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

SUBJECT: Archaeology – Geophysical Field Assistance January 6, 2015

TO: Dr. Brian Jones
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Purpose:
At the request of the Connecticut State Archaeologist, a ground-penetrating radar (GPR) survey was conducted at a historical cemetery located in Southington, Connecticut.

Principal Participants:
Scott Brady, Friends of the Office of State Archaeology (FOSA) member
Brian Jones, Connecticut State Archaeologist, Connecticut Archaeology Center, Univ. of Connecticut, Storrs, CT
Debbie Surabian, State Soil Scientist CT/RI, USDA-NRCS, Tolland, CT

Activities:
All activities were completed Wednesday October 29, 2014. This report has been updated since November 4, 2014 to include more images.

Summary:

1. At the Merriman Cemetery in Southington, CT, GPR provided added insight into subsurface conditions, which may be attributed to marked and unmarked graves. Although the radar worked well at this site, providing adequate penetration depths and resolution of subsurface features, interpretations were plagued by undesired clutter. The level of clutter and the absence of clearly defined and specific targets fostered uncertainty and weaken confidence in interpretations.

2. At the site, the use of geophysical techniques provided archaeologists with added insight into subsurface conditions and the presence of possible unmarked graves. All results, however, are interpretative and must be confirmed with ground-truth excavations.

Regards,

Deborah Surabian
State Soil Scientist

cc:
Lisa Coverdale, State Conservationist, USDA-NRCS, Tolland, CT
James Doolittle, Research Soil Scientist, USDA-NRCS-NSSC, Newtown Square, PA
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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. A 400 MHz antenna was used in the study described in this report. A scanning rate of 64 scans/sec and a scanning time of 50 ns were used. 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., was used to process the radar records. [1] Processing was restricted to setting the initial pulse to time zero, color table and transformation selection, and marker editing.

Ground-Penetrating Radar and Archaeological Investigations:
GPR is a non-invasive geophysical method that provides an expedient and effective tool to support archaeological investigations. GPR can detect disturbances and the intrusion of foreign objects in soils. GPR results however, vary with soil properties. Soils with low clay, moisture, and soluble salt contents are considered well suited to GPR investigations.

GPR has been successful in locating burials and identifying unmarked gravesites in many types of soils. On radar records, the depth, shape, size, and location of subsurface features may be used as clues to infer burials. Burials are however difficult to distinguish in soils having numerous rock fragments, tree roots, animal burrows, modern cultural features, or segmented horizons and layers. These scattering bodies produce undesired subsurface reflections that complicate radar records and can make burials indistinguishable from the background clutter.

At first most burials generally contrast with the surrounding soil matrix, but over time buried objects decay and become less contrasting with the soils. During the decaying process, body fluids, salts, and gases of decomposition are electrically conductive and absorb the radiated radar energy resulting in a “whiteout” area or zone of no signal return beneath the buried body. With the passage of time, it is more likely that GPR will detect the soil disturbance within the grave shaft or the partially or totally intact coffin rather than the bones themselves. In soils that lack contrasting soil horizons, the detection of soil disturbances or grave shafts is a bit more difficult. Interpreting radar records and attempting to identify burials is also difficult in soils with a high prevalence of stones.

Even under favorable site conditions the detection of disturbances, objects, or burials is never assured with GPR. The detection of such features is affected by (1) the electromagnetic gradient existing between the feature and the soil, (2) the size, depth, and shape of the buried feature, and (3) the presence of scattering bodies within the soil (Vickers et al., 1976).

Survey Procedures:
At the Merriman Cemetery, a grid was constructed using two equal length and parallel lines, which formed the opposing sides of a rectangular area. These two parallel lines defined a grid area. Survey flags were inserted in the ground at intervals of 50-cm along each of these two lines. For positional accuracy, GPR traverses were completed along a reference line, which was stretched and sequentially moved between corresponding flags on the two parallel grid lines. Pulling the 400 MHz antenna along the reference line completed a GPR traverse. Walking, in a back and forth manner, along the reference line, which was moved sequentially between similarly numbered flags on the two parallel survey lines, completed the GPR survey.

Study Area:
Merriman Cemetery is the second oldest cemetery in Southington. Inscriptions on gravestones indicate that most burial occurred between 1764 and 1863. Records from a 1934 survey indicated that there were 37 marked gravesites in the Merriman Cemetery. Presently there are only 34 gravestones and officials believe that there may be an additional 10 unmarked gravesites.

