United States Department of Agriculture

Natural Resources Conservation Service

c/o USDA Forest Service
11 Campus Boulevard
Suite 200
Newtown Square, PA 19073
(610) 557-4233; FAX: (610) 557-4200

Subject: Geophysical Assistance -- Archaeological

Date: 26 February 2001

To: Margo L. Wallace
State Conservationist
USDA-NRCS,
344 Merrow Road
Tolland, Connecticut 06084-3917

Purpose:
To assist the Connecticut NRCS Staff, Connecticut State Archaeologist, and local historians assess a site for possible buried historic remnants at Warehouse Point, East Windsor, Connecticut.

Participating Agencies:
Arthur Basto Archaeological Society (ABAS)
Connecticut State Museum of Natural History
East Windsor Historical Society
Friends of the Office of State Archaeology (FOSA)
Hartford County Soil and Water Conservation District
Heritage River Commission
USDA-Natural Resources Conservation Service

Participants:
Kenneth Beatrice, Archaeologist, FOSA/ABAS, Hadlyme, CT
Nicholas Bellantoni, Connecticut State Archaeologist, University of Connecticut, Storrs, CT
Dave Cook, Archaeologist, FOSA/ABAS, Rocky Hill, CT
Joshua Clague, Hartford SWCD, Windsor, CT
Jim Doolittle, Research Soil Scientist, USDA-NRCS, NSSC, Newtown Square, PA
Robert Ellis, Historian, East Windsor Historical Society, East Windsor, CT
Margie Faber, Ass't. State Soil Scientist, USDA-NRCS, Windsor, CT
Vivian Felten, CT Basin Project Coordinator, USDA-NRCS, Windsor, CT
Micah Lewis, Earth Team Volunteer, USDA-NRCS, Windsor, CT
Dan Parizek, Soil Scientist, USDA-NRCS, Windsor, CT
Paul Scannell, Heritage River Commission, East Windsor, CT

ACTIVITIES:
All field activities were completed on 20 February 2001.

Background:
Volunteer Park is situated along the Connecticut River at Warehouse Point. This park is being developed for recreational purposes and a footpath will be constructed. The Connecticut State Archaeologist requested a geophysical survey to help assess the site for possible buried remnants of historic structures and features. The site is located in an area of Ondawa sandy loam, 0 to 3 percent slopes (Shearin and Hill, 1969). Areas formerly mapped as Ondawa soils have been reclassified as Occum soils. This very deep, well drained soil formed in alluvial sediments. Occum is a member of the coarse-loamy, mixed, superactive, mesic Fluventic Dystrudepts family.

Equipment:
The radar unit used in this study was the Subsurface Interface Radar (SIR) System-2000, manufactured by Geophysical Survey Systems, Inc.[1] The SIR System-2000 consists of a digital control unit (DC-2000) with keypad, VGA video screen, and connector panel. A 12-volt battery powered the system. This system is backpack portable and, with an antenna, requires two people to operate. Morey (1974), Doolittle (1987), and Daniels (1996) have discussed the use and operation of GPR. A 400 MHz antenna was used in this study. The scanning time was 60 nanoseconds (ns); the scanning rate was 32 scan/second. The radar data were stored on disc and printed in the field on a model 608 printer.

A GEM300 sensor, manufactured by Geophysical Survey Systems, Inc., was used in this study.[1] Geophysical Survey Systems, Inc, (1998) has described the principles of operation for the GEM300 sensor. The GEM300 sensor is configured to simultaneously measure up to 16 frequencies between 330 and 20,000 Hz with a fixed intercoil spacing of 1.3 m. The sensor records both inphase, quadrature, and conductivity measurements. Output is the mutual coupling ratio in parts per million or apparent conductivity (mS/m).

Field Procedures:
An irregularly shaped 80 by 600 foot grid was established across the site. A wooden rail fence along the northern border of the park served as a reference line. The grid intervals were 10 (east-west) and 50 (north-south) feet. Survey flags were inserted in the ground at each grid intersection and served as reference points. The 400 MHz antenna was pulled along each of the nine, north-south trending grid lines. The GPR provides a continuous profile of the subsurface. As the radar antenna was pulled passed each flag, the operator impressed a vertical mark on the radar record. The vertical marks identified the reference points (flagged positions). The reference points provide a horizontal scale and identify relative locations along each traverse line.

