UNITED STATES DEPARTMENT OF AGRICULTURE
NATURAL RESOURCES CONSERVATION SERVICE

CHESTER, PA 19013
610-490-6042

Subject: Electromagnetic Induction (EM)
Union, Columbia, Northumberland, and
Lycoming Counties, Pennsylvania
April 19 and 20 1995

Date: 25 April 1995

To: Janet Oertly
State Conservationist
USDA-NRCS
Harrisburg, PA

Purpose:
To use EM technique to assess potential seepage from animal waste structures and sources of groundwater contamination.

Participants:
Bruce Benton, Geologist, NRCS, Harrisburg, PA
Jim Doolittle, Research Soil Scientist, NRCS, Chester, PA
Phil Durst, Montour County Ext. Director, PSU, Danville, PA
Andy Hibbs, District Engineer, Union County SWCD, Lewisburg, PA
Dennis Norman, Technician, Lycoming SWCD, Williamsport, PA
George Phillips, Soil Conservationist, Northumberland County CD, Sunbury, PA
Lynda Schlegel-Culver, Legislative Aide, PA House of Representatives, Sunbury, PA
John Zaginoyla, Area Engineer, NRCS, Bloomsburg, PA

Activities:
Investigations were conducted in Union and Columbia Counties on 19 April and in Northumberland and Lycoming Counties on 20 April 1995.

Equipment:
The electromagnetic induction meters were the EM38 and EM31, manufactured by GEONICS Limited. The observation depth of an EM meter is dependent upon intercoil spacing, transmission frequency, and coil orientation relative to the ground surface. The EM38 meter has a fixed intercoil spacing of 1.0 m. It operates at a frequency of 13.2 kHz. The EM38 meter has effective observation depths of about 0.75 and 1 m in the horizontal and vertical dipole orientations, respectively.[1] The EM31 meter has a fixed intercoil spacing of 3.66 m. It operates at a frequency of 9.8 kHz. The EM31 meter has effective observation depths of about 3 and 6 m in the horizontal and vertical dipole orientations, respectively.[2] Measurements of conductivity are expressed as milliSiemens per meter (mS/m).

1. McNeill, J. D. 1986. Geonics EM38 ground conductivity meter operating instructions and survey interpretation techniques. Technical Note TN-21. Geonics Ltd., Mississauga, Ontario. p. 16.

2. McNeill, J. D. 1979. EM31 operating manual for EM31 noncontacting terrain conductivity meter. Geonics Ltd., Mississauga, Ontario. p. 35.

To help summarize the results of this study, the SURFER program, developed by Golden Software, Inc., was used to develop two-dimensional plots of the study site in Union County. Simulated plots of the study site were created using kriging methods with an octant search. The data was smoothed using cubic spline interpolation.

Field Methods

A survey grid was established near Paul Hetrick's manure storage structure in Union County. The grid consisted of thirty-one, equally spaced (25 foot interval) observation points. The grid was located on the east, south, and west sides of the structure. At each observation point, measurements were obtained with the EM38 and the EM31 meters in both the horizontal and vertical dipole orientation.

The well sites in Columbia County had been filled and did not require the use of EM techniques. At the Roger Swartz farm in Lycoming County, the contaminated wells were located among farm structures and utility lines. These "cultural features" produced high levels of noise which interfered with and thwarted the use of EM techniques.

At the Roger Foresman's farm in Northumberland County, a walking survey was conducted with the EM31 around the perimeter of farm structures, adjoining fields, and along the Conrail line and a gas pipeline. The purpose of this survey was to observe general spatial patterns of apparent conductivity, and to detect anomalous patterns which could suggest a potential source(s) of the contamination.

Discussion:

Paul Hetrick Manure Storage Structure -

The concrete structure is 54 feet in diameter and 10 feet in height. A metal fence tops the structure. The structure was built in 1991 and appears to be operating well. The structure is located in an area of Berks shaly silt loam, 8 to 15 percent slopes.