The Merriman Cemetery is mostly open with large trees around the boundary. The area is mapped as Windsor loamy sand, 0 to 3 percent slopes (36A) as shown in Figure 1. Windsor soils are formed in glacial outwash, more specifically, well sorted sands and gravels derived mainly from granite, gneiss, and schist. Windsor soils are considered well suited to GPR applications.

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

Figure 1. A soil map from the Soil Survey of the State of Connecticut via Gmaps. The red circle indicates the approximate location of Merriman Cemetery. The soil mapped across this area is 36A Windsor loamy sand, 0 to 3 percent slopes.

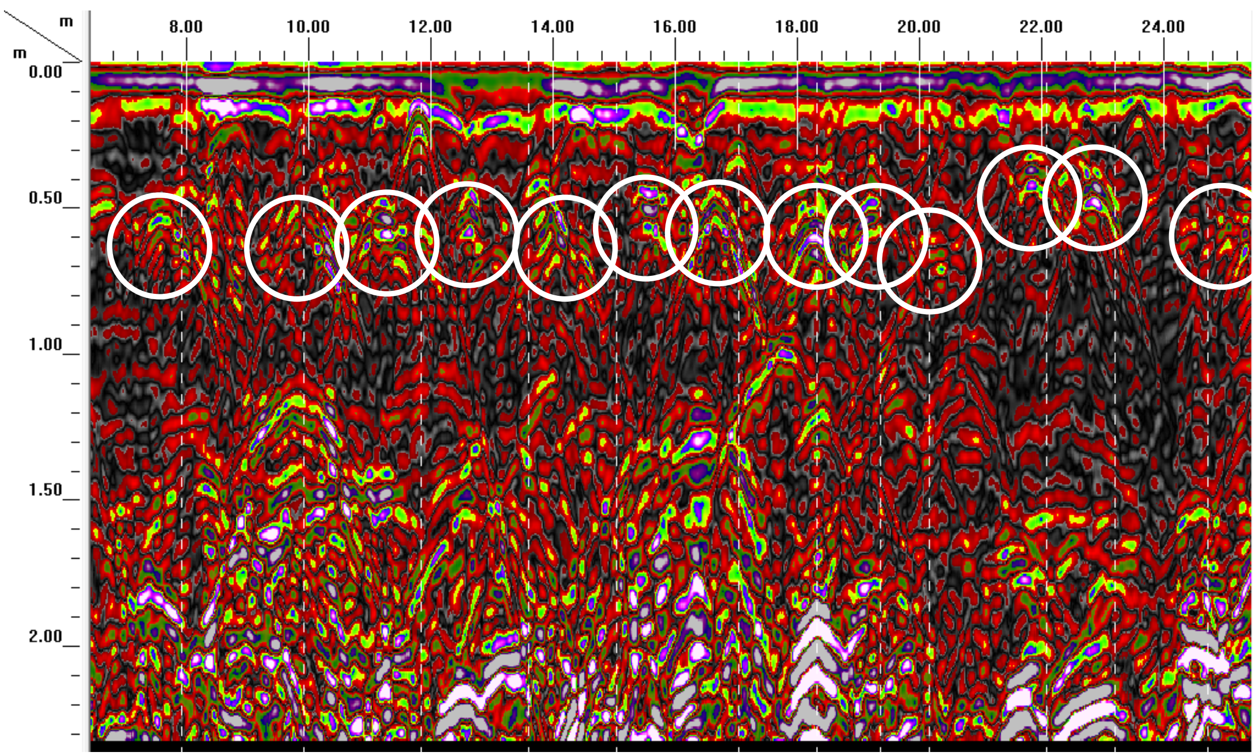

Figure 2. A two-dimensional radar record showing an area with a high concentration of high amplitude reflections (circled in white) that occur at relatively shallow and consistent depths. The white circles indicate thirteen, high amplitude reflection hyperbolas believed to represent burials. The vertical, white-colored, dashed lines indicate the location of the twelve headstones. Dips, cuts, and breaks near the soil surface may indicate soil disturbance of natural soil materials that occurred during the burials.