Measurements were taken with the GEM300 sensor held at hip-height in both the horizontal and vertical dipole orientations along each of the nine north-south grid lines. Inphase, quadrature phase, and conductivity data were recorded with the GEM-300 sensor at three different frequencies (19950, 14730, and 9810 Hz). Data was continuously recorded at intervals of 1 second.

Results:
GPR Survey:
The locations of the nine GPR traverse lines and several conspicuous cultural features related to the park are shown in Figure 1. The GPR worked well at this site providing appropriate observation depths and resolution of subsurface features. Several subsurface strata were apparent on the radar profiles. In addition, several prominent point and planar reflectors were identified on the radar profiles. These reflectors are believed to represent buried cultural features. These features have been sited in Figure 2. Those reflectors that occur along radar traverse lines Y = 70 and 80 feet (Files 37 and 38) occur in embankment materials and are associated with a modern road. The identified anomalies are dispersed across the site and no major subsurface cultural feature was identified on the radar profiles. Clusters of point anomalies indicate areas with high "cultural noise" and are the most favorable sites for exploratory observations by archaeologists. The most conspicuous area of high cultural noise is located in the southeast corner of the study area (see Figure 2).

Electromagnetic Induction (EMI) Survey:
Electromagnetic induction measures vertical and lateral variations in magnetic and/or electrical fields associated with induced subsurface currents. Data is expressed as inphase, quadrature phase, or apparent conductivity. The inphase and quadrature phase responses represent the ratio of the secondary magnetic field to the primary magnetic field at receiver coil. Inphase refers to the part of the signal that is in phase (has zero phase shift) with the primary or reference signal. The inphase signal is more sensitive to buried metallic objects and has been referred to as the "metal detection" mode. Quadrature phase refers to the part of the signal that is 90 degrees out of phase with the primary signal. The quadrature phase response is linearly related to the ground conductivity. Some highly conductive targets with small cross-sections, such as pipes, may show up better in the quadrature phase because of the channelization of current.

Traditionally, EMI data are expressed as apparent conductivity. The GEM300 sensor automatically converts quadrature phase data into apparent conductivity data. Values of apparent conductivity are expressed in milliSiemens per meter (mS/m). Apparent conductivity is a weighted, average measurement for a column of earthen materials to a specific depth (Greenhouse and Slaine, 1983). Variations in apparent conductivity are caused by changes in the electrical conductivity of earthen materials. The electrical conductivity of soils is influenced by the volumetric water content, type and concentration of ions in solution, temperature and phase of the soil water, and amount and type of clays in the soil matrix (McNeill, 1980). The apparent

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

conductivity of soils increases with increases in soluble salts, water, and clay contents (Kachanoski et al., 1988; Rhoades et al., 1976).

Values of apparent conductivity are seldom diagnostic in themselves, but lateral and vertical variations in these measurements can be used to infer changes in soils and soil properties and the locations of buried artifacts. Interpretations are based on the identification of spatial patterns within data sets. To assist interpretations, computer simulations are normally used.

Figures 4 and 5 contain plots of EMI data collected within the survey area. Data shown in figures 4 and 5 were collected in the horizontal and vertical dipole orientations. The shallower-sensing horizontal dipole orientation is more sensitive to changes in conductivity that occur near the soil surface. The deeper-sensing vertical dipole orientation is more sensitive to changes in conductivity that occur at greater soil depths. In each figure and above each plot the frequency and whether the data represents inphase (i) or apparent conductivity (c) measurements are indicated. These image maps use different colors to represent the data. Colors are associated with percentage values (in relation to the minimum and maximum values).

Data collected with the GEM300 sensor at different frequencies were similar. The most conspicuous features identified in each figure and plot are from modern, aboveground, park equipment. Along survey line Y = 20, the GEM300 sensor passed by metallic park tables, outdoor fireplaces, and a park bench. The conspicuous anomalies along this traverse line represent these features. Along survey line 50, a gazebo caused the prominent EMI response between observation points X =100 and 150. With the exception of interference from these modern cultural features, the EMI survey revealed no evidence of any buried cultural features.

Conclusions:

In the search for buried cultural features with geophysical techniques, success is never guaranteed. Even under ideal site and soil conditions, buried cultural features will be missed. The usefulness of geophysical techniques for site assessment purposes depends on the amount of uncertainty or omission that is acceptable. Ground-penetrating radar and electromagnetic induction surveys of Volunteer Park revealed no evidence supporting the presence of major buried cultural features such as former homes, buildings, or fortifications.