Interpretations of the EM data are based on the identification of spatial patterns within the data set. The EM data have been displayed in two-dimensional contour plots (figures 1, 2, 3, and 4). In these plots, to help emphasize the spatial distribution of apparent conductivity values, colors and filled contour lines have been used. Each plot represents the spatial distribution of apparent conductivity values over a specified observation depth. Other than showing trends in values of apparent conductivity (i.e. zones of higher or lower electrical conductivity), no significance should be attached to the colors themselves.

Comparing the plots, values of apparent conductivity, as a rule, appear to decrease with increasing observation depth (responses of the EM38 and EM31 meters in the horizontal dipole orientation were typically greater than those in vertical dipole orientation). This

relationship is believed to reflect the concentration of animal waste products in surface layers of the soil. Animal wastes appear to have been carried by runoff from an adjoining animal holding area (located to the immediate north of the grid site). For each meter, in the horizontal dipole orientation (figures 1 and 3), two plume-like features of higher apparent conductivity values can be traced across the grid site in a general north to south direction. These plumes reflect near surface conditions, occur in wet areas, and have values of apparent conductivity decreasing with increasing distance and in a down-slope direction away from the animal holding areas.

High values of apparent conductivity in the extreme northeast corner of the grid site were believed to reflect, in part, noticeably higher concentrations of animal waste on the soil surface and interference from adjoining metal fence lines, farm structures, and utility lines.

In general, measurements taken with EM meters within 20 feet of the manure storage structure were influenced by the structure. These measurements were anomalously high and should be disregard in the interpretation of the EM data and simulated plots.

Roger Foresman's Farm Structure -

Mr Foreman's wells have become contaminated. The purpose of this brief survey was to discern possible patterns suggesting contamination within the upper 6 meters of the soil surface. A walking survey was conducted with the EM31 around the perimeter of farm structures, adjoining fields, and along the Conrail line and a gas pipeline.

Values of apparent conductivity were low (3 to 5 mS/m) and relatively invariable around the farm buildings. No anomalous patterns were observed. Traversing the slope of the terrace before the farm structures, values of apparent conductivity increased gradually and uniformly from the summit to the foot slope area. Values on the summit ranged from 3 to 4 mS/m; values on the foot slope ranged from 9 to 11 mS/m. Difference between these slope components were attributed principally to wetter soil conditions on lower-lying foot slope areas. Values along a nearby drainageway varied from 10 to 11 mS/m.

A traverse was conducted with the EM31 meter in a north - south direction and at a distance of about 200 feet from the Conrail railway line. Values of apparent conductivity increased gradually from north (4 to 5 mS/m) to south (7 to 9 mS/m). Within a wet area adjoining the railway line, values of apparent conductivity were the highest observed (12 to 13 mS/m). While not considered exceptionally high, values of apparent conductivity within the wet area were anomalously high in relation to surrounding areas and soil types. Over a nearby stream (located to the north of the wet area), values of apparent conductivity ranged from 7 to 9 mS/m. It was suggested that soil samples be collected within this wet area.

Results from the EM survey were inconclusive. With the exception of one wet area, no well-expressed anomalous patterns were observed suggesting contamination within the upper 6 meters of the profiled

soil and earthen materials. The anomaly observed in the wet area was weakly expressed and may reflected variations in soil types.

It was a pleasure to work with members of your fine staff.

With kind regards.

