USDA

United States Department of Agriculture

SUBJECT: MGT - Cultural Resources – Geophysical June 30, 2014

TO: Lisa R. Coverdale
State Conservationist,
NRCS, Tolland, Connecticut

File Code: 330 -20 -7

Purpose:
The purpose of this visit was to transfer an EM38 meter and Allegro field computer to Debbie Surabian and to provide refresher training on its setup. In addition, ground-penetrating radar was used on two cultural resources sites that are being investigated by the Connecticut State Archaeologist, Connecticut Archaeology Center, University of Connecticut, and the Friends of the Office of State Archaeology. These cooperative studies help demonstrate NRCS's commitment in Connecticut to the protection and preservation of our nation's cultural resources and historic properties.

Participants:
Nicholas Bellantoni, State Archaeologist, Connecticut Archaeology Center, University of Connecticut, Storrs, CT
Jim Doolittle, Research Soil Scientist, NSSC, NRCS, Newtown Square, PA
Debbie Surabian, State Soil Scientist, NRCS, Tolland, CT
April Clayton, Earth Team Volunteer, NRCS, Tolland, CT

Activities:
All activities were completed during the period of May 12-23, 2014.

Summary:

1. An EM38 meter (S/N 064623; AG0002943084) and Allegro CX field computer (S/N 36642) were transferred from Jim Turenne (Assistant State Soil Scientist, West Wareham, Rhode Island) to Debbie Surabian. This equipment is on loan from the National Soil Survey Center.

2. Electromagnetic induction (EMI) has been used to map differences in soil types, estimate differences in soil water content, depict groundwater flow patterns; assess variations in soil texture, compaction, organic matter content, and pH; and determining the depth to subsurface horizons, stratigraphic layers and bedrock. In Connecticut, it is anticipated that the EM38 meter will be useful in archaeological investigations and the mapping and characterization of anthropogenic soils, saline and coastal wetlands, and soil properties that affect soil health.

3. At two sites in Windham County, EMI was used to characterize variations in soil physical properties across different parcels of land where soil health is being studied. At these sites, producers are interested in soil health, sustenance of profitable yields, and environmental quality. Repeated use of EMI is planned to help monitor the state of soil health in both space and time.

4. At the Henry Woodward House in Columbia, Connecticut, no unusual, subsurface reflection patterns, which would suggest the existence of former structures, were identified with GPR in the open areas surrounding the house.

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5. In an expansive open area at the site of the former Windham Town Farm in Willimantic, the possible existence of hidden, subsurface structural features and unmarked graves was explored with GPR. Though several subsurface reflection patterns were identified on radar records, no subsurface reflection pattern provided the necessary geometry that could be attributed to either former structural features or unmarked graves.

It was the pleasure of Jim Doolittle and the National Soil Survey Center to work in Connecticut and be of assistance to you, your staff, and your cooperators.

JONATHAN W. HEMPEL
Director
National Soil Survey Center

Attachment (Technical Report)

cc:
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Technical Report

Jim Doolittle

Background:
At the request of the Connecticut State Archaeologists, ground-penetrating radar (GPR) surveys were conducted at the Walter Woodward house in Columbia, and the historical grounds of the former Windham Town Farm in Willimantic (Figure 1). At both sites, random GPR traverses were carried-out in an attempt to locate buried cultural features.

Figure 1. Historic sketch of the Windham Town Farm courtesy of Dr Nicholas F. Bellantoni.

The Woodward house was built between 1767 and 1791 by Henry Woodward. The grounds around this house were surveyed with GPR in an attempt to locate remnants of any past structures. The present owner, Walter Woodward, is a descendant, an Associate Professor of History at the University of Connecticut and the Connecticut State Historian.

The site (41.7167 ° N, 72.2320° W) of the former Windham Town Farm (the poor farm) is presently occupied by a Friendly's Restaurant near the intersection of Columbia Avenue and Main Street in Willimantic, Connecticut. This site is directly north of the Old Willimantic Cemetery. The open field to the immediate west of this site was surveyed with GPR in an attempt to locate possible buried structural remnants and perhaps pauper graves related to the former Town Farm.

In addition, electromagnetic induction (EMI) surveys were carried-out at Woodstock Orchards (41.9300 N, 71.9875 W) and Elm Farm LLC (41.9820 N, 71.9705 W) in Windham County. At these sites, EMI was used to characterize variations in soil texture, compaction, and moisture contents across different parcels of land where soil health studies are being conducted. At these sites, producers are deeply interested in soil health, sustenance of profitable yields, and environmental quality. Repeated use of EMI is planned to help monitor the state of soil health in both space and time.