Interpretations are considered preliminary estimates of site conditions. The results of geophysical site investigations do not substitute for direct observations, but rather reduce their number, direct their placement, and supplement their interpretations. All interpretations made in this report should be verified by ground-truth observations.

All radar records from this study have been forwarded to Nick Bellantoni for review and documentation of the survey.

It was my pleasure to be of assistance to you, your staff, and the State Archaeologist

With kind regards,

James A. Doolittle
Research Soil Scientist

cc:

R. Ahrens, Director, USDA-USDA, National Soil Survey Center, Federal Building, Room 152,100 Centennial Mall North, Lincoln, NE 68508-3866

N. Bellantoni, Connecticut State Archaeologist, Office of State Archaeology, 3107 Horsebarn Hill Road, U-214, Storrs, CT 06269-4214

V. Felten, Connecticut River Basin Area project Coordinator, USDA-NRCS, 627 River Street, Windsor, CT 06095

C. Olson, National Leader for Soil Investigations, USDA-USDA, National Soil Survey Center, Federal Building, Room 152,100 Centennial Mall North, Lincoln, NE 68508-3866

H. Smith, Director of Soils Survey Division, USDA-NRCS, Room 4250 South Building, 14th & Independence Ave. SW, Washington, DC 20250

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GPR SURVEY OF VOLUNTEER PARK
EAST WINDSOR, CONNECTICUT
LOCATION OF SURVEY LINES