Results:

In Figure 2, the two-dimensional radar record shows thirteen areas of high amplitude reflections circled in white, which are believed to represent burials. On this radar record, all scales are expressed in meters. The twelve vertical, white-colored, dashed lines on the radar record correspond to the locations of grave markers and supposedly known burials. These vertical lines were impressed on the radar record as the 400 MHz antenna passed in front of the center of headstones. The multiple reflection hyperbolas, which occur at relatively shallow, but varying depths, are associated with these headstones. The dips, breaks, and cuts of the soil materials near the soil surface (0 to 20 cm depths) may indicate soil disturbance and settlement associated with the burials.

Figure 3, shows a three dimensional pseudo-image of Merriman Cemetery. On this pseudo-image, all scales are expressed in meters. The dimensions of the cube are 13 by 26 meters. The cube has been depth-sliced at a depth of approximately 2 meters below the soil surface. High amplitude reflectors are seen scattered about in the cemetery suggesting these areas contain contrasting soil materials. When linked together and highlighted with dashed lines the anomalous features seem to line up with the layout of the cemetery and the placement of the burials in an east to west direction (shown left to right in this plot).

Although multiple, relatively shallow. High-amplitude hyperbolic reflections are evident along the radar traverse shown in Figure 2, these features were not as clearly seen on other radar records collected within the cemetery. While other reflection hyperbolas were evident, these reflectors were less clear, closer to the surface, or masked by other subsurface reflections. As a consequence, many of these shallower reflectors could not be clearly identified as burials, and many escaped recognition.

