United States Department of Agriculture | **Natural Resources Conservation Service** | **11 Campus Boulevard Suite 200 Newtown Square, PA 19073**

Subject: Soils – Electromagnetic Induction (EMI) Field Assistance **Date:** 11 April 2008

To: Mark Demitroff
822 Main Avenue
Vineland, NJ
08360-9346

Ronnie Lee Taylor
State Soil Scientist
USDA-Natural Resources Conservation Service
220 Davidson Ave., 4th Floor
Somerset, NJ 08873-4115

Purpose:
To use electromagnetic induction (EMI) to investigate and characterize wind streaks on Coastal Plain sediments of central New Jersey.

Participants:
Mark Demitroff, PhD Candidate, Geography Department, University of Delaware, Newark, DE
Jim Doolittle, Research Soil Scientist, USDA-NRCS-NSSC, Newtown Square, PA
Jennifer LaPoma, Graduate Student, Geology Department, Montclair State University, Montclair, NJ

Activities:
All activities were completed on 26 March 2008.

Summary:

1. Results of EMI surveying were inconclusive. The EM38-MK2 meter would not properly calibrated at either site (*instrument zero* was not obtained with the narrower, receiver-transmitter separation). The inability to properly calibrate this meter is attributed to interference, which possibly stemmed from the mineralogy of sand grains.

2. At the Ocean County Airport Site, a linear, bead-like pattern of anomalous EMI responses is apparent in the EMI data. This linear pattern trends in a west-northwest to east-southeast direction and could represent a wind streak furrow containing higher-density, darker-colored, sand-size minerals.

3. No distinctive patterns were evident on plots of EMI data collected at the Lakehurst Naval Air Station Site.

It was my pleasure to participate in this investigation of wind streaks in central New Jersey.

With kind regards,

James A. Doolittle
Research Soil Scientist
National Soil Survey Center

cc:
B. Ahrens, Director, National Soil Survey Center, USDA-NRCS, Federal Building, Room 152,100 Centennial Mall North, Lincoln, NE 68508-3866
S. Carpenter, State Soil Scientist/MLRA Office Leader, USDA-NRCS, 75 High Street, Room 301, Morgantown, WV 26505
M. Golden, Director of Soils Survey Division, USDA-NRCS, Room 4250 South Building, 14th & Independence Ave. SW, Washington, DC 20250
W. Tuttle, Soil Scientist (Geophysical), USDA-NRCS-NSSC, P.O. Box 974, Federal Building, Room 206, 207 West Main Street, Wilkesboro, NC 28697
L. West, National Leader, Soil Investigation Staff, USDA-NRCS, National Soil Survey Center, Federal Building, Room 152,100 Centennial Mall North, Lincoln, NE 68508-3866

Background:
Alternating linear bands of lighter and darker tonal patterns are evident on aerial photographs of the Sand Barrens in central New Jersey. Linear, dune-like patterns of low relief are known as wind streaks (Mark Demitroff, personal communication). During the Pleistocene, cold air descended from the continental ice sheets and blew across New Jersey. These high velocity winds stirred-up loose surficial materials and produced aeolian sands dunes and wind streaks. The wind streaks are orientated in a north-northwest to south-southwest orientation and are as longs as 15 km (Mark Demitroff, personal communication). These aeolian sands contain ferrous minerals including titanium. Grains of these higher-density materials were deposited in the furrows, where lower-density, more silica rich materials had been removed. Concentrations of titanium sands may be detectable with electromagnetic induction (EMI) methods.

Equipment:
The EM38-MK2 meter, manufactured by Geonics limited (Mississauga, Ontario) was used in this investigation.[1] This meter requires only one person to operate. No ground contact is required with this meter. The EM38-MK2 meter operates at a frequency of 14,500 Hz. The EM38-MK2 meter weighs about 5.4 kg (11.9 lbs). The meter has one transmitter coil and two receiver coils. The receiver coils are separated from the transmitter at distances of 1.0 and 0.5 m. This configuration provides effective depth ranges of 1.5 and 0.75 m in the vertical dipole orientation and 0.75 and 0.38 m in the horizontal dipole orientation. Operating procedures for the EM38-MK2 meter are described by Geonics Limited (2007). This meter measures the apparent conductivity (EC_a) and susceptibility of earthen materials, which are expressed in milliSiemens/meter (mS/m), and parts per thousand (ppt), respectively. The EM38-MK2 meter can provide simultaneous measurements of both quadrature-phase (conductivity) and in-phase (susceptibility) components within two depth ranges.