Equipment:
The radar unit used in the archaeological studies is the TerraSIRch Subsurface Interface Radar (SIR) System-3000, manufactured by Geophysical Survey Systems, Inc. (GSSI; Salem, NH). The SIR-3000 system consists of a digital control unit (DC-3000) with keypad, SVGA video screen, and connector panel. A 10.8-volt lithium-ion rechargeable battery powers the system. The SIR-3000 weighs about 9 lbs. and is backpack portable. With an antenna, the SIR-3000 system requires two people to operate. Jol (2009) and Daniels (2004) discuss the use and operation of GPR. A relatively high frequency, 400 MHz antenna was used in these investigations. This antenna provided satisfactory exploration depth and high resolution of subsurface features in the measured soils. The RADAN for Windows (version 7.0) software program (developed by GSSI) was used to process the radar records and to improve pattern recognition.

The EM38 meter is manufactured by Geonics Limited (Mississauga, Ontario).[1] This meter weighs about 3.1 lbs. and needs only one person to operate. The EM38 meter has one transmitter and one receiver coil that are spaced 1-m apart. The EM38 meter operates at a frequency of 14,600 Hz. When placed on the soil surface, this meter has effective penetration depths of about 0.75 m and 1.5 m in the horizontal and vertical dipole orientation, respectively (Geonics Limited, 1998).

The Geonics DAS70 Data Acquisition System is used with the EM38 meter to record and store both apparent conductivity (EC_a) and position data.[1] The acquisition system consists of the EM38 meter, an Allegro CX field computer (Juniper Systems, North Logan, UT), and a Garmin Global Positioning System (GPS) Map 76 receiver (with CSI Radio Beacon receiver, antenna, and accessories that are fitted into a backpack) (Olathe, KS).[1] When attached to the acquisition system, the EM38 meter is keypad operated and measurements can be automatically triggered. The DAT38W software program developed by Geomar Software Inc. (Mississauga, Ontario) was used to record, store, and process EC_a and GPS data.[1]

To help summarize the results of the EMI surveys, SURFER for Windows, version 10.0 (Golden Software, Inc., Golden, CO), was used to construct simulations of EC_a data.[1] Grids of EC_a data shown in this report were created using kriging methods with an octant search.

EMI Study Sites:
Woodstock Orchard:
Woodstock Orchard is located about 1.6 mi west-southwest of South Woodstock. The survey area is mapped as Paxton and Montauk fine sandy loams, 3 to 8 percent slopes (84B) and Woodbridge fine sandy loam, 0 to 3 percent slopes (45A). The very deep, well drained Paxton and Montauk and moderately well drained Woodbridge soils formed in lodgement till on hills and drumlins. These soils are moderately deep to a densic contact. Compared to Paxton soils, Montauk soils have sandy substrata. The taxonomic classifications of these soils are listed in Table 1.

Elm Farm LLC:
A second EMI study site is located on the Elm Farm LLC about 0.4 mi east-southeast of East Woodstock. This survey area is mapped as Agawam fine sandy loam, 3 to 8 percent slopes (29B), Hinckley gravelly sandy loam, 3 to 15 percent slopes (38C), and Rippowam fine sandy loam (103). The very deep, well drained Agawam and excessively drained Hinckley soils formed in sandy, water deposited material on

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

outwash plains and high stream terraces. The very deep, poorly drained Rippowam soils formed in alluvial sediments on flood plains subject to frequent flooding. The taxonomic classifications of these soils are listed in Table 1.

Table 1. Taxonomic Classification at the EMI Study Sites.

Soil Series	Taxonomic Classification
Agawam	Coarse-loamy over sandy or sandy-skeletal, mixed, active, mesic Typic Dystrudepts
Hinckley	Sandy-skeletal, mixed, mesic Typic Udorthents
Montauk	Coarse-loamy, mixed, subactive, mesic Oxyaquic Dystrudepts
Paxton	Coarse-loamy, mixed, active, mesic Oxyaquic Dystrudepts
Rippowam	Coarse-loamy, mixed, superactive, nonacid, mesic Fluvaquentic Endoaquepts
Woodbridge	Coarse-loamy, mixed, active, mesic Aquic Dystrudepts

Survey Procedures:
Random or *wild-cat* GPR surveys were conducted across accessible areas surrounding the Woodward house in Columbia, and the site of the historical Windham Town Farm in Willimantic. For these surveys, a distance-calibrated survey wheel with encoder was bolted onto the antenna and provided better control over signal pulse transmission and data collection. Each radar traverse was stored as a separate file.

