectric properties, the greater the amount of energy that is reflected back to an antenna, and the more intense the amplitude of the reflected signals will be on the radar record. The areas marked with green cylinders in Figure 15 show areas of higher amplitude features and indicate the three known gravesites. The areas marked with green cylinders and white stars in Figure 15 show areas of high amplitude features and represent the three anomalies within the survey area. The three anomalies lie behind Sarah and Nancy and are in line with Felix. This coincides with how a cemetery is laid out, in straight rows with paths in between each row. The layout of this cemetery plot has the burials laid in a north-south direction with paths running east/west that provide access to the individual plots. Knowing the pattern of this plot and interpreting the anomalies in the radar record as a cemetery plot suggest that there may be additional burials in this survey area. These three anomalies may be deemed worthy of further attention by archaeologists.

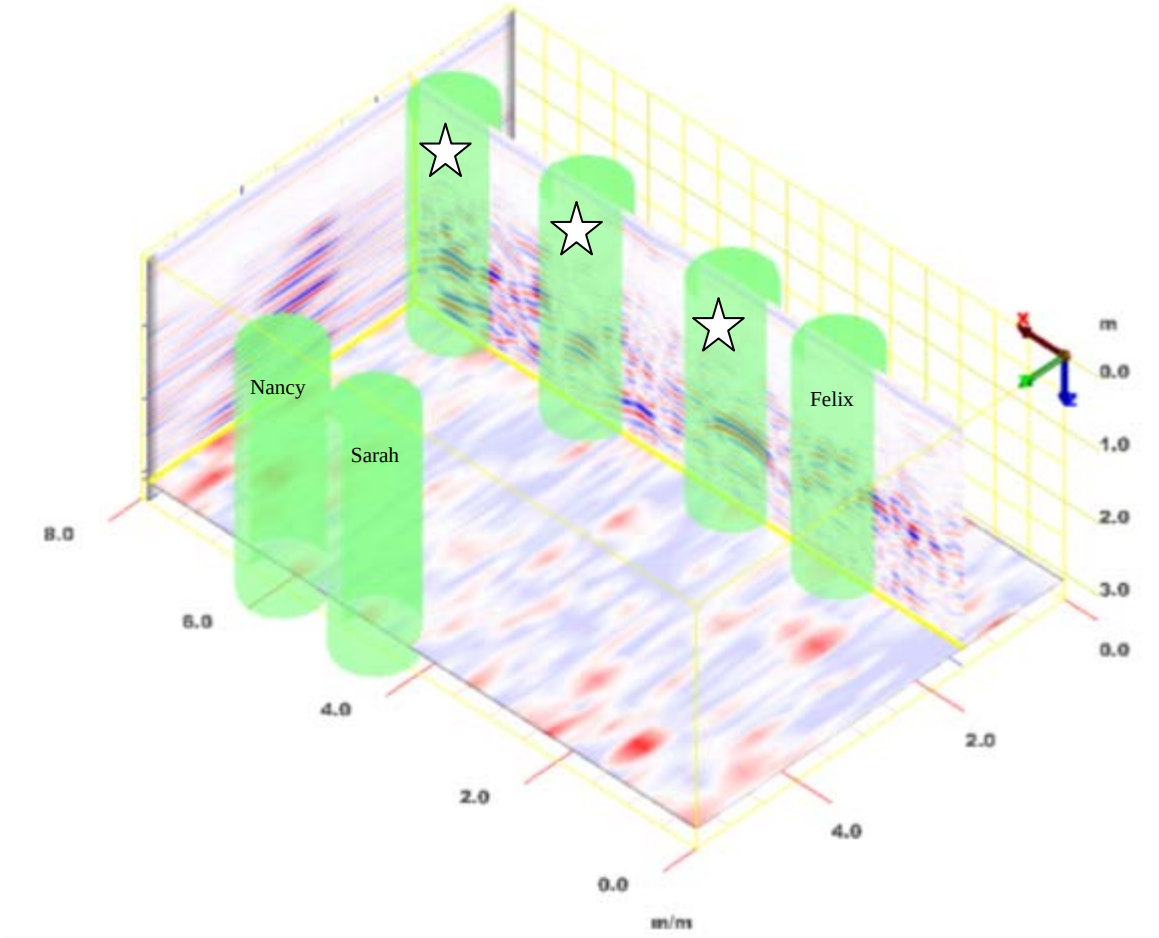


*Figure 15. A three-dimensional image showing the GPR grid of the Ruggles Family plot. The green cylinders indicate marked graves of Sarah, Nancy, and Felix Ruggles. The green cylinders with white stars indicate anomalies similar to the known gravesites in the survey area. The three anomalies lie behind Sarah and Nancy and are in line with Felix. This coincides with how a cemetery is laid out, in straight rows with paths in between each row. These three anomalies may be deemed worthy of further attention by archaeologists.*

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