James A. Doolittle
Research Soil Scientist

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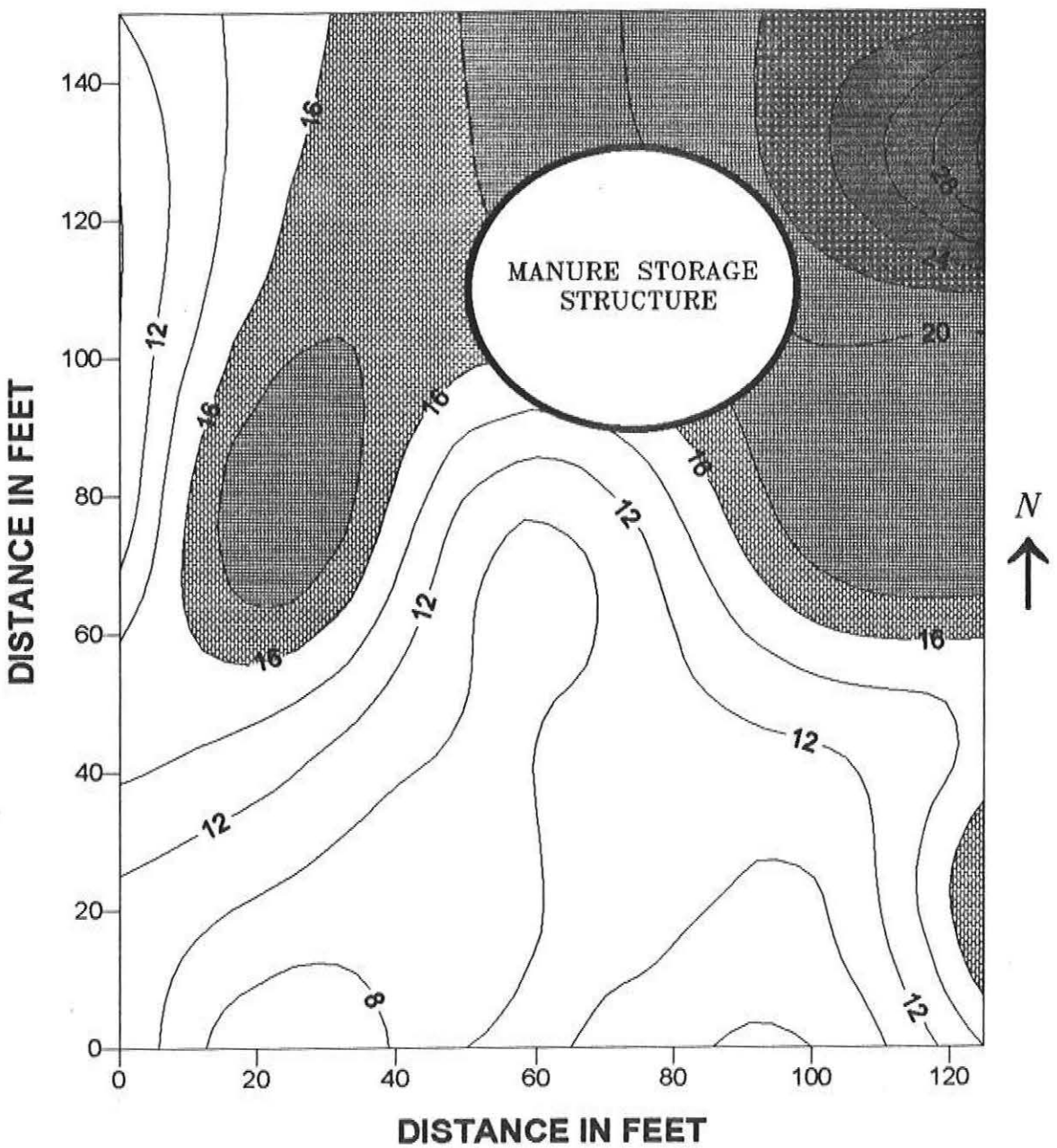
EM 38 METER SURVEY
HORIZONTAL DIPOLE ORIENTATION
MANURE STORAGE STRUCTURE
UNION COUNTY, PENNSYLVANIA