Figure 2. Earth Team Volunteer April Clayton conducts an EMI survey across a parcel of land that is being converted from growing vegetables into an orchard. Several soil health studies are being carried out at this site by the Connecticut NRCS staff.

Training and field investigations were conducted at two sites in Windham County with an EM38 meter. The EM38 meter was used to measure the EC_a of the soils. Apparent conductivity is a weighted, average conductivity measurement for a column of earthen materials to a specific depth (Greenhouse and Slaine, 1983). Variations in EC_a are produced by changes in the electrical conductivity of earthen materials. Apparent conductivity increases with increases in moist, clay and/or soluble salt contents. Interpretations of EMI data are based on the identification of spatial patterns within data sets.

The EM38 meter was operated in the continuous mode with measurements recorded at 1-sec intervals. The EM38 meter was held about 2 inches above the ground surface with its long axis parallel to the direction of traverse (Figure 2). Walking at a fairly brisk and uniform pace, in a random back and forth manner across each study area completed the EMI survey.

Results:

Henry Woodward House

Several of the subsurface "anomalies" detected with GPR were "flagged" and the soil was probed at these locations. However, no significant cultural features were identified at any of these sites. Figure 3 is a representative radar record from the Woodward House site. In Figure 3, all scales are expressed in meters. This record was collected immediately behind the Woodward House. Two subsurface interfaces have been identified with white- and green-colored, segmented lines on the radar record shown in Figure 3. One layer boundaries (green-colored) is at depths of about 50 cm. The other boundary (white-colored) ranges in depth from about 1 to 1.75 m. A rectangle, composed of white-colored segments, appears to outline an area of cut and fill. The three white-colored circles identify three prominent point reflectors. These reflectors could represent larger rock fragments, roots, animal burrows or artifacts. As no cores were extracted along this radar traverse, the preceding discussion is simply interpretative.

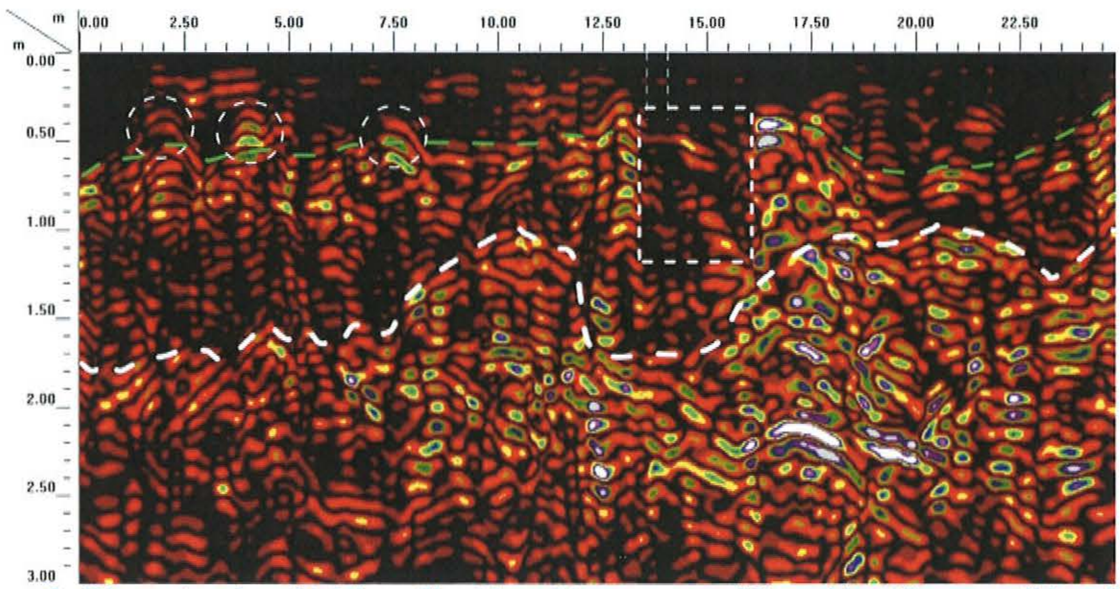

Figure 3. The rectangle, which is outlined by white, segmented lines, identifies a possible refilled area behind the Woodward House in Columbia.

Windham Town Farm:

Figure 4 contains a representative radar record from the site of the former Windham Town Farm. On this radar record, the depth and distance scales are expressed in meters. The rectangle that is enclosed by white-colored segmented lines is believed to contain the reflections from a buried drainage line. While several interfaces and point reflectors were evident on the radar records from this site, other than the buried drainage line shown in Figure 4, no other reflector could be identified as a buried cultural feature without added ground-truth diggings.

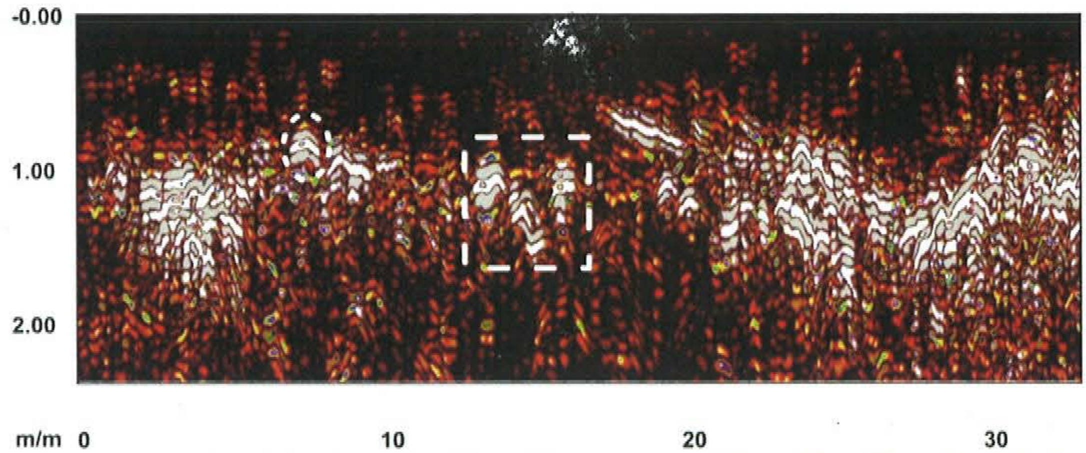

Figure 4. The rectangle, which is outlined by white, segmented lines, identifies a buried pipe at the site of the former Windham Town Farm.

Woodstock Orchard:

The soils are electrically resistive as a result of their low clay and soluble salt contents. A total of 6899 EC_a measurements were made across the Woodstock Orchards study area with the EM38 meter operated in the vertical dipole orientation. In the deeper-sensing (0 to 60 inches) vertical dipole orientation, EC_a averaged 4.8 mS/m and ranged from-2.8 to 63.4 mS/m. The more extreme EC_a values were attributed to farm implements and metallic artifacts scattered across the site. However, the EC_a of one-half the measurements were between only 4.2 and 5.5 mS/m.

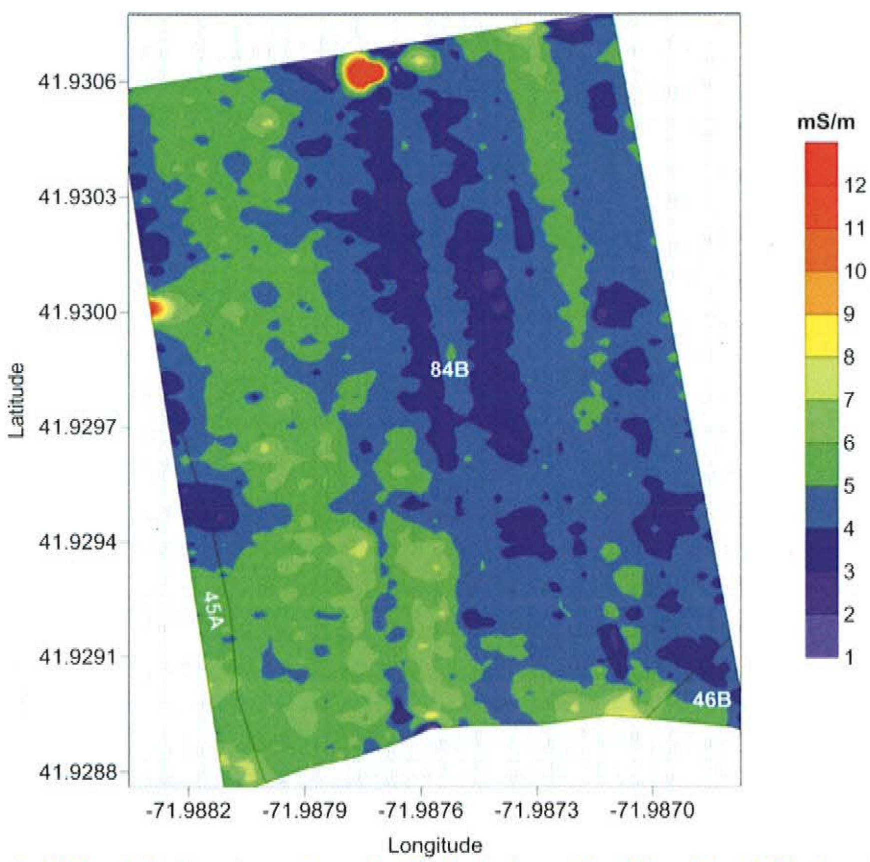

Figure 5. This plot of apparent conductivity is from the Woodstock Orchards site.

Figure 5 is a choropleth map showing the spatial distribution of EC_a measured with the EM38 meter. This plot was constructed from 6899 EC_a measurements. Apparent conductivity is relatively low (< 5 mS/m) and invariable (standard deviation 1.6 mS/m) across this site. Areas of moderately low (5 to 8 mS/m) were identified as being more moist. Two locations on this map have anomalously high EC_a (>10 mS/m). This is attributed to metallic features.

Elm Farm LLC:

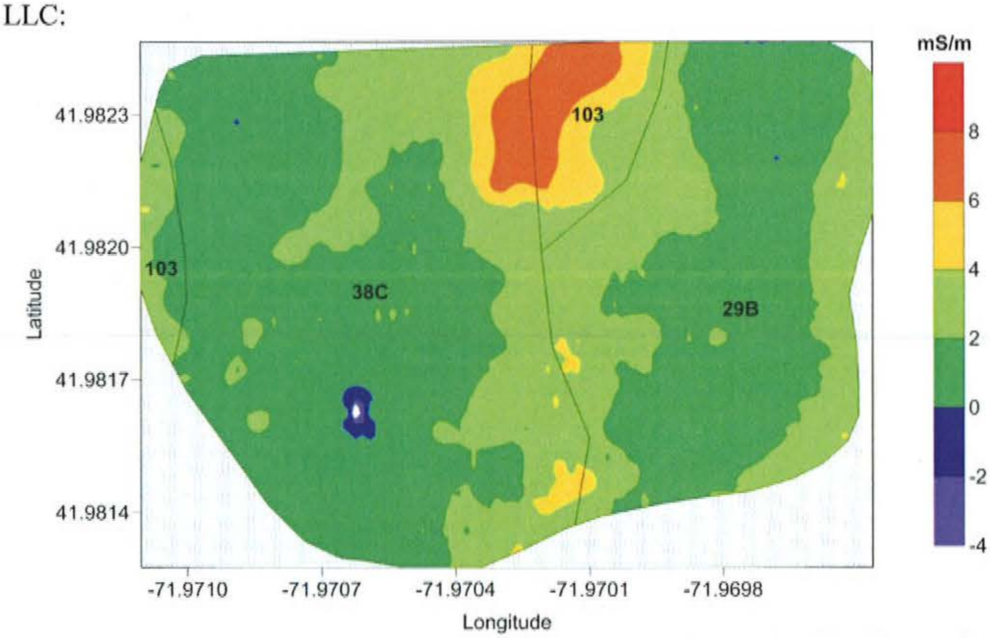

Figure 6. Relative low and invariable EC_a were recorded at the Elm Farm site.

The soils at the Elm Farm study site were coarser textured and have a lower EC_a than those at the Woodstock Orchard site. At the Elm Farm, a total of 3407 EC_a measurements were made across the study area with the EM38 meter operated in the vertical dipole orientation. In the deeper-sensing (0 to 60 inches) vertical dipole orientation, EC_a averaged only 2.0 mS/m and ranged from-18.0 to 8.5 mS/m. The EC_a of one-half the measurements were between 1.0 and 2.8 mS/m.

Figure 6 is a choropleth map showing the spatial distribution of EC_a measured with the EM38 meter. This plot was constructed from 3407 EC_a measurements. Apparent conductivity is relatively low < 4 mS/m) and invariable (standard deviation 1.5 mS/m) across this site. Areas of moderately low (4 to 8 mS/m) were identified as having higher clay and moisture contents. These areas corresponded to the approximate delineation of Rippowam soil (103). In Figure 6, the negative EC_a anomaly in the southwest portion of the site was attributed to a buried metallic artifact.

References:

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