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

Subject: -- Geophysical Assistance -- **Date:** 22 March 2006

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Purpose:
The purpose of this investigation was to complete electromagnetic induction (EMI) surveys of two small drainage basins that are located in MLRA 115 (The Central Mississippi Valley Wooded Slopes) in Union and Alexander Counties, southern Illinois. This study supports the *Southern Illinois Soil Landscape/Soil-Geochemical Landscape Study* initiated by Sam Indorante (Soil Survey Project Leader, USDA-NRCS, Carbondale, IL) and Mike Wilson (Research Soil Scientist, USDA-NRCS, National Soil Survey Center, Lincoln, NE). The EMI surveys provide an additional layer of soil information, which may be helpful in the development of regional soil-landscape and ground water flow models.

Participants:
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Activities:
All field activities were completed during the period of 27 February to 2 March 2006.

Results:

1. Though much is inferential at this time, EMI appears to have segmented the landscape within two small drainage basins into distinct hydropedological units. Maps of apparent conductivity can help us to better understand the influence of soil and stratigraphic layering on water flow, and the impact of water movement and chemical transport on the development of soils.

2. Lateral water flow along less permeable layers in anisotropic drift materials and evaporative discharge in seepage zones has been hypothesized to explain chemical transport and sodium redistribution in some soils of this area (Indorante, 1998). During periods of wetness, the perching and lateral movement of water results in the preferential movement and accumulation of salts and bases in seepage zones, and leads to the differentiation of soils. Interpretative results of EMI surveys and limited ground-truth observations support these hypotheses.

3. Menfro soil dominates both drainage basins and landscapes. Polygons of this soil have been mapped principally on the basis of similar morphology, but different slope phases. If the interpretations and model proposed by this study are confirmed by the core samples, which have been sent to the National Soil Survey Laboratory for analysis, it is anticipated that chemical and physical properties will vary noticeably between samples collected on plane and convex summit, shoulder and upper back slope, and samples collected on lower-lying plane and concave back slopes.

4. Water is a driving force in soil development and differentiation. Hydropedology provides the necessary links which makes these landscapes and soil forming processes more understandable.

With kind regards,

James A. Doolittle
Research Soil Scientist
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cc:
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Background:
Electromagnetic induction (EMI) is a non-invasive geophysical method that measures the apparent conductivity (EC_a) of earthen materials. Apparent conductivity is principally dependent upon the moisture, clay and soluble salt contents of soils (McNeill, 1980a). Electromagnetic induction is an accepted tool for the refinement and improvement of maps prepared with traditional survey methods. Because EMI data can be rapidly and effortlessly gathered, with EC_a measured on a second-by-second basis, data populations are relatively large and sites can be more comprehensibly covered in a shorter period of time than with conventional survey tools and methods. Areas with different EC_a have been associated with different soils and hydropedological properties. As a result of spatial differences in EC_a, small areas with dissimilar soils and hydropedological properties, which may be overlooked using traditional survey tools and methods, are often depicted on EC_a maps.

Recently, EMI has been used in hydropedological investigations to help characterize spatial and temporal variations in soil moisture contents, depth to water tables, and groundwater flow patterns at different scales and levels of resolution. Allred et al. (2005) observed that EC_a is strongly affected by the near-surface volumetric water content and the depth to the water table. Several researchers have documented the positive relationship that exists between EC_a and soil water content, and the negative relationships that exist among relative elevation, depth to water tables, and EC_a (Khakural et al., 1998; Sheets and Hendrickx, 1995; Kachanoski et al., 1990 and 1988). Because of these relationships, EMI has been used successfully to map spatial and temporal variations in water table depths (Schumann and Zaman, 2003; Doolittle et al., 2000) and drainage classes (Kravchenko et al., 2002).

Apparent conductivity is sensitive to changes in soil water content, and the concentration and mobility of ions dissolved in the soil solution (Allred et al., 2005). In arid and semiarid areas, EMI has been used to characterize unsaturated flow (Scanlon et al., 1999), estimate rates of groundwater recharge (Cook et al., 1989a, 1989b, 1992), map groundwater discharge zones (Richardson and Williams, 1994), and to assess differences in soluble salt contents across landscapes (Cook et al., 1989a). In humid areas, where the concentration of dissolved electrolytes is low, spatial changes in EC_a have been principally related to changes in volumetric water content and soil texture (Kachanoski et al., 1990).

