Comparative Study of EM38DD and EM38-MK2 meters.

An EM38-MK2 meter has been loaned to the National Soil Survey Center (NSSC) by Geonics Limited for field evaluations. Presently, the EM38 and EM38DD meters are the principal device used to map soil variability by soil scientists. The NSSC, as a rule, uses the EM38DD meter. An EMI survey was conducted in an area of hay land in Bayfield County, Wisconsin. The fields are bounded on the east by a wooded, more steeply sloping area; on the north by a farm road; and on the west by a county road. A utility line crosses the northwest corner of the survey area. This line produced interference that masked soil patterns in this portion of the survey area...

The field is mapped as Porting-Herbster complex, 0 to 6 percent slopes, and Morganlake loamy sand, 0 to 6 percent slopes. Table 1 lists the taxonomic classifications of these soils. The very deep, moderately well drained Portwing and the somewhat poorly drained Herbster soils formed in clayey glacial till and/or clayey lacustrine deposits over stratified loamy and/or sandy lacustrine deposits. The thickness of the clayey till and depth to the stratified substratum ranges from 40 to 60 inches. The weighted average clay content of the particle-size control section ranges from 35 to 60 percent. Depth to free carbonates ranges from 20 to 40 inches. The very deep, moderately well drained Morganlake soils formed in sandy outwash and in the underlying loamy glacial till. The thickness of the sandy mantle and depth to till range from 20 to 40 inches. Reaction ranges from moderately acid to moderately alkaline in the till. The till averages 15 to 50 percent fine sand or coarser and 18 to 35 percent clay in at least the upper 5 inches.

Table 1. Taxonomic composition of soils

Soil Series	Taxonomic Classification
Herbster	Fine, mixed, superactive, frigid Aeric Glossaqualfs
Morganlake	Sandy over loamy, mixed, active, frigid Alfic Oxyaquic Haplorthods
Portwing	Fine, mixed, superactive, frigid Oxyaquic Glossudalfs

Equipment:

Geonics Limited manufacturers the EM38DD and the EM38-MK2 meters.[1] Both meters are portable and require only one person to operate. No ground contact is required with either meter. Geonics Limited (2000) describes the use and operation of the EM38DD meter. The EM38DD meter consists of two EM38 meters bolted together and electronically coupled. One unit acts as a master unit (meter that is positioned in the vertical dipole orientation and having both transmitter and receiver activated) and one unit acts as a slave unit (meter that is positioned in the horizontal dipole orientation with only the receiver switched on). Each meter has a 1 m intercoil spacing and operates at a frequency of 14,600 Hz. The EM38DD meter has effective penetration depths of about 0.75 and 1.5 m in the horizontal and vertical dipole orientations, respectively (Geonics Limited, 2000).

The EM38-MK2 meter consists of transmitter and two receiver coils that are horizontal coplanar. The transmitter coil is positioned at spacings of 0.5 and 1.0 meters from the receiver coils. The meter is operated in the vertical dipole orientation. In this orientation, the effective depth of penetration is 1.5 times the intercoil spacing. The meter provides depth-weight apparent conductivity (EC_a) measurements for the upper 75 and 150 cm of the soil profile.

The Geonics DAS70 Data Acquisition System was used to record and store both EMI and GPS data.[1] The acquisition system consists of an EM38DD or an EM38-MK2 meter, Allegro field computer, and Trimble AG114 GPS receiver. [1] With the acquisition system, the EMI meters are keypad operated and measurements are automatically triggered every second.

To help summarize the results of this study, SURFER for Windows (version 8.0) software developed by Golden Software, Inc.,[1] was used to construct two-dimensional simulations. Grids were created using kriging methods with

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

an octant search.

Survey Procedures:
EMI surveys were competed with both meters held about 2 to 3 inches above the ground surface with their long axes parallel to the direction of traverse. Walking at a fairly brisk and uniform pace, in a random back and forth pattern across the survey area, the EM38DD and EM38-MK2 meters recorded 1232 AND 1242 geo-referenced measurements, respectively. The operator of one meter followed the path of the other operator and meter at a distance of about 25 feet to avoid interference. Table 2 shows the basic statistics for these two EMI surveys.

Table 2 Basic Statistics for EMI surveys conducted in Bayfield County, Wisconsin.

	EM38-MK2		**EM38DD**	
	Shallow	**Deep**	**Horizontal**	**Vertical**
Mean	14.0	18.8	21.8	23.2
Standard Dev.	7.1	9.7	13.5	13.1
Minimum	1.9	2.0	-2.4	-4.9
Maximum	45.9	72.5	184.1	104.6
25% tile	6.9	9.1	11.6	11.1
75% tile	19.3	26.1	28.6	32.9

Higher and more variable EC_a were measured with the EM38DD meter than with the EM38-MK2 meter. This is attributed to calibration errors and/or minor position errors. Setup procedures were carefully followed, but the two meters did not provide identical EC_a at the same observation points or across the survey area. It is also possible that the EM38DD meter is less stable. As measurements collected with the EM38DD meter in horizontal dipole orientation were the most variable, concern is directed at possible sources of interference (operator motions, eyelets on operators boots, and variations in the column of air between the bottom of the meter and the soil surface while surveying).

In the setup procedure for both meters, it is uncertain whether a final instrument zero calibration is needed when the meters are placed on the ground surface.

