File Jim Doolittle

United States Department of Agriculture | Soil Conservation Service | 160 East 7th Street, Chester, PA 19013-6092

Subject: Electromagnetic Induction (EM) Surveys of Cicero Town Park, Cicero, New York

Date: November 27, 1992

To: Paul A. Dodd
State Conservationist
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Purpose:
The purpose of this investigation was to assess the distribution of suspected disturbed soil conditions, buried cultural features, and fill materials within the Cicero Town Park.

Participants:
Jim Doolittle, Soil Specialist, SCS, Chester, PA
Ed Stein, Soil Scientist, SCS, Utica, NY
Tyrone Goddard, SoilScientist (Technology), SCS, Syracuse, NY
Donald Lynch, Area Engineer, SCS, Utica, NY
Jody Hawley, Director of Parks and Recreation, Cicero, NY
John Kersel, Park laborer, Cicero, NY

Activities:
The park commission had established a grid across the ball field prior to the arrival of the EM equipment. The EM survey was completed within 2 hours on the morning of 23 November 1992.

Equipment:
The electromagnetic induction meter used was the EM31 manufactured by Geonics Limited. Measurements of conductivity are expressed as milliSiemens per meter (mS/m). With the EM31 meter in the horizontal dipole orientation, the investigation depth is about 2.75 meters. With the EM31 meter in the vertical dipole orientation, the investigation depth is about 5.5 meters. Measurements reflect the apparent or bulk conductivity integrated over a horizontal distance of about 3.86 meters and a vertical depth defined by the orientation of the coils.

Survey procedures:
A 350 by 350 foot grid was established across the site. The grid covered an approximately 2.8 acres. The grid interval was 50 feet. Data were collected at 65 observation points. At each of these sites, EM measurement were taken with each meter in both the horizontal and vertical dipole orientations. Data was plotted using SURFER (ver. 4.0) software. Kriging interpolation and octant search methods were used to construct the enclosed two-dimensional plots.

Discussion:
The attached, two-dimensional plots summarize the spatial distribution of apparent conductivity values within the upper 2.75 meters (Figure 1), and the upper 5.5 (Figure 2) meters of the study area. In each figure, the general locations of the baseball infield, backstop, and fences have been plotted. A 2 mS/m interval was used in each of these figures.

The study site is located in an area of Niagara silt loam, 0 to 4 percent slopes. A small delineation of Collamer silt loam, 2 to 6 percent slopes occurs in the extreme northwestern corner of the study area. The higher horizontal response in the northwest corner of the study site may be a manifestation of this difference in soil type. Niagara is a member of the fine-silty, mixed, mesic Aeric Ochraqualfs family. Collamer is a member of the fine-silty, mixed, mesic Glossoboric Hapludalfs family

In each figure, elevated EM responses occur along the eastern margin of the study site. These elevated responses have been produced by near surface metallic objects (backstop near "A") and buried metallic features (near "B", and suspected utility or pipe lines which are parallel with and near the eastern boundary of the survey area). Because of the grid interval used (50 feet) and the computer simulation program used, the zone of elevated EM responses appears wider than it is believed to be.

With the exception of the areas already noted in this report, iso-conductivity lines across the ball field appear gradational and are assumed to reflect natural variations in soil types and conditions.

Results:
Geophysical tools provided a rapid, cost effective, and nondestructive method for site assessments. This survey provides no evidence of a landfill or excessively disturbed soil conditions existing at this site. Interpretations of the EM data should be verified by direct observations and soil borings. In addition, the coarseness of the grid interval (50 feet) invalidates any inclination towards a higher level of interpretation than warranted from the data.

It was my pleasure to work in your state and with members of your fine staff.

With kind regards.