EM 38 METER SURVEY
VERTICAL DIPOLE ORIENTATION
MANURE STORAGE STRUCTURE
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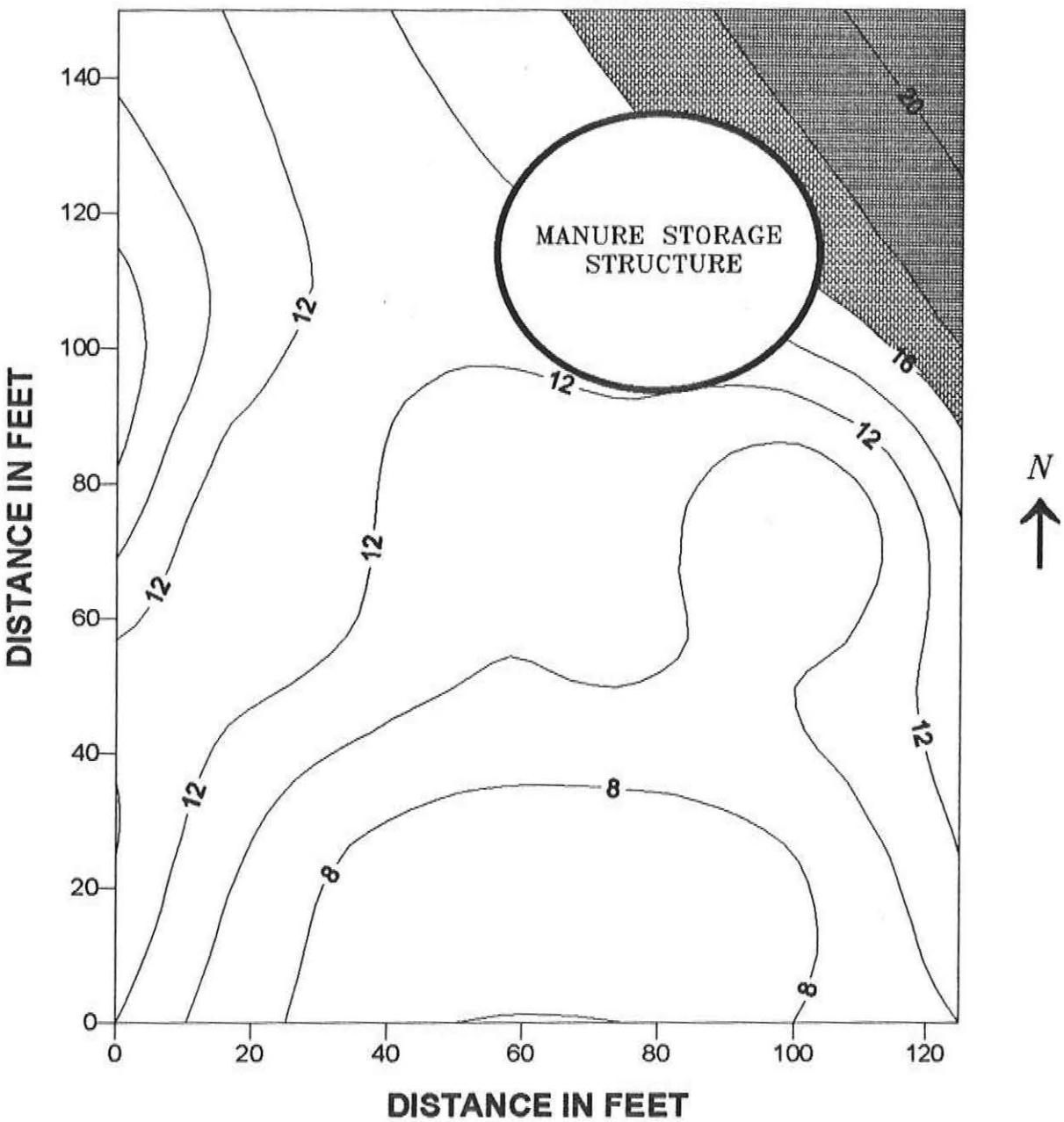