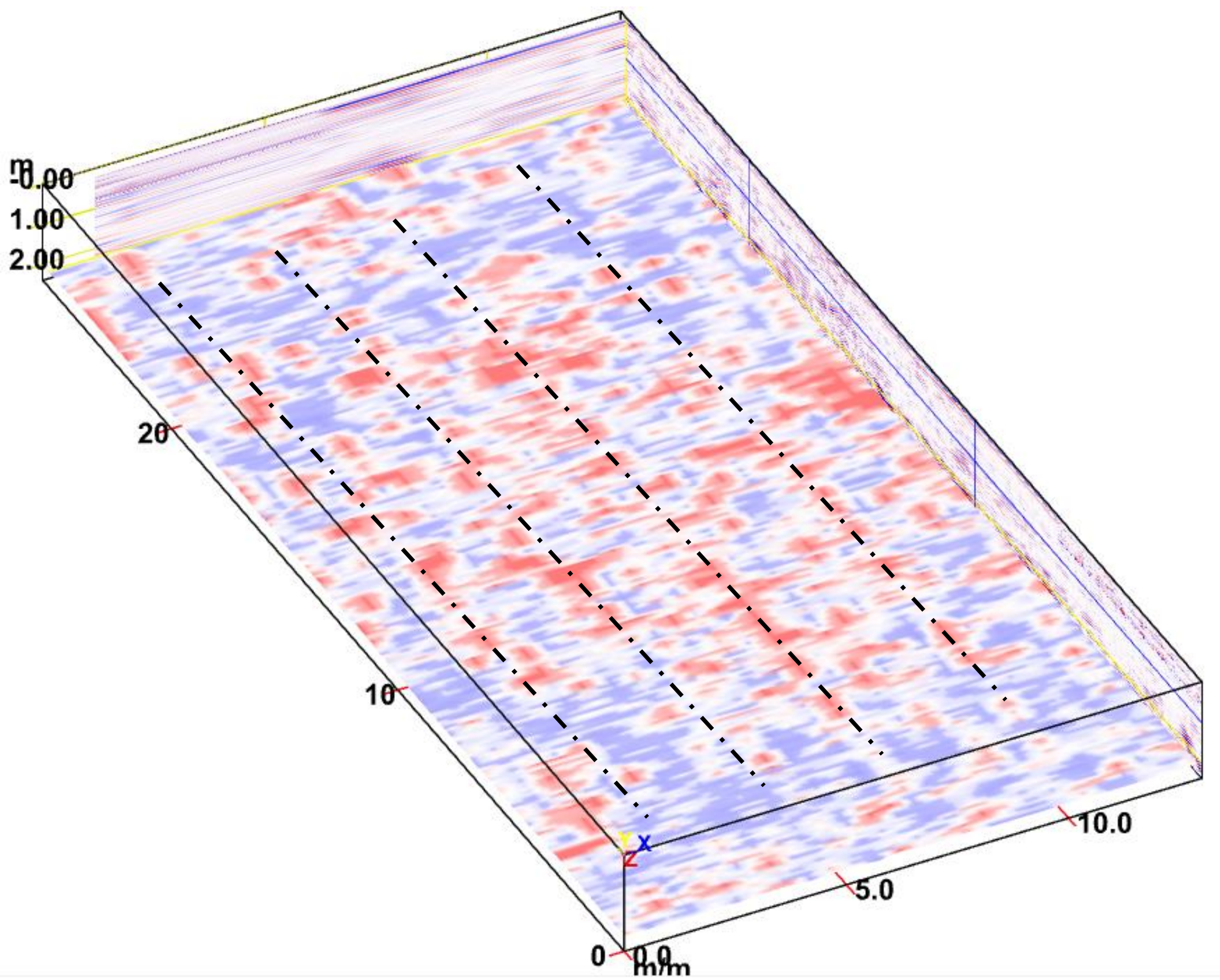

Figure 3. A three dimensional pseudo-image of Merriman Cemetery. The cube is 13 by 26 meters and at a depth of approximately 2 meters below the soil surface. High amplitude reflectors are seen scattered about in the cemetery suggesting these areas contain different soil or fill materials. When linked together and highlighted with dashed lines the anomalous features seem to line up with the layout of the cemetery and the placement of the burials in an east to west direction.

GPR Results at 133cm

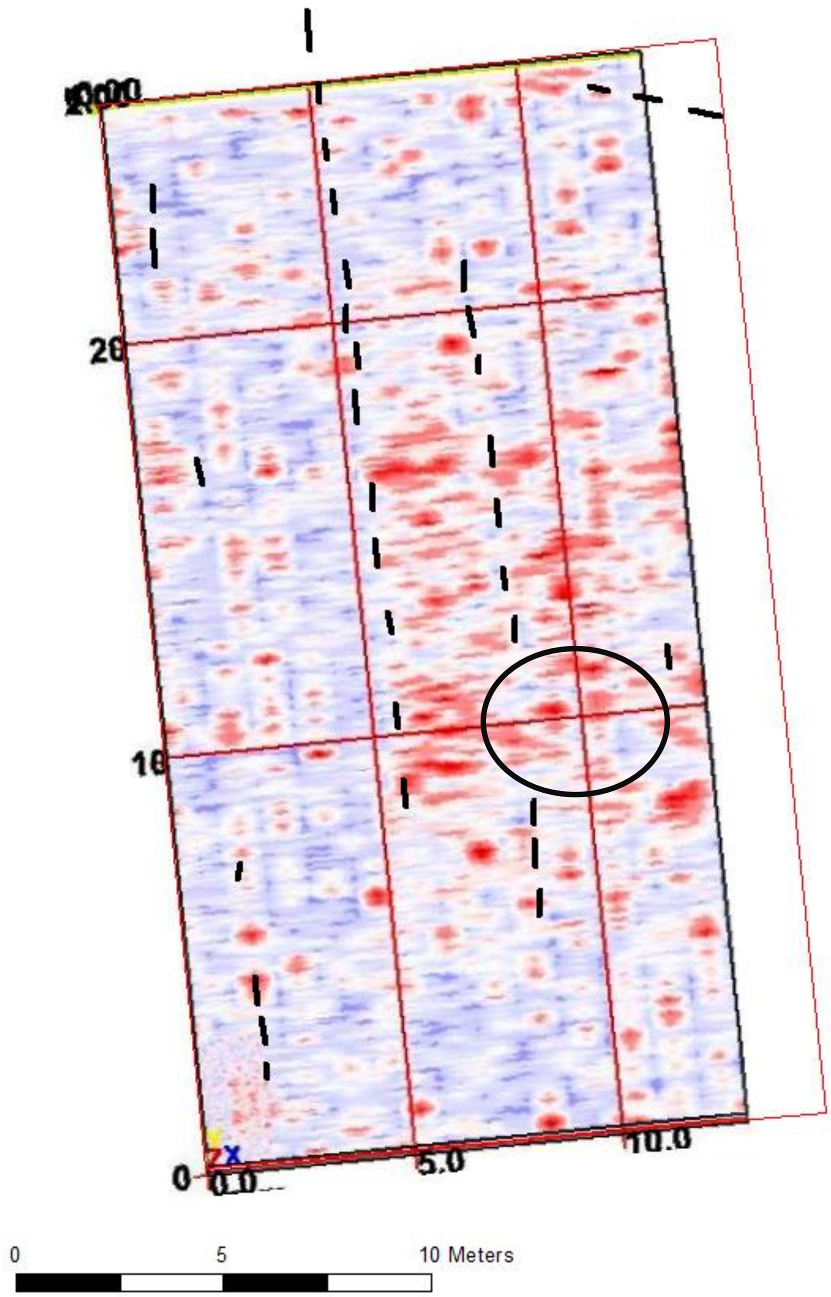

Figure 4. A two-dimensional radar record at a depth of 133 centimeters from the soil surface showing an area with a high concentration of high amplitude reflections (circled in black) that occur at relatively consistent depths alongside the marked graves. Headstones are marked with a black line (image courtesy of Dr. Brian Jones).