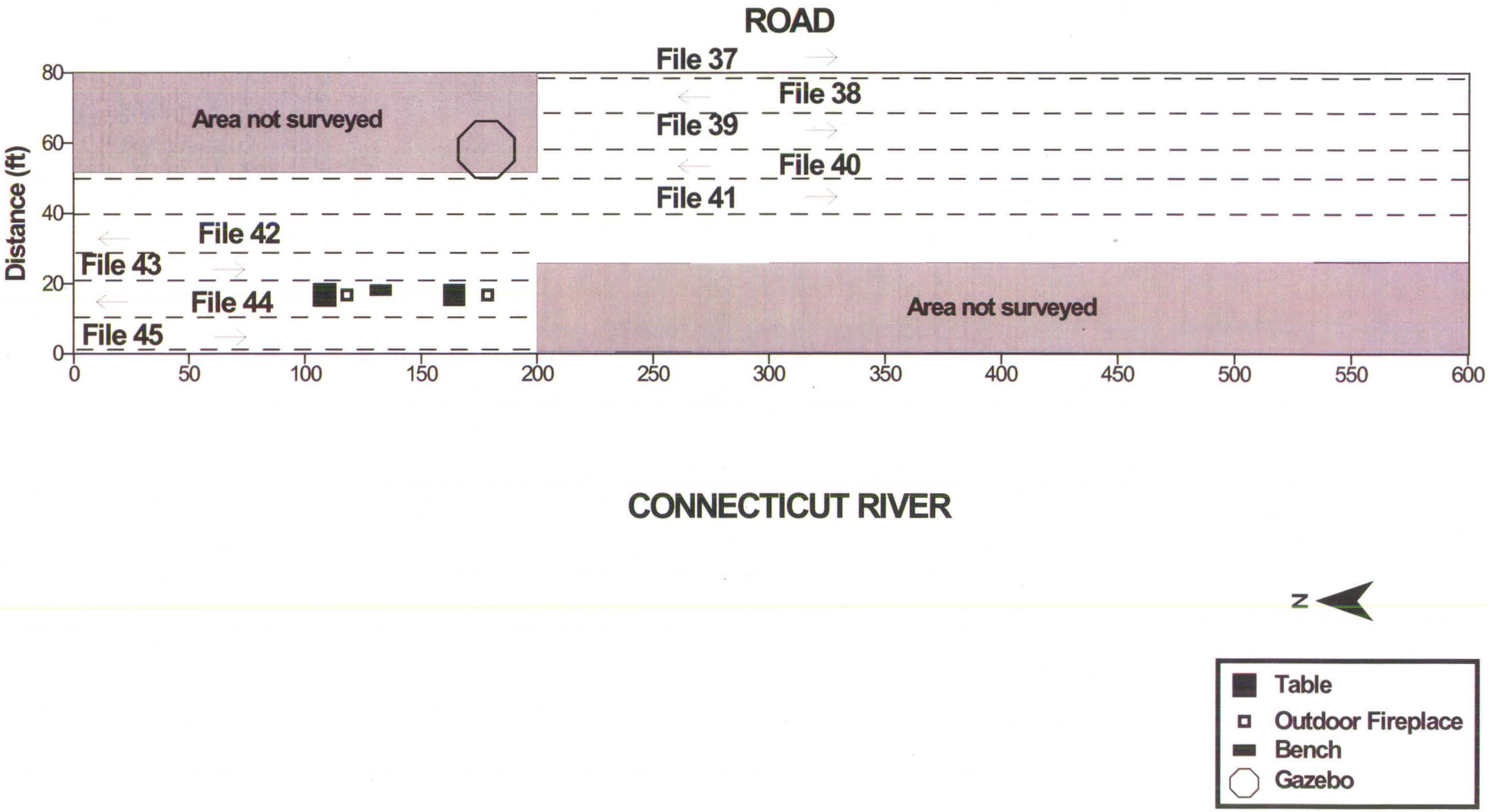

Figure 1

GPR SURVEY OF VOLUNTEER PARK
EAST WINDSOR, CONNECTICUT
LOCATION OF IDENTIFIED ANOMALIES

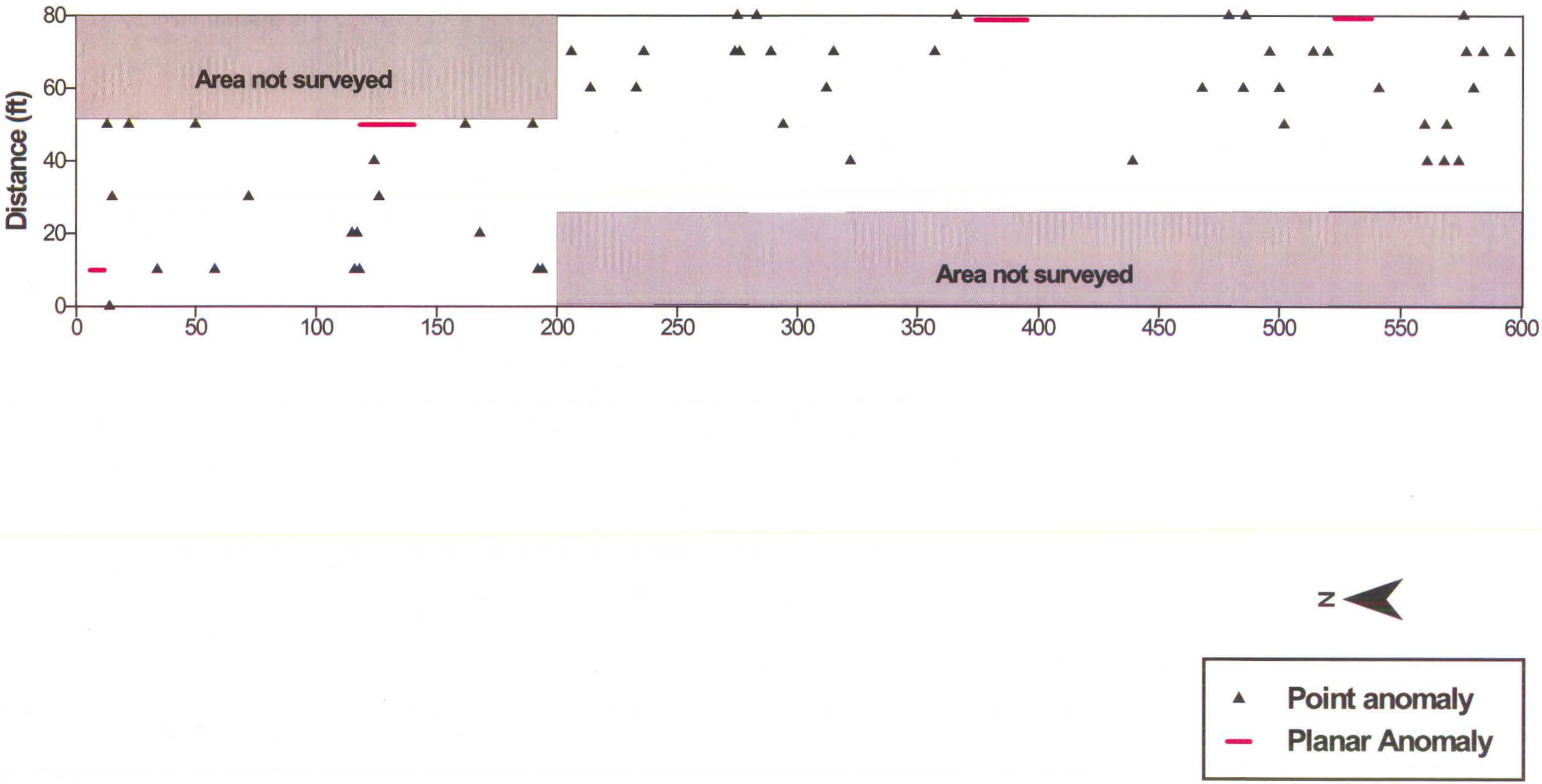