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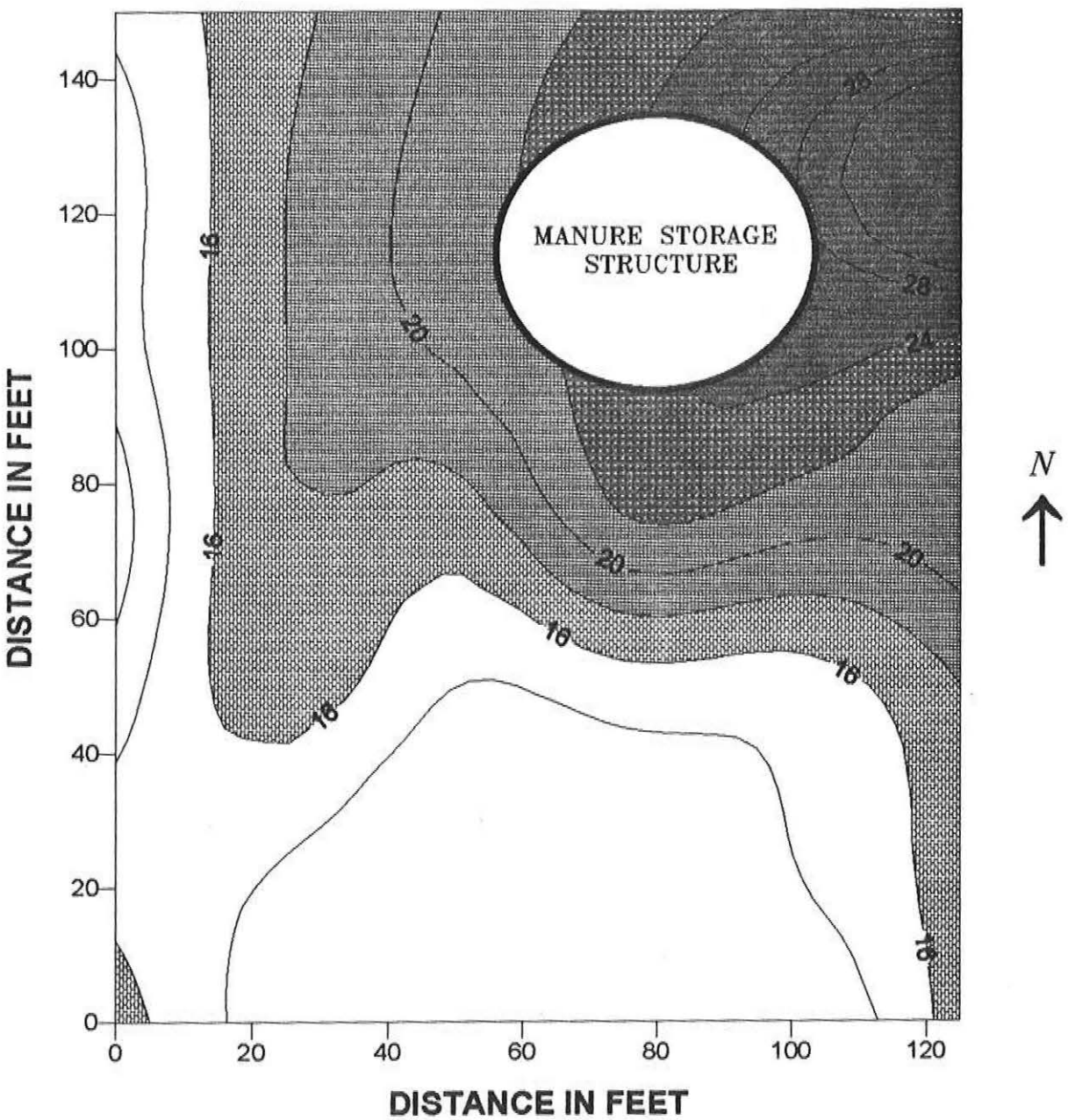

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