The coordinates of each EC_a measurement were recorded with a Trimble AgGPS114 L-band DGPS (differential GPS) antenna (Trimble, Sunnyvale, CA).[1] An Allegro CX field computer (Juniper Systems, North Logan, UT) was used to record and store both EMI and position data.[1] The DAT38-MK2W software program developed by Geomar Software Inc. (Mississauga, Ontario) was used to record, store, and process EMI and GPS data.[1]

To help summarize the results of the EMI surveys, SURFER for Windows (version 8.0), developed by Golden Software, Inc. (Golden, CO), was used to construct the simulations shown in this report.[1] Grids of EMI data were created using kriging methods with an octant search.

Field Methods:
For each survey, the EM38-MK2 meter was operated in the deeper-sensing, vertical dipole orientation. The EM38-MK2 meter was operated in the continuous (measurements recorded at 1-sec intervals) mode. EMI and GPS data were simultaneously recorded in the Allegro CX field computer. While surveying, the EM38-MK2 meter was held about 5 cm (about 2 inch) above the ground surface and orientated with its long axis parallel to the direction of traverse. Surveys were completed by walking at a uniform pace, in a back and forth pattern across each site.

Study Sites:

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

The study sites are located at the Ocean County Airport (39.9199^{o} North Latitude and 74.30201 ^{o} West Longitude) and at the Lakehurst Naval Air Station (40.03955^{o} North Latitude and 74.34124 ^{o} West Longitude). The approximate locations of the survey areas are shown in Figure 1. The Ocean County Airport Site (Figure 1, right-hand image) is located in an area of Lakewood sands, 0 to 5 % slopes (LasB). The very deep, excessively drained Lakewood soils formed in marine sands. Lakewood is a member of the mesic, coated Spodic Quartzipsamments family. The Lakehurst Naval Air Station Site (Figure 1, left-hand image) is located in an area of Downer sandy loam, 2 to 5 % slopes (DoeB). The very deep, excessively drained Downer soils formed in marine sediments. Downer is a member of the coarse-loamy, siliceous, semiactive, mesic Typic Hapludults family.

Figure 1. Soil maps have been overlaid on aerial photographs of the Lakehurst Naval Air Station Site (left-hand image) and the Ocean City Airport Site (right-hand image).

Results:

At each site, the EM38-MK2 meter would not properly calibrated (*instrument zero* was not obtained with the narrower, receiver-transmitter separation). The meter is new, has recently been calibrated by its manufacturer, and is operating properly. The inability to properly calibrate this meter is attributed to interference, which possibly stemmed from the mineralogy of the sand grains.

Figure 2 contain computer simulations of the EMI data. The EMI data shown in this figure were collected at the Ocean County Airport (left-hand plots) and the Lakehurst Naval Air Station (right-hand plots). These plots show the spatial distribution of data that were collected with the EM38-MK2 meter in both the inphase (upper plots) and quadrature phase (lower plots) modes. The inphase data is expressed in parts per thousand (ppt); the quadrature phase data is expressed as apparent conductivity (EC_a) measured in milliSiemens/meter (mS/m). In Figure 2, the same color scheme, but different color ramps or scales have been used in each plot.

At both sites, the majority of EMI responses were relatively low and invariable. While data collected in the inphase mode is often more sensitive to buried metallic objects (McNeill, 1983), similar spatial patterns were observable in each mode of measurement. At the Ocean County Airport Site, a linear bead-like pattern of anomalous EMI responses is apparent in both sets of EMI data. This linear pattern trends in a west-northwest to east-southeast direction and could represent a wind streak furrow, which contains high-density and dark colored, sand-size minerals. If the EMI

responses are attributed to the mineralogy of the sand grains, the distribution of more ferrous minerals is not uniform within the furrow.

On the plots from the Lakehurst Naval Air Station an anomalous EMI pattern is evident in the extreme southwestern corner of the study area. This anomaly could be part of a larger linear pattern. In order to confirm that this anomaly is part of a larger linear feature, the survey area would have to be enlarged.