Figure 2

EMI SURVEY OF VOLUNTEER PARK
EAST WINDSOR, CONNECTICUT
GEM300 SENSOR - HORIZONTAL DIPOLE ORIENTATION

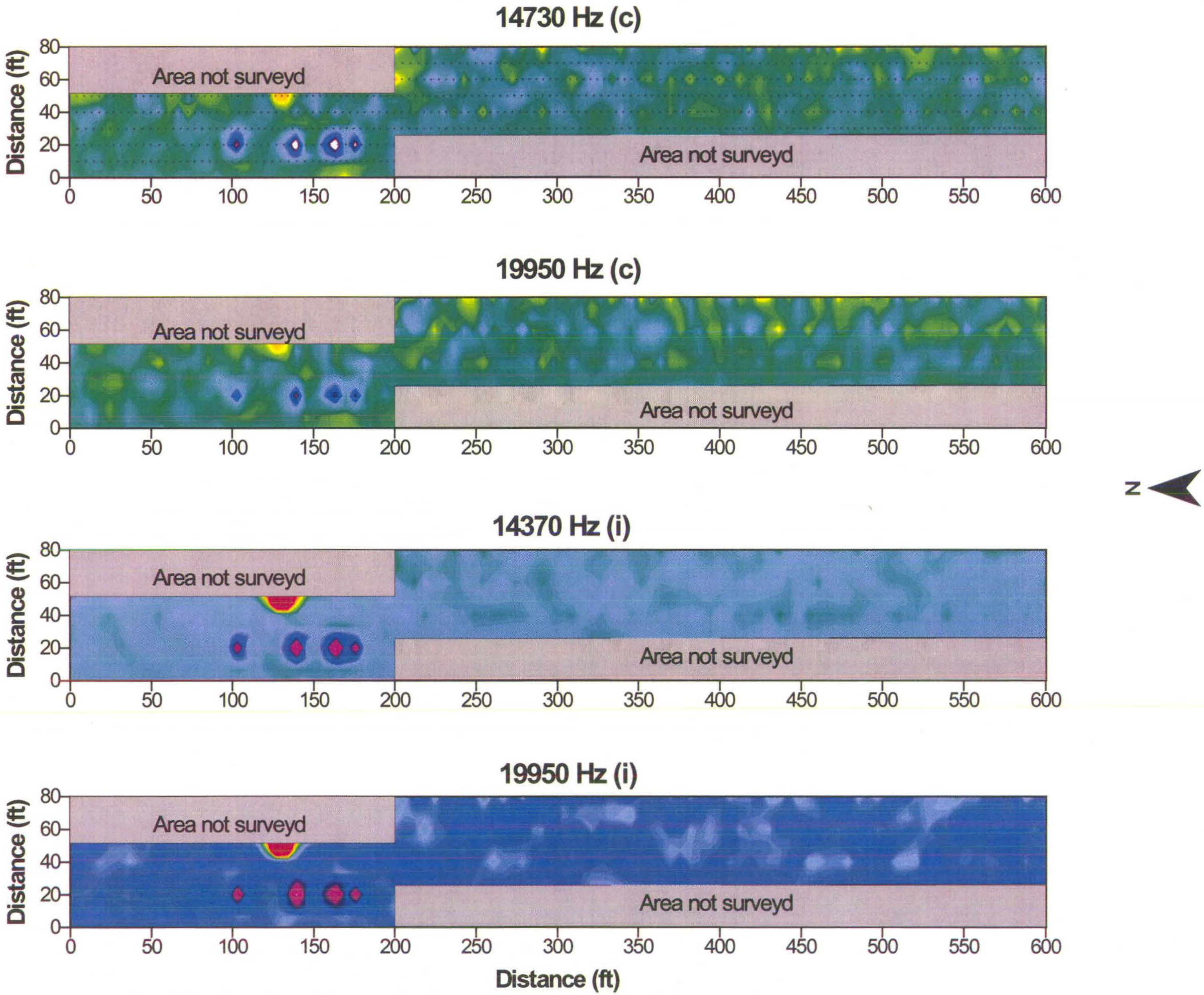