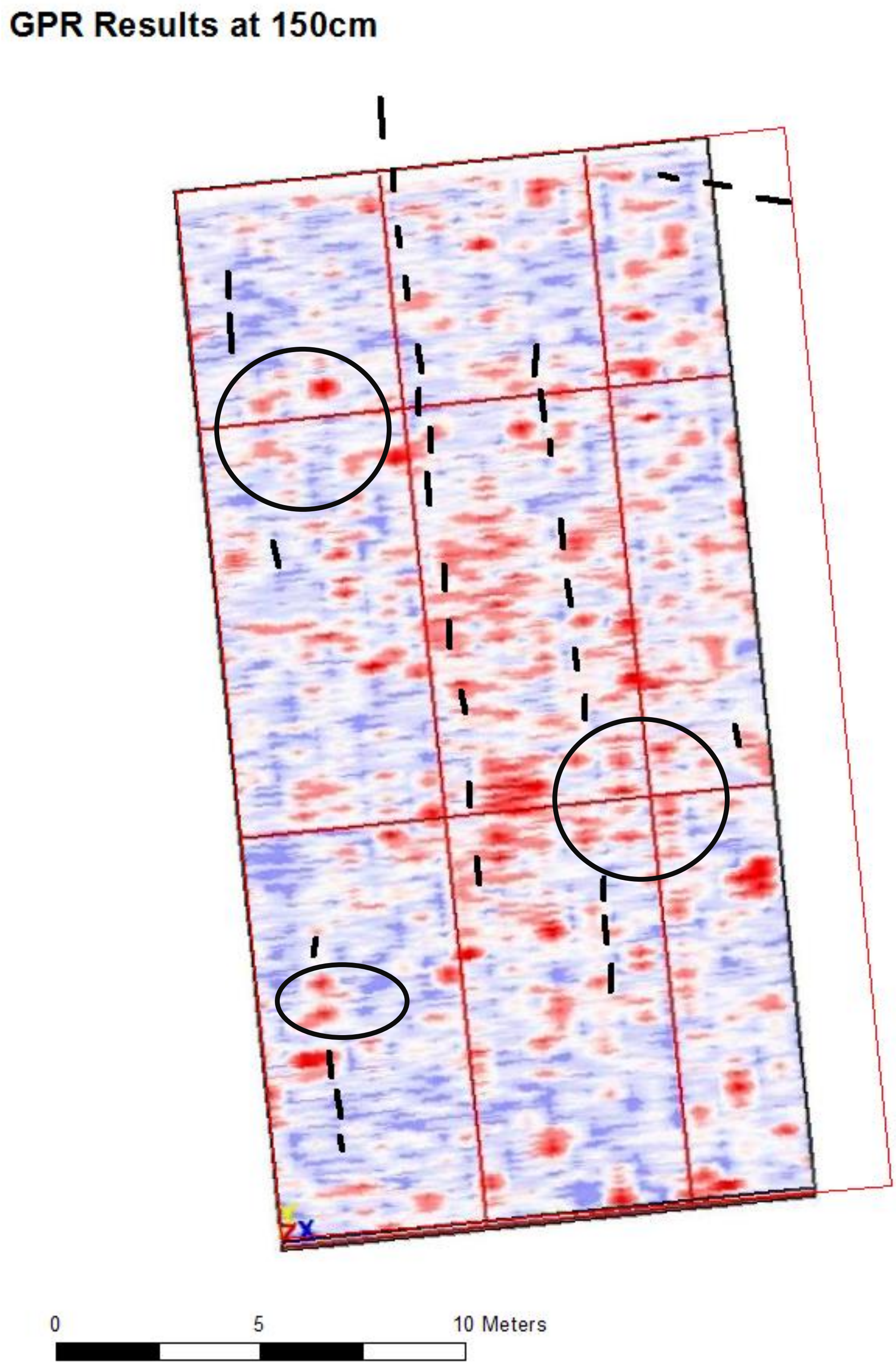

Figure 5. A two-dimensional radar record at a depth of 150 centimeters from the soil surface showing areas with a high concentration of high amplitude reflections (circled in black) that occur at relatively consistent depths alongside the marked graves. Headstones are marked with a black line (image courtesy of Dr. Brian Jones).