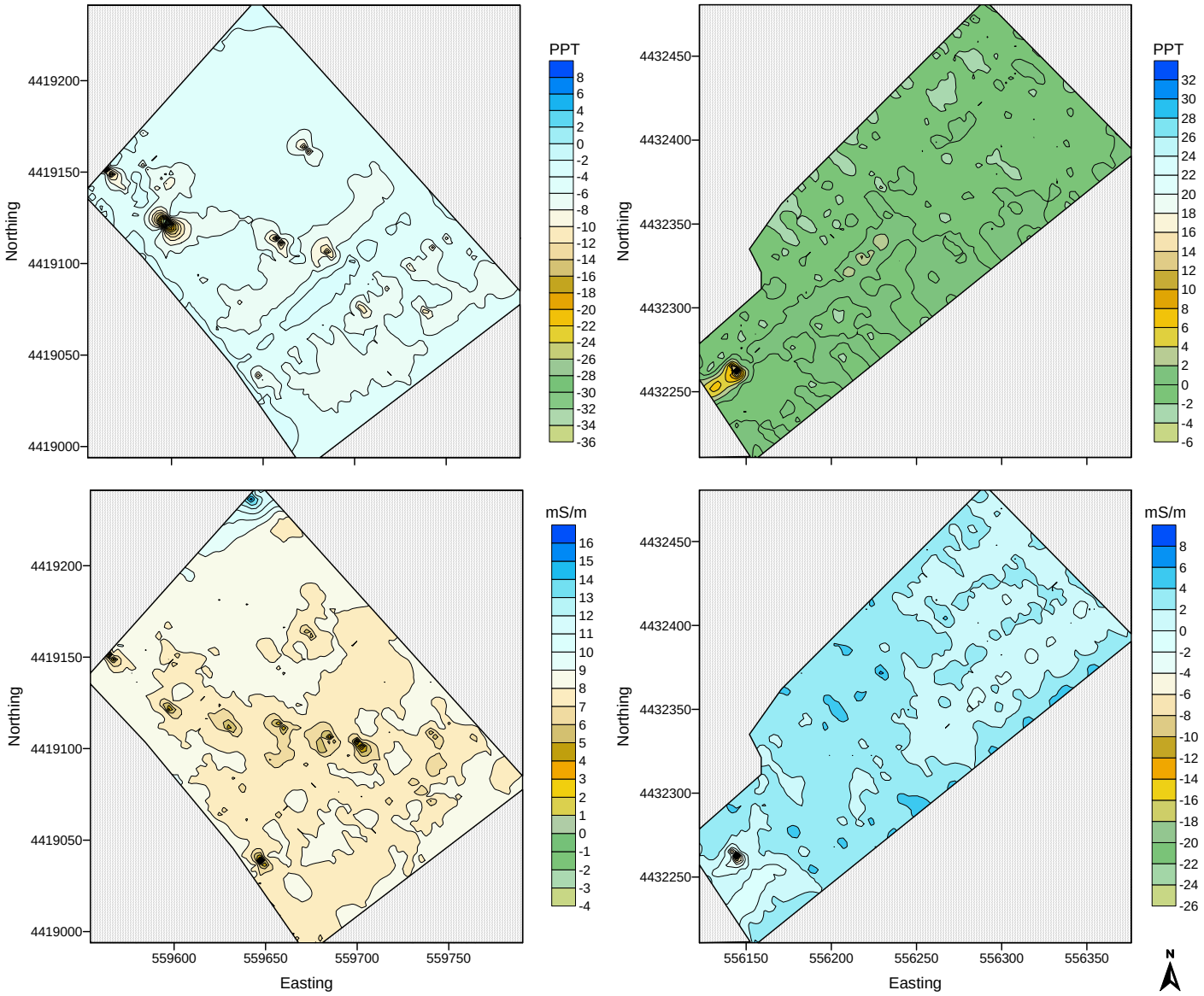

Figure 2. Two-dimensional plots of the EMI data collected at Ocean County Airport (left-hand plots) and Lakehurst Naval Air Station (right-hand plots). The EMI data were collected with the EM38-MK2 meter orientated in the vertical dipole orientation and are for the 1.0 meter separation.

References:

Geonics Limited, 2007. EM38-MK2 ground conductivity meter operating manual. Geonics Ltd., Mississauga, Ontario.

McNeill, J. D., 1983. Use of EM31 inphase information. Technical Note TN-11. Geonics Ltd., Mississauga, Ontario.