In this study, EMI was used as a rapid reconnaissance tool to map EC_a across two small drainage basins dominated by Menfro soils in the Upper Mississippi Valley Wooded Hillslopes Area (MLRA 155) of southern Illinois. Differences in EC_a were associated with hydropedological properties and different landscape components within these two small drainage basins.

Equipment:
The EM31 and EM38 meters (manufactured by Geonics Limited, Mississauga, Ontario) were used in this study.[1] Both meters are portable and need only one person to operate. No ground contact is required with either meter. The EM38 meter weighs about 1.4 kg (3.1 lbs), has a 1-m intercoil spacing, and operates at a frequency of 14,600 Hz. When placed on the soil surface, it has a theoretical penetration depth of about 1.5 m in the vertical dipole orientation (Geonics Limited, 1998). The size and light weight of this instrument makes it suited for pedestrian surveys conducted on steeply-sloping, forested terrains provided there is limited underbrush and ground cover (see Figure 1, left).

The EM31 meter weighs about 12.4 kg (27.3 lbs), has a 3.7-m intercoil spacing, and operates at a frequency of 9,810 Hz. McNeill (1980b) has described the operation of the EM31 meter. When placed on the soil surface, the EM31 meter provides a theoretical penetration depth of about 6 meters in the vertical dipole orientation (McNeill, 1980b). The relatively large boom extension of this instrument makes it difficult to maneuver in forested terrains (see Figure 1, right).

The Geonics DAS70 Data Acquisition System was used with the two EMI meters to record and store both EC_a and position data.[1] The acquisition system consisted of an EMI meter; an Allegro CE or CX field computer (Juniper Systems, North Logan, UT) with the Geonics Limited's DAT31W or DAT38W, or the Geomar's Trackmaker 31 software (Geomar Software, Inc., Mississauga, Ontario); and a Garmin Global Positioning System (GPS) Map 76 receiver (with a CSI Radio Beacon receiver, antenna, and accessories that are fitted into a backpack) (Garmin

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

International, Inc., Olathe, KS).[1] When attached to the acquisition system, each EMI meter is keypad operated and measurements can be automatically triggered.

To help summarize the results of the EMI surveys, the 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 EC_a data were created using kriging methods with an octant search.


Figure 1. Operation of EM38 (left) and EM31 (right) meters in the forested, sloping terrains of the Bean Ridge Road Site, Union County, Illinois.

Study Sites:
This study is being conducted within two small drainage basins in southern Illinois. These drainage basins are identified by local features and known as the Morgan Pond and Bean Ridge Road Sites. Noticeable divides separate each drainage basin from surrounding basins. Each drainage basin contains an intermittent stream that only flows for part of the year. The stream within each basin is identified on topographic maps by a line of blue dashes and dots. The two intermittent streams have no tributaries.

Figure 2. A view across the Morgan Pond Site looking towards the northwest.

Both sites are underlain by limestone bedrock. Limestone bedrock outcropped along the lower reaches of the stream channel at the Bean Ridge Road Site. Major soils recognized at the two sites include Drury, Menfro, Wakeland and Winfield. Table 1 lists the taxonomic classifications of the soils observed within the two drainage basins. Table 2 summarizes some of the basic properties of these soils. Most soils are very deep and formed in silty loess or alluvial deposits. Although the Drury series is described as "deep," no contrasting materials are listed in its Official Series Description. In the Soil Data Mart for Alexander County, Drury soil is described as being very deep. The soils recognized within the two sites are very deep and belong to the coarse-silty or fine-silty particle-size and the active or superactive cation-exchange activity classes (Table 1). The upland loessial soils are Alfisols. Alluvial soils along the stream channel are either Entisols or Inceptisols. Though taxonomically distinct and belonging to different particle-size classes, differences in clay contents among most of the soils are considered slight. At the time of the EMI surveys, soils were moist throughout. Differences in clay and moisture contents, though considered slight, were initially assumed to be responsible for the modestly variable EC_a responses that were evident across the two sites.