GPR Results at 200cm

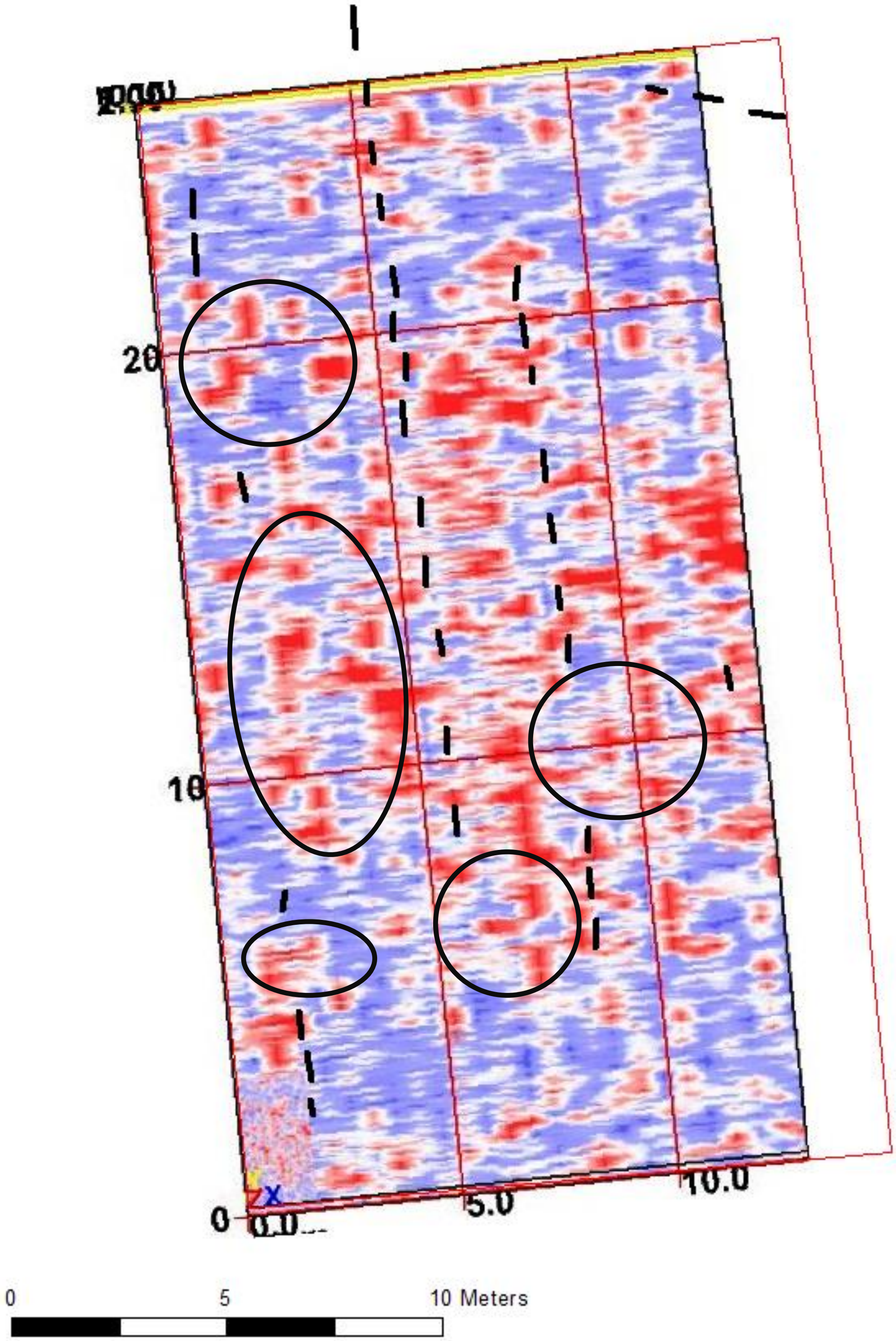

Figure 5. A two-dimensional radar record at a depth of 200 centimeters from the soil surface showing areas with a high concentration of high amplitude reflections (circled in black) that occur at relatively consistent depths alongside the marked graves. Headstones are marked with a black line (image courtesy of Dr. Brian Jones).

