United States Department of Agriculture | **Natural Resources Conservation Service** | **5 Radnor Corporate Center, Suite 200 Radnor, PA 19087-4585**

Subject: Geophysical Assistance -- **Archaeological** **Date:** 2 November 1998

To: Margo L. Wallace
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PURPOSE:
To assist Connecticut NRCS Staff, the Connecticut State Archaeologist, and students enrolled in the Hartford Renaissance Magnet program at the Lewis Fox Middle School assess the number and locations of African-American graves within the "Ancient Burying Grounds", Hartford, Connecticut.

PARTICIPANTS:
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Howard Denslow, Resource Conservationist, USDA-NRCS, Storrs, CT
Jim Doolittle, Research Soil Scientist, USDA-NRCS, Radnor, PA
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Pamela Silvestri, Archaeologist, Vernon, CT

ACTIVITIES:
All field activities were completed on 26 October 1998.

EQUIPMENT:
The ground-penetrating radar (GPR) unit used in this study was the Subsurface Interface Radar (SIR) System-2, manufactured by Geophysical Survey Systems, Inc.[1] The SIR System-2 consists of a digital control unit (DC-2) with keypad, VGA video screen, and connector panel. A 12-volt battery powered the system. Morey (1974), Doolittle (1987), and Daniels and others (1988) have discussed the use and operation of GPR. The antenna used was the model 5103 (400 mHz).

To help summarize the results of this study, the SURFER for Windows software program developed by Golden Software Inc. was used to construct two-dimensional simulations.[2] Grids were created using kriging methods.

BACKGROUND:
A group of Hartford middle-students initiated a research project to better understand the histories of slaves and freed African-Americans interred within the "Ancient Burying Grounds," Hartford, Connecticut. These students have found evidence that over 300 African-Americans were buried within the "Ancient Burying Grounds" in unmarked graves. At the request of the student's teacher, Ms. Billie Anthony, and the Connecticut State Archaeologist, Nicholas Bellantoni, NRCS provided ground-penetrating radar field assistance.

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[1] Trade names have been used in this report to provide specific information. Their use does not constitute endorsement.
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STUDY SITE:

The “Ancient Burying Grounds” is located in downtown Hartford, Connecticut. The area surveyed with GPR was located near the northwest corner of the cemetery.

FIELD PROCEDURES:

An irregularly shaped, 10 by 28-meter survey grid was laid out across the study site (see Figure 1). The grid was located near the extreme northwest corner of the cemetery. Survey lines were established at a distance of three meters from the western boundary to the cemetery. The grid intervals were 1 meter (east – west lines) and 2 meters (north – south lines). Survey flags were inserted in the ground at each grid intersection and served as reference points. Pulling the 400 mHz antenna along each of the eleven north-south trending grid lines completed radar traverses.

GROUND-PENETRATING RADAR:

Background:

In the search for buried cultural features with GPR, success is never guaranteed. Even under ideal site and soil conditions, some buried cultural features will be missed with GPR. The usefulness of GPR depends on the amount of uncertainty or omission that is acceptable to archaeologists.

Archaeologists use ground-penetrating radar to facilitate excavation strategies, decrease field time and costs, and locate buried artifacts and archaeological features. Ground-penetrating radar have been used to locate buried cultural features in many areas of the world (Batey, 1987; Berg and Bruch, 1982; Bevan, 1977, 1984a and 1984b; Bevan and Kenyon, 1975; Bevan et al., 1984; Bruzewicz et al., 1986; Cole, 1988; Dolphin and Yetter, 1985; Doolittle, 1988; Doolittle and Miller, 1991, Gibson, 1989; Grossman, 1979; Imai et al., 1987; Kenyon, 1977; Parrington, 1979; Sakayama et al., 1988; Vaughan, 1986; Vickers and Dolphin, 1975; Vickers et al., 1976; and Weymouth and Bevan, 1983). More recently, forensic scientists have used GPR for crime scene investigations (Davenport et al., 1990; Hoving, 1986; Mellett, 1992; and Strongman, 1992).

The detection of buried cultural features is affected by the electromagnetic gradient existing between the buried cultural feature and the soil; the size, shape, and orientation of the buried cultural feature; and the presence of scattering bodies within the soil (Vickers et al., 1976). The amount of energy reflected back to an antenna by an interface is a function of the dielectric gradient existing between the buried cultural feature and the soil. The greater and more abrupt the difference in electromagnetic properties, the greater the amount of energy reflected back to the antenna, and the more intense will be the amplitude of the recorded image. Buried cultural features with electromagnetic properties similar to the surrounding soil matrix are poor reflectors of electromagnetic energy and are difficult to detect on radar profiles (Doolittle, 1988; Gibson, 1989; Vaughan, 1986).