Table 1.
Taxonomic Classification of Soils

Series	Taxonomic Classification
Belknap	Coarse-silty, mixed, active, acid, mesic Fluvaquentic Endoaquepts
Bunkum	Fine-silty, mixed, superactive, mesic Aquic Hapludalfs
Coulterville	Fine-silty, mixed, superactive, mesic Aeric Epiaqualfs
Drury	Fine-silty, mixed, superactive, mesic Dystric Eutrudepts
Homen	Fine-silty, mixed, active, mesic Oxyaquic Hapludalfs
Hosmer	Fine-silty, mixed, active, mesic Oxyaquic Fragiudalfs
Menfro	Fine-silty, mixed, superactive, mesic Typic Hapludalfs
Plumfield	Fine-silty, mixed, active, mesic Aquic Fragiudalfs
Wakeland	Coarse-silty, mixed, superactive, nonacid mesic Aeric Fluvaquents
Wilbur	Coarse-silty, mixed, superactive, mesic Fluvaquentic Eutrudepts
Winfield	Fine-silty, mixed, superactive, mesic Oxyaquic Hapludalfs

Table 2.
Characteristics of Soils

Series	Characteristics
Belknap	Very deep, SWP soils that formed in silty alluvium on flood plains.
Bunkum	Very deep, SWP soils that formed in loess and a silty pedisediment.
Coulterville	Very deep, SWP soils that formed in loess on uplands.
Drury	Deep, WD soils that formed in silty local alluvial sediments on foot slopes.
Homen	Very deep, MWD soils that formed in loess or a silty pedisediment on uplands.
Hosmer	Very deep, MWD soils that formed in loess on uplands. Moderately deep to fragipan
Menfro	Very deep, WD soils that formed loess on upland ridge tops, back slopes and benches
Plumfield	Very deep, MWD soils that formed in loess or pedisediment on side slopes. Shallow to fragipan.
Wakeland	Very deep, SWP soil that formed in silty alluvium on flood plains.
Wilbur	Very deep, MWD soils that formed in alluvium on flood plains.
Winfield	Very deep, MWD soils that formed in loess on ridge tops and side slopes.

The Morgan Pond Site is located in the NW ¼ of the NE ¼ of Section 28, T 13 S, R 1 W in Union County (see Figure 2). Relief is about 5.5- m within this site. An intermittent stream flows to the northeast and into Adds

Branch, a tributary to the Cypress Creek. The site is presently in CRP, but was formerly used for row crops and pasture. Map units delineated within this drainage basin include: Menfro silt loam, 2 to 5 % slopes (M. U. 79B); Menfro silt loam, 5 to 10 % slopes, severely eroded (M. U. 79C3); Menfro silt loam, 10 to 18 % slopes, severely eroded (M. U. 79D3); and Wakeland silt loam, 0 to 2 % slopes, frequently flooded (M. U. 3333A). Polygons of Menfro soils dominate higher-lying, convex summit, shoulder and back slope areas. The polygon of Wakefield soil is restricted to lower-lying, plane and concave slopes adjacent to the intermittent stream.