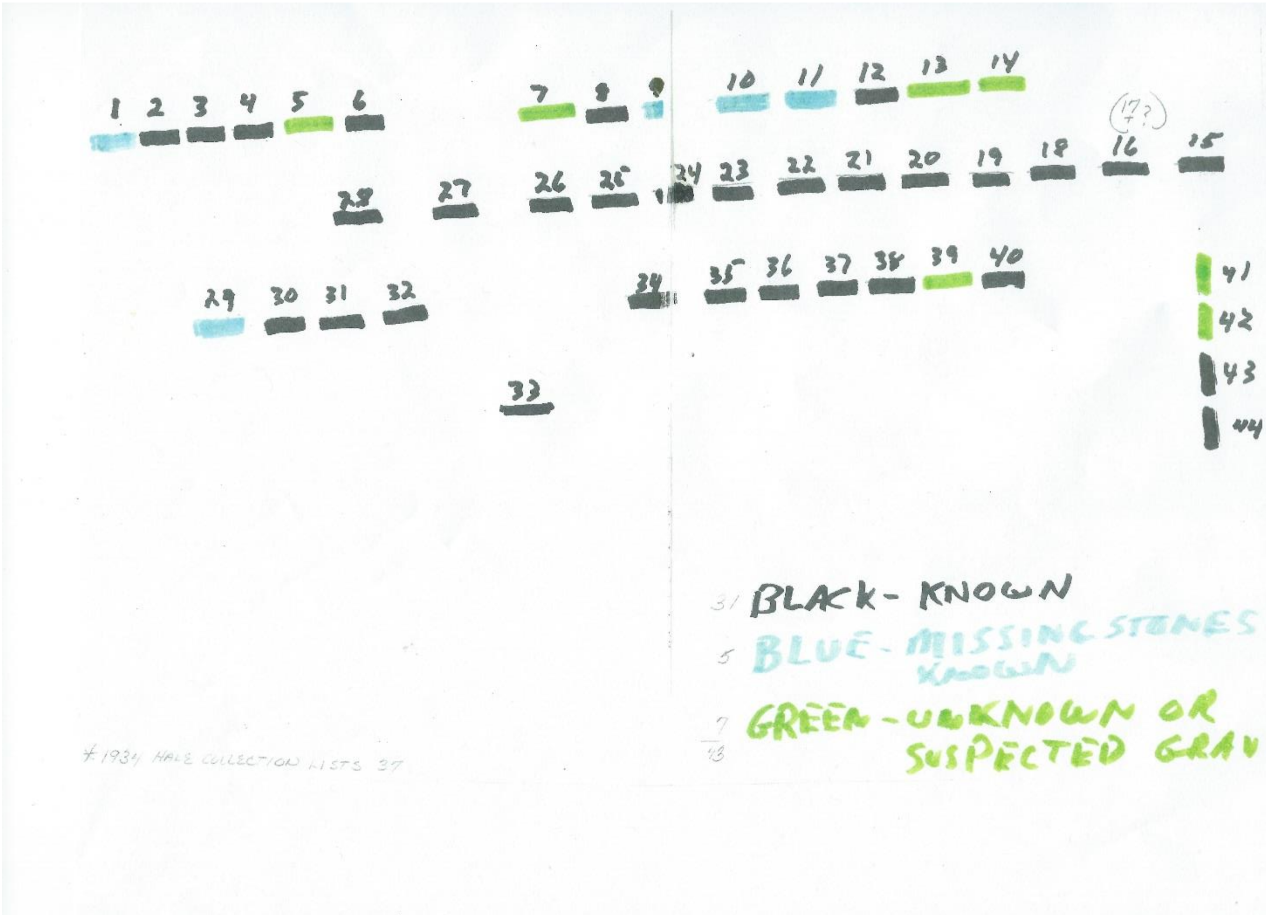

Figure 7. A drawing from the caretakers of the cemetery of where known, missing, and suspected burials are in the cemetery. While no recorded reflection pattern could be conclusively identified as a burial, several locations having anomalous reflection patterns were identified in the previous figures and may be deemed worthy of further attention by archaeologists.

References:

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