The majority of recently buried cultural features contrast with the surrounding soil matrix. However, with the passage of time, buried cultural features decay or weather and become less electrically contrasting with the surrounding soil matrix. For burials, the degree of preservation is dependent on both intrinsic and extrinsic factors. Intrinsic factors include the shape, size, density and chemistry of the cultural feature. Intrinsic factors are dependent upon the length of burial as well as the genetic age and health of the deceased (Killam, 1990). Extrinsic factors influencing the degree of preservation include time, soil type, moisture content, temperature, flora and fauna (Killam, 1990). Corpses deteriorate more rapidly in highly acidic soils than in neutral or alkaline soils (Mellett, 1992). Rodriquez and Bass (1985) noted direct correlations between rates of decomposition and soil type, soil temperature, and depth of burial.

The size, orientation, and depth to a buried cultural feature affect detection. Large, electrically contrasting features reflect more energy and are easier to detect than small, less contrasting features. Small, shallowly buried features will be missed, unless located directly beneath the aperture of the radar’s antenna. With GPR surveys covering extensive areas and using large grid intervals, the detection of small cultural features is considered fortuitous. The detection of a corpse reported by Mellett (1992) is an example of a fortuitous detection. Small, deeply buried cultural features are difficult to discern on radar profiles. In many soils, signal attenuation limits observation depths. In addition, the reflective power of a buried feature decreases proportional to the fourth power of the distance to the object (Bevan and Kenyon, 1975).

Bevan (1991) noted that GPR is more likely to detect the disturbed soil within a grave shaft, a partially or totally intact coffin, or the chemically altered soil materials surrounding a burial rather than the bones themselves.

Killam (1990) believes that most bones are too small and not directly detectable with GPR. This author noted that the disruption of soil horizons makes most graves and some cultural features detectable. However, in soils that lack contrasting horizons or geologic strata, the detection of a grave shaft is improbable. In addition, with the passage of time, natural soil-forming processes erase signs of disturbances.

In highly attenuating soils, profiling depths are restricted and many subsurface features are not directly sensed with GPR. Under highly attenuating conditions, the location and identification of buried cultural features are frequently inferred from bowed, disrupted, or disturbed soil horizons. At many sites, the most distinctive feature of a grave is the disturbed soil materials that fill and cover the grave shaft (Bevan, 1991). However, caution must be exercised in interpreting these features as a number of artificial and natural processes can produce disturbed soil conditions.

Cultural features are difficult to distinguish in soils having numerous rock fragments, roots, animal burrows, modern cultural features, debris or fill layers. These scattering bodies produce undesired subsurface reflections that complicate radar imagery and can mask reflections from buried cultural features. Frequently, “desired” cultural features are indistinguishable from background clutter. In soils having numerous scattering bodies, GPR surveys often provide little meaningful information to supplement traditional sampling methods (Bruzewicz et al., 1986). The identification of buried cultural features was complicated by scattering bodies in surveys conducted by Bevan (1991), Dolphin and Yetter (1985), Doolittle (1988), and Vaughan (1986).

Results:

Radar profiles collected within the cemetery were interpretable and contained an abundance of subsurface information. Depth of observation, while unconfirmed, was considered adequate for the detection of burials (a scanning time of 40 nanoseconds was used). A cursory review of the radar profiles revealed numerous point and planar reflectors. The radar records contain an abundance of additional, less expressed point reflectors. These may also represent burials. However, because of their poor expression, interpretations were considered imprudent without some ground-truth verification of the faint imagery. Other reflectors were more strongly expressed on radar profiles. Forty-seven of these reflectors were considered to be *very conspicuous*. Some of these prominent point reflectors are believed to represent burials. Some may represent rock fragments, roots, or other buried cultural features.

The approximate locations of point reflectors are plotted in Figure 1. The alignment of two or more point reflectors frequently provides strong evidence of a burial. In Figure 1, several point reflectors located in adjacent rows are aligned. These aligned reflectors provide stronger indications of possible burials. A prominent, subsurface planar reflector was evident on 6 radar traverses. Though irregularly shaped, the area occupied by this reflector was adjoining on consecutive radar profiles. The strong reflection from this reflector suggests a buried cultural layer or feature.

CONCLUSIONS:

1. Interpretations contained in this report are considered preliminary estimates of site conditions. These interpretations do not substitute for direct observations, but rather reduce their number, direct their placement, and supplement their interpretations. Interpretations should be verified by ground-truth observations.

2. A large number of buried point reflectors were identified within the grid. Some of these reflectors are believed to represent burials. A review of the radar profiles showed that several point reflectors are aligned and suggest eleven likely burials. Location maps have been prepared for the two surveyed areas. These maps may help archaeologists develop search strategies.

3. A high probability exists that unmarked graves are present in the area surveyed with GPR. As the radar detects but does not identify subsurface features, it is uncertain whether these features represent the graves of African-Americans.

4. Copies of the radar profiles from the Ancient Burial Grounds have been turned over to Nicholas Bellantoni for use and further interpretations.

It was my pleasure to be of some assistance to you, your staff, and the students of the Lewis Fox Middle School.

With kind regards,

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Research Soil Scientist

cc:
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