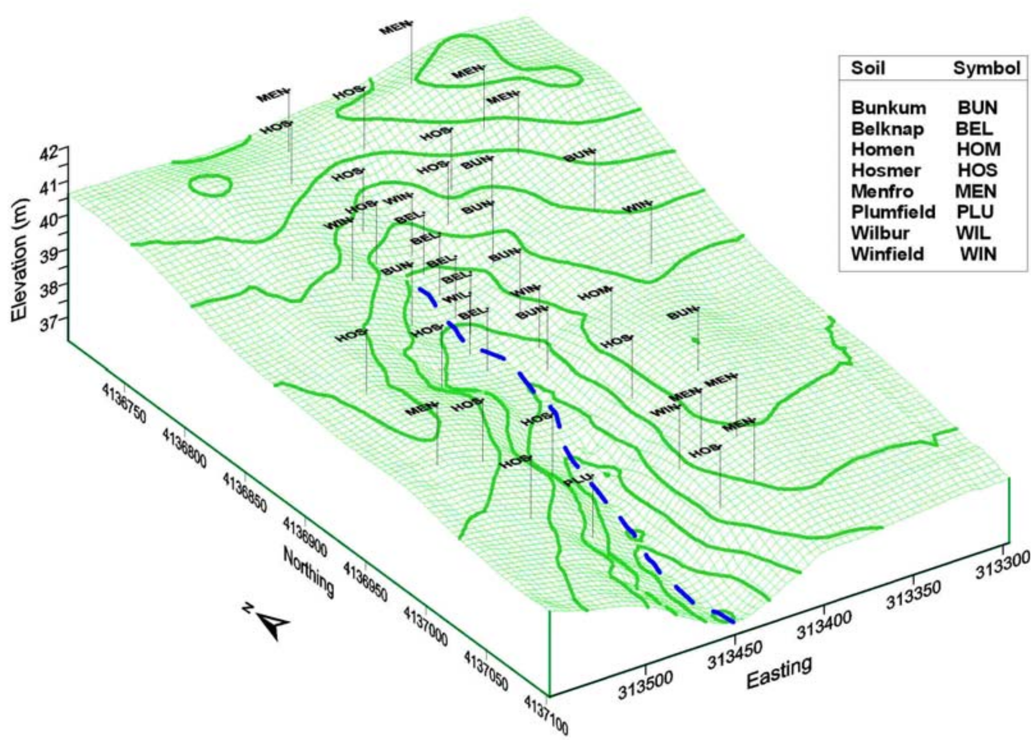

Figure 3. Three-dimensional block diagram showing relative elevation and the locations and names of the soils identified within the Morgan Pond Site.

Detailed topographic surveys were completed of each drainage basin. Figure 3 is a three-dimensional surface net diagram showing the relative topography within the Morgan Pond Site. In the diagram shown in Figure 3, the contour interval is 50 cm. The approximate location of the intermittent stream that drains this basin is shown on this plot. As part of this study, a total of 50 cores were obtained within the drainage basin. Approximately 10 cores were taken from each major soil-landscape component. The locations and names of the soil identified at each of these cores are shown in Figure 3. Based on core-observations, higher-lying, convex summit, shoulder and back slope areas are dominated by Menfro (about 40 %), Hosmer (about 25 %) and Winfield (about 20 %) soils, with minor inclusions (about 15 %) of Bunkum and Homen soils. Lower-lying, plane and concave areas adjacent to the intermittent stream are dominated by Belknap (about 35 %) and Hosmer (about 20 %) soils, with inclusions (about 45 %) of Bunkum, Plumfield, Wilbur and Winfield soils.

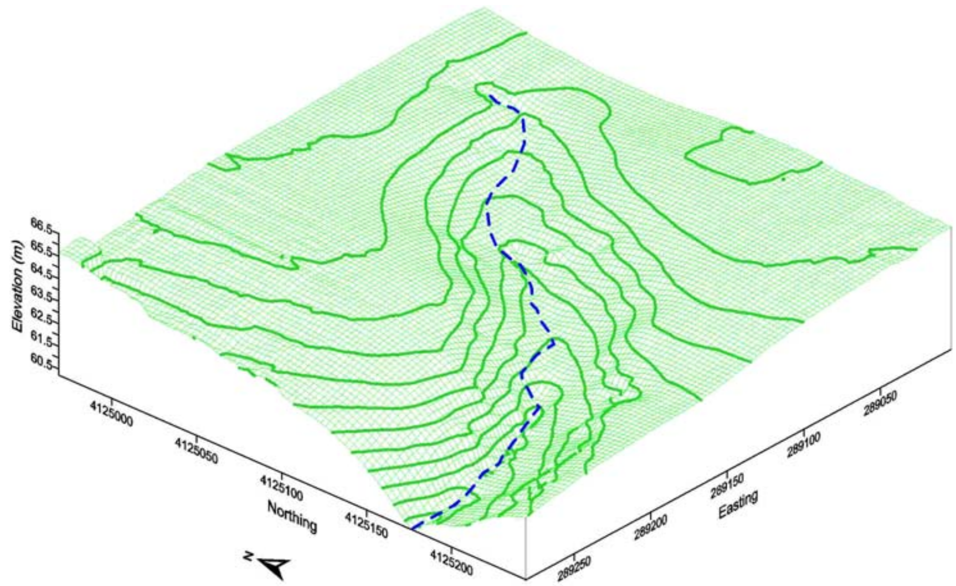

Figure 3. Three-dimensional block diagram showing the topography of the Bean Ridge Road Site.

The Bean Ridge Road Site is a forested area located in the SE ¼ of Section 31, T 13 S, R 2 W in Alexander County (see Figure 1). Relief is about 6.3-m within this site. The intermittent stream is deeply channeled and flows to the northeast and east into Ambeer Creek, a tributary to the West Branch of Sandy Creek. Compared with the Morgan Pond Site, slopes within the Bean Ridge Road Site are more complex and typically shorter and steeper. Map units delineated within this site include: Drury silt loam, 10 to 18 % slopes (M. U. 75D); Menfro silt loam, 5 to 10 % slopes, eroded (M. U. 79C2); Menfro silt loam, 10 to 18 % slopes (M. U. 79D); and Winfield silt loam, 18 to 25 % slopes, severely eroded (M. U. 477E3).

Figure 4 is a three-dimensional surface net diagram showing the relative topography of the Bean Ridge Road Site. In the diagram shown in Figure 4, the contour interval is 50 cm. The approximate location of the intermittent stream that drains this basin is shown on this plot. At the time of this report, no soil cores had been obtained within this drainage basin.

Field Procedures:

Both meters were operated in the vertical dipole orientation and continuous mode, with measurements recorded at 1-sec intervals. The EM31 was held at hip-height with its long axis generally orientated parallel to the direction of traverse. The EM38 meter was generally orientated with its long axis parallel to the direction of traverse. Where possible, the EM38 meter was held about 5 cm (2 inches) above the ground surface. However, steep slopes, tree limbs, underbrush, and fallen forest debris made walking difficult and caused the meter to vary slightly in height (see Figure 1, left). Where possible, traverses were conducted parallel with the slope contours.

Results:

<u>Morgan Pond Site</u>

Table 3 summarizes the results of the EMI surveys that were conducted with the EMI meters at the Morgan Pond Site. For the shallower-sensing (0 to 1.5 m) EM38 meter (operated in the vertical dipole orientation (EM38-V)), EC_a ranged from -15.8 to 35.5 mS/m. Negative values are attributed to metallic artifacts that were discarded or buried in the field and crossed or closely approached with the EMI meter during the survey. With the EM38 meter, EC_a averaged 16.3 mS/m with a standard deviation of 4.6 mS/m. One-half the EC_a measurements recorded with the EM38 meter were between 13.0 and 19.1 mS/m. For the deeper sensing (0 to 5 m) EM31 meter (operated in the vertical dipole orientation (EM31-V)), EC_a ranged from 14.4 to 49.7 mS/m. Apparent conductivity averaged 25.3 mS/m with a standard deviation of 4.7 mS/m. One-half the EC_a measurements were between 21.7 and 28.6 mS/m.

Table 3
Basic EMI Statistics for EMI surveys at Morgan Pond Site, Union County.
(Other than the number of observations, all values are in mS/m)

	EM38-V	EM31-V
Number	5407	5407
Mean	16.3	11.2
Standard Deviation	4.6	7.8
Minimum	-0.8	-87.9
Maximum	35.5	79.5
25%-tile	13.0	8.8
75%-tile	19.1	11.6

Figures 5 and 6 contain plots of EC_a measured with the EM38 and EM31 meters, respectively. In each plot, a two-dimensional map of EC_a has been draped over a three-dimensional topographic plot of the site. In each plot, the isoline interval is 2 mS/m and the same color scale is used.

Absolute EC_a values varied with each instrument and their effective penetration depths. This reflects differences in the depth-weighting function, and the effective depth and volume measured with each instruments. Although absolute values did vary with each EMI instrument, the resulting spatial patterns of EC_a are remarkably similar and conformed to landscape components. Comparing Figures 5 and 6, it is evident that EC_a increases with depth (measurements obtained with the deeper-sensing EM31 meter are typically higher than those obtained with the shallower sensing EM38 meter). This trend is assumed to principally reflect increased moisture contents with increasing soil depth.

The lowest range in EC_a was measured with each meter on higher-lying, convex summit and shoulder slopes. These landscape components are dominated by the very deep, well drained Menfro and moderately well drained Hosmer soils. Here, EC_a measured with the EM38 and EM31 meter ranged from 12 to 16 mS/m and from 20 to 24 mS/m, respectively. Upper back slopes are dominated by the very deep, moderately well drained Hosmer and Winfield soils. Upper back slopes appear to have slightly higher EC_a than higher-lying, convex summit and shoulder slopes. On upper back slope, EC_a typically ranged from 16 to 20 mS/m and 24 to 28 mS/m, for the EM38 and EM31 meters, respectively. The highest EC_a was measured with both meters on lower-lying, plane and concave lower back slopes that formed a band around the lower-lying alluvial soils. These lower back slope components are dominated by the very deep, moderately well drained Hosmer, Plumfield, and Winfield soils and the somewhat poorly drained Bunkum soil (see Figure 3). Here, EC_a ranged from 18 to 26 mS/m and 28 to 36 mS/m for the EM38 and EM31 meters, respectively. The very deep, somewhat poorly drained Belknap and the moderately well drained Wilbur soils occur on concave foot slopes along the drainage channel. Here, EC_a ranged from 14 to 20 mS/m and 26 to 30 mS/m for the EM38 and EM31 meters, respectively. The lower than anticipated EC_a along the stream channel was attributed to lower clay and (presumably) moisture contents of these coarse-silty soils.

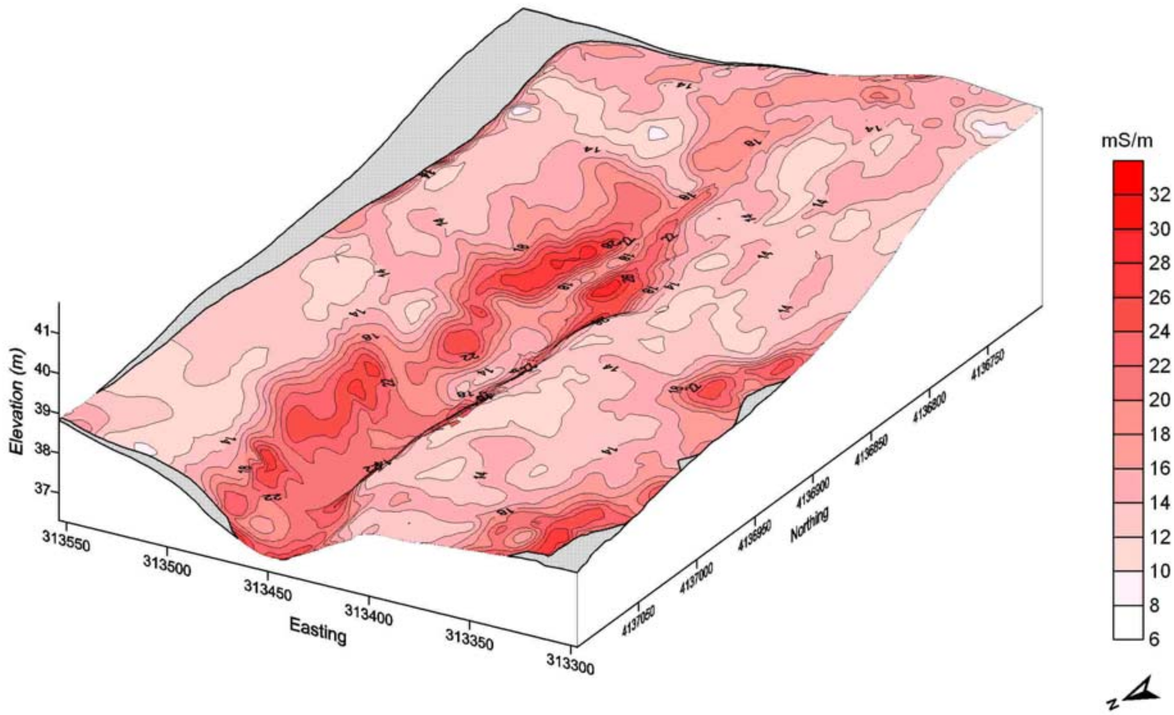

Figure 5. Plot of EC_a collected with the EM38 meter in the vertical dipole orientation at the Morgan Pond Site.

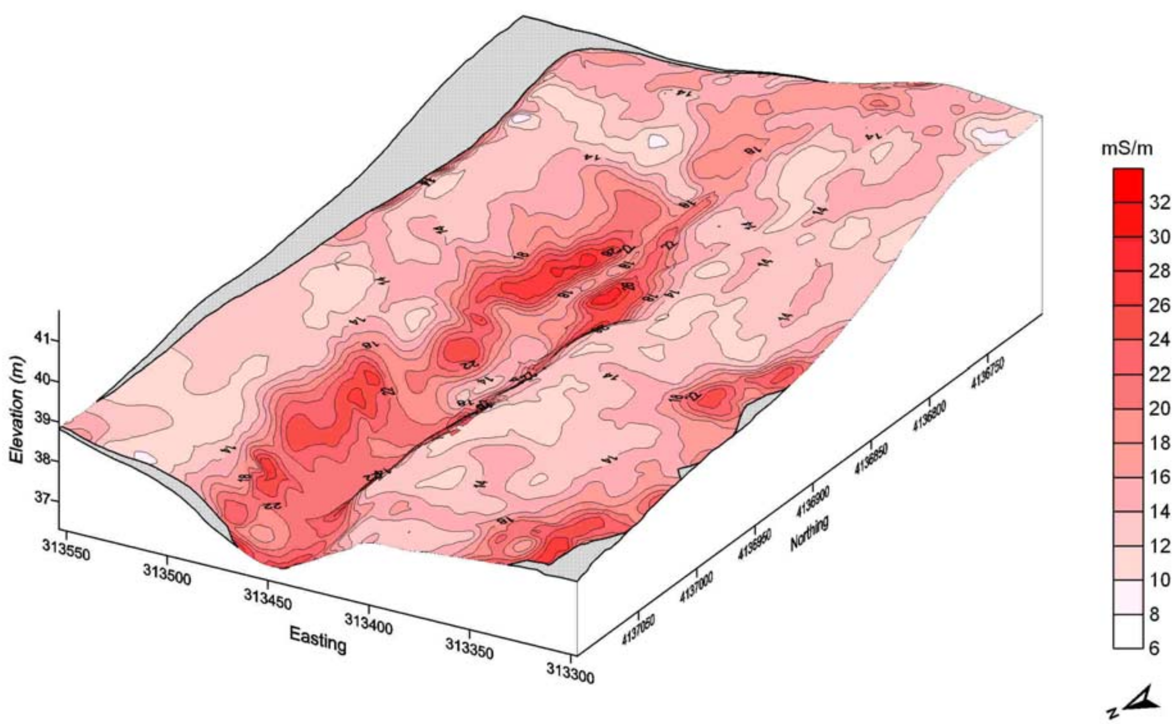

Figure 6. Plot of EC_a collected with the EM31 meter in the vertical dipole orientation at the Morgan Pond Site.

Bean Ridge Road Site

Table 4 summarizes the results of the EMI surveys that were conducted at the Bean Ridge Road Site. Compared with the Morgan Pond Site, EC_a was generally lower at the Bean Ridge Site. The lower EC_a can be attributed to shallower depths to resistive bedrock and more sloping and dissected areas (which favors greater water runoff). For the shallower-sensing EM38 meter (operated in the vertical dipole orientation (EM38-V)), EC_a ranged from about -8.9 to 39.2 mS/m. Negative values are attributed to metallic artifacts that were discarded or buried in the field and crossed or closely approached with the EMI meter during the survey. With the EM38 meter, EC_a averaged 13.6 mS/m with a standard deviation of 4.2 mS/m. One-half the EC_a measurements were between 10.6 and 16.2 mS/m. For the deeper sensing EM31 meter (operated in the vertical dipole orientation (EM31-V)), EC_a ranged from about 2.0 to 31.4 mS/m. Apparent conductivity averaged 17.7 mS/m with a standard deviation of 3.6 mS/m. One-half the EC_a measurements were between 16.3 and 19.6 mS/m.

Table 4
Basic EMI Statistics for EMI surveys at Bean Ridge Road Site, Alexander County.
(Other than the number of observations, all values are in mS/m)

	EM38-V	EM31-V
Number	4124	2411
Mean	13.6	17.7
Standard Deviation	4.2	3.6
Minimum	-8.9	2.0
Maximum	39.2	31.4
25%-tile	10.6	16.3
75%-tile	16.2	19.6

Figures 7 and 8 contain plots of EC_a measurements recorded with the EM38 and EM31 meters at the Bean Ridge Road Site, respectively. In each plot, a two-dimensional map of EC_a has been draped over a three-dimensional topographic plot of the site. In each plot, the isoline interval is 2 mS/m and the same color scale is used.

Absolute EC_a values varied with each instrument and their effective penetration depths. This reflects differences in the depth-weighting function, and the effective depth and volume measured with each instruments. Comparing Figures 7 and 8, it is evident that EC_a increases with depth (measurements obtained with the deeper-sensing EM31 meter are typically higher than those obtained with the shallower sensing EM38 meter). This trend is assumed to principally reflect increased moisture contents with increasing soil depth.

Similar spatial patterns of EC_a can be found at the Bean Ridge Road Site as were found at the Morgan Pond Site. Lower values of EC_a occur on summit, shoulder and upper back slopes. The lower EC_a on these slope components is attributed to soils with similar clay contents, but better drainage and lower soil moisture contents. As at the Morgan Pond Site, a conspicuous band of higher EC_a occurs on lower back slopes. Here, higher EC_a is attributed to lateral seepage of ground water. Limestone bedrock is electrically resistive and outcrops along the lower reaches of the drainage channel. In areas where the limestone outcrops or is close to the soil surface, EC_a is exceptionally low (see plots in Figures 7 and 8).

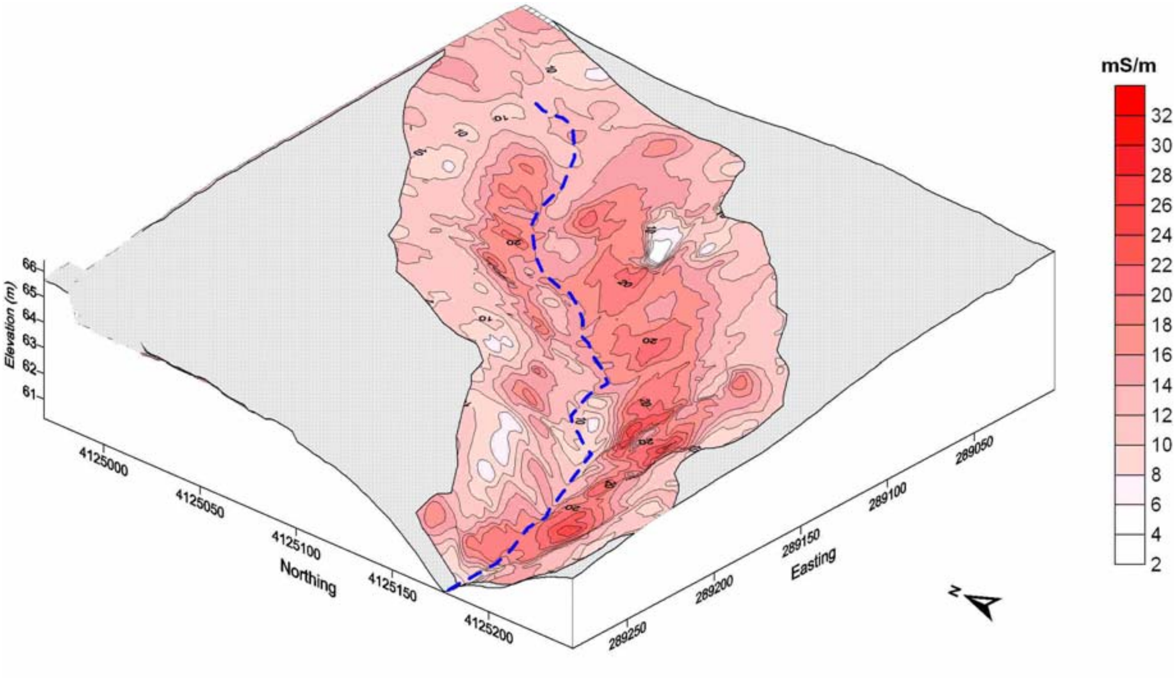

Figure 7. Plot of EC_a collected with the EM38 meter in the vertical dipole orientation at the Bean Ridge Road Site.