James A. Doolittle
Soil Specialist

cc:
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figure 1

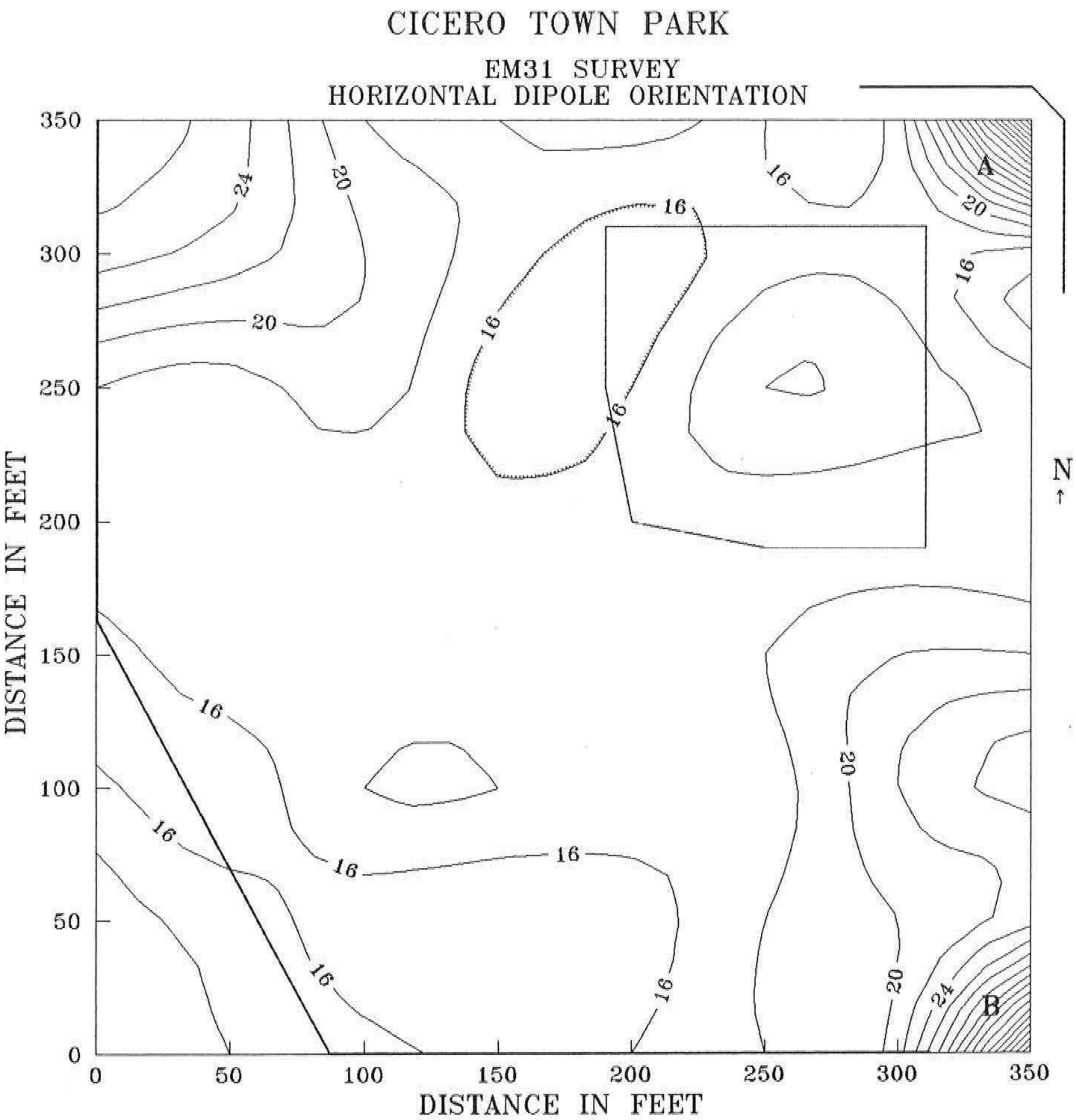
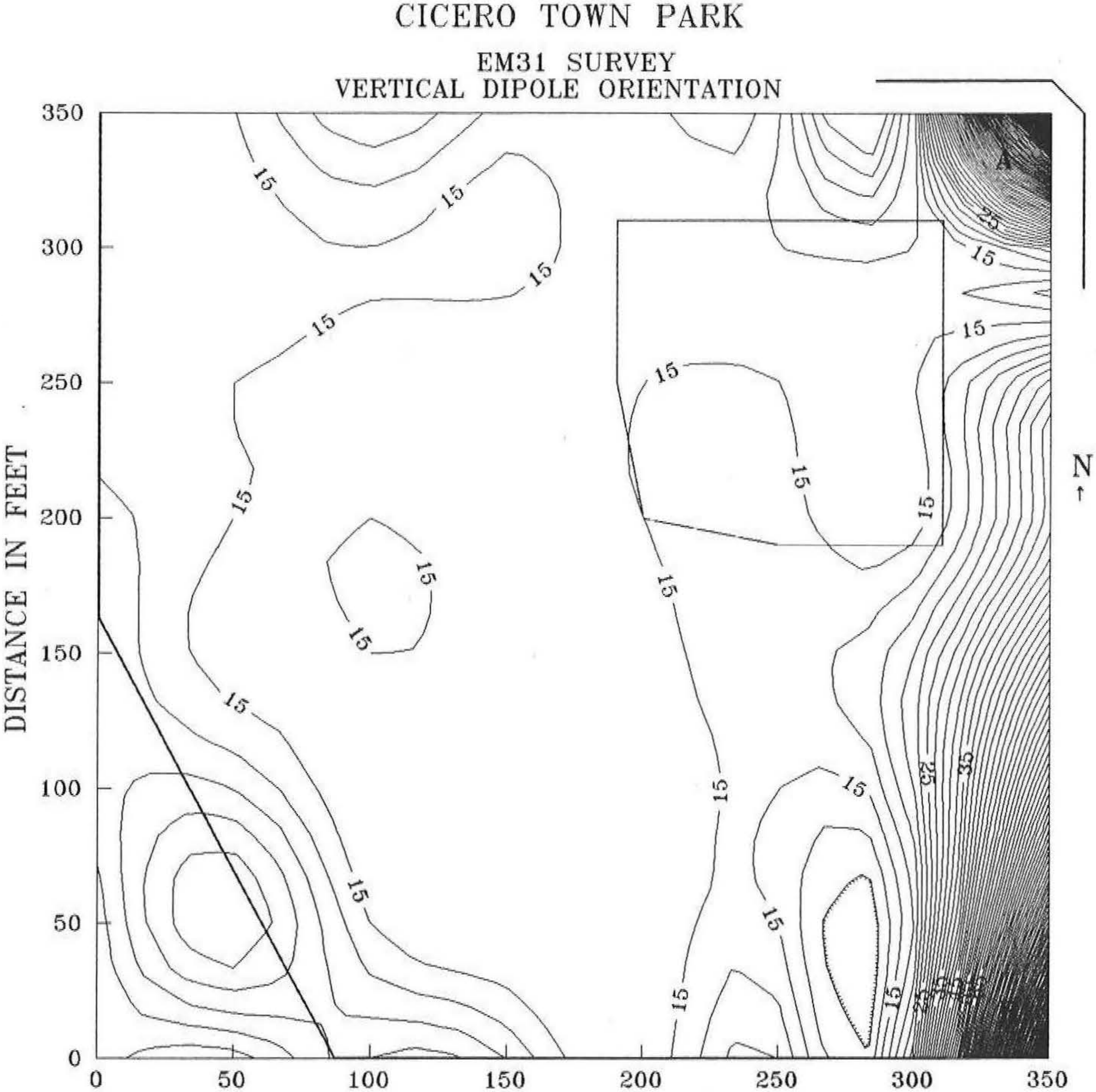