Plots of EC_a collected with the EM38DD and EM38-MK2 meters are shown in Figure 1. In each plot similar color ramps and isoline (6 mS/m) intervals have been used. In each plot, the likely location of the buried utility cable is shown in the northwest (upper left-hand) corner of the survey area. Regardless of device, orientation, or intercoil spacing, major spatial patterns are strikingly similar. In general areas mapped as the sandy Morganlake soils have lower EC_a (<12 mS/m) than areas mapped as the finer-textured Porting and Herbster soils (>18 mS/m). Though not verified, areas with intermediate EC_a are believed to represent transitional soils.

The EC_a maps closely approximate the soil map for these fields. However, the area of low (< 12 mS/m) EC_a soils shown in the west-central portion of the survey area had been missed by traditional Order-2 soil mapping.

With each meter, EC_a increases with increasing penetration depth. For the EM38DD meter, EC_a measured in the shallower sensing horizontal dipole orientation was less than EC_a measured in the deeper-sensing vertical dipole orientation. For the EM38-MK2 meter, EC_a measured with the shallower sensing 0.5 m intercoil spacing was less than EC_a measured in the deeper-sensing 1.0 m intercoil spacing. This reflects the general soil profile characteristic of increasing clay content with increasing soil depth.

The data collected with the EM38-MK2 meter appears less noisy and is preferred. Data collected with the EM38DD meter was more variable over short distances and more extreme.

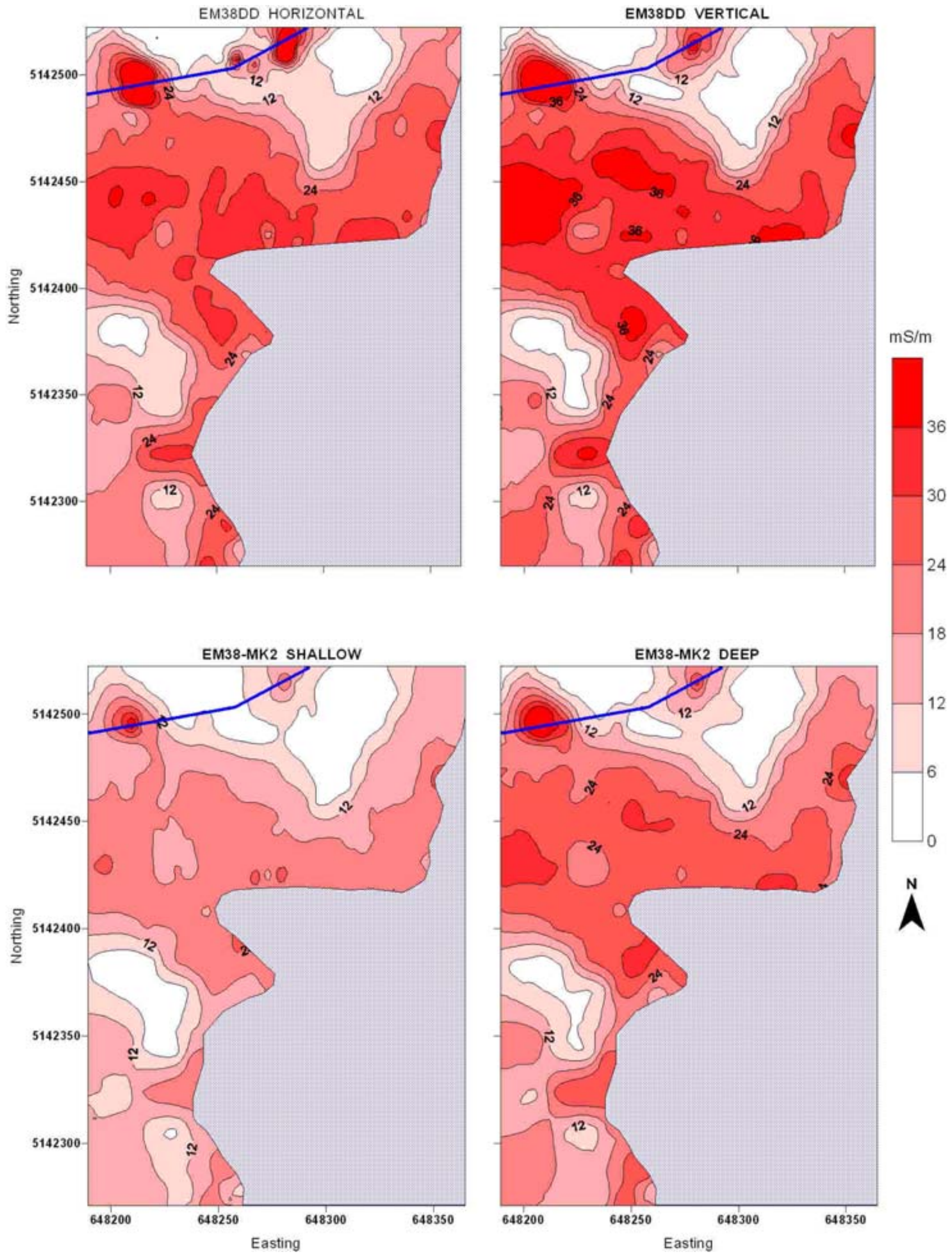

Figure 1. Plots of EC_a from the Bayfield County site.

Reference:

Geonics Limited. 2000. EM38DD ground conductivity meter: Dual dipole version operating manual. Geonics Ltd., Mississauga, Ontario.