Figure 3

EMI SURVEY OF VOLUNTEER PARK
EAST WINDSOR, CONNECTICUT
GEM300 SENSOR - VERTICAL DIPOLE ORIENTATION

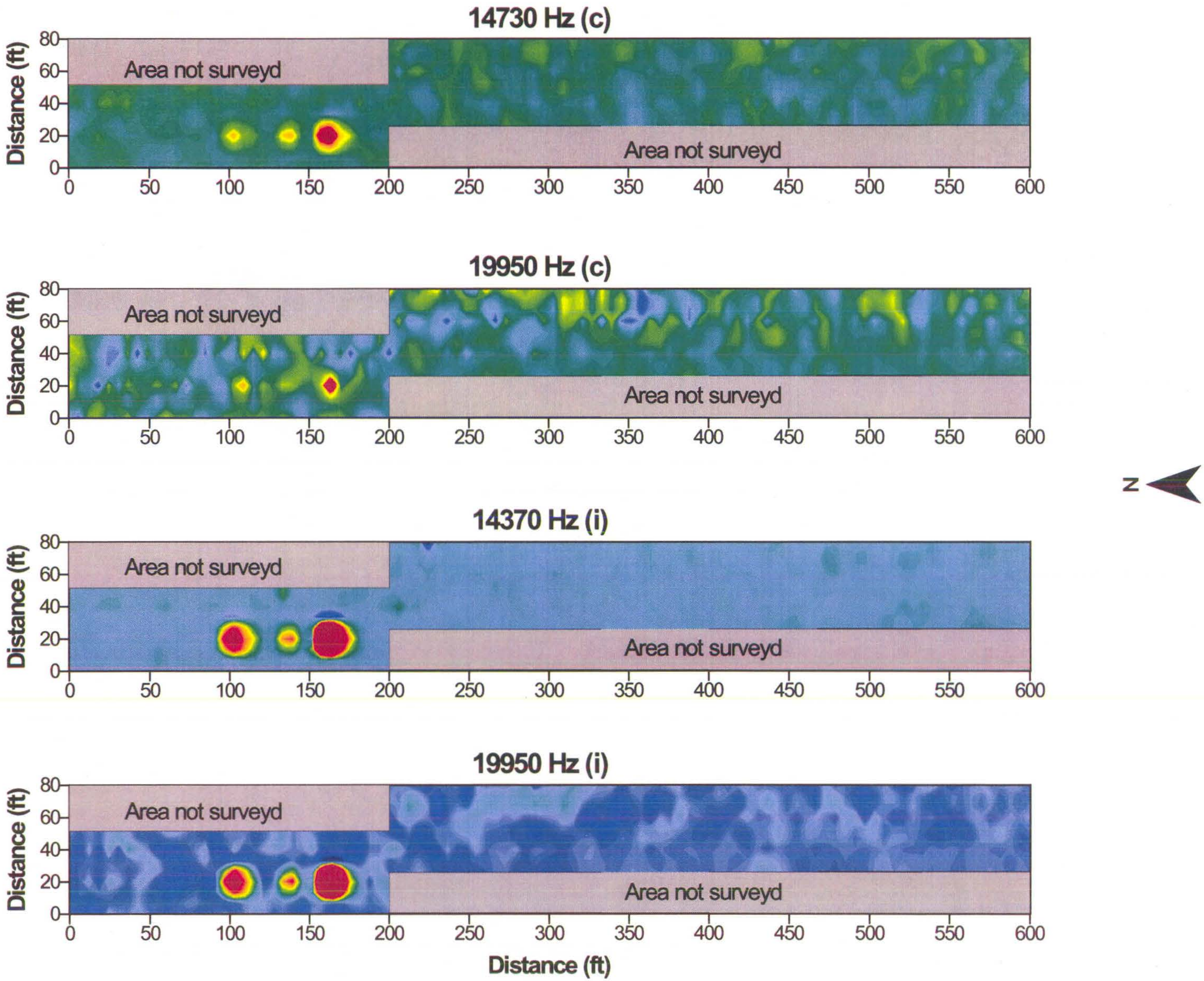

Figure 4