CICERO TOWN PARK
EM31 SURVEY
HORIZONTAL DIPOLE ORIENTATION
DISTANCE IN FEET
DISTANCE IN FEET
0
50
100
150
200
250
300
350
24
20
20
16
16
16
16
16
16
16
16
16
16
20
20
20
24
A
B
N

FIGURE 2


CICERO TOWN PARK
EM31 SURVEY
VERTICAL DIPOLE ORIENTATION
DISTANCE IN FEET
DISTANCE IN FEET
0
50
100
150
200
250
300
350
15
25
35
A
N

Review of Electromagnetic Induction Methods

Electromagnetic inductive (EM) technique is a surface-geophysical method in which electromagnetic energy is used to measure the terrain or apparent conductivity of earthen materials. Electromagnetic inductive (EM) methods have been used extensively to measure the apparent conductivity of saline (Corwin and Rhoades, 1982, 1984, and 1990; De Jong, 1979; Kingston, 1985; Rhoades and Corwin, 1981; Rhoades and Halvorson, 1977; Slavich and Read, 1985; Williams, 1983; Williams and Baker, 1982; Williams and Hoey, 1987; and Wollenhaupt et al., 1986) and sodic (Ammons et al., 1989) soils. In addition, this technology has been used to map bedrock surfaces (Zalasiewicz, 1985), thickness of clays (Palacky, 1987) or sand and gravel deposits (McNeill, 1988), measure soil water content (Kachanoski et al., 1988) and for groundwater investigations (McNeill, 1988). These studies have documented the ease and accuracy of EM interpretations and its applications over broad areas and soil types.

For surveying, an EM meter is placed on the ground surface or held above the surface at a specified distance. A power source within the EM meter generates an alternating current in the transmitter coil. The current flow produces a primary magnetic field which induces electrical eddy currents in the soil. The induced current flow is proportional to the electrical conductivity of the intervening medium. The eddy currents create a secondary magnetic field in the soil. The secondary magnetic field is of the same frequency as the primary field but of different phase and direction. The primary and secondary fields are measured as a change in the potential induced in the receiver coil. At low transmission frequency, the ratio of the secondary to the primary magnetic field is directly proportional to ground conductivity. Values of terrain conductivity are expressed in milliSiemen per meter (mS/m).

Electromagnetic methods measure the apparent conductivity of earthen materials. Apparent conductivity is the weighted average conductivity measurement for a column of earthen materials to a specified penetration depth (Greenhouse and Slaine; 1983). Factors influencing the conductivity of earthen materials include: (i) the volumetric water content, (ii) the amount and type of ions in soil water, (iii) the amount and type of clays in the soil matrix, and (iv) the soil temperature. Variations in the meters response are produced by changes in sediment type, degree of saturation, nature of the ions in solution, and metallic objects.

The depth of penetration is dependent upon the intercoil spacing, transmission frequency, and coil orientation relative to the ground surface. Table 1 list the anticipated depths of measurements for the EM31, EM34-3, and EM38 meters. The actual depth of measurement will depend on the conductivity of the earthen material(s) scanned.

TABLE 1

Depth of Measurement
(all measurements are in meters)

Meter	Intercoil Spacing	Depth of Measurement Horizontal	Vertical
EM31	3.7	2.75	6.0
EM34-3	10.0	7.5	15.0
	20.0	15.0	30.0
	40.0	30.0	60.0
EM38	1.0	0.75	1.5

The conductivity meters provide limited vertical resolution and depth information. However, as discussed by Benson and others (1984), the absolute EM values are not necessarily diagnostic in themselves, but lateral and vertical variations in these measurements are significant. The seasonal variation in soil conductivity (produced by variations in soil moisture and temperature) can be added to the statement by Benson. Interpretations of the EM data are based on the identification of spatial patterns in the data set appearing on two-dimensional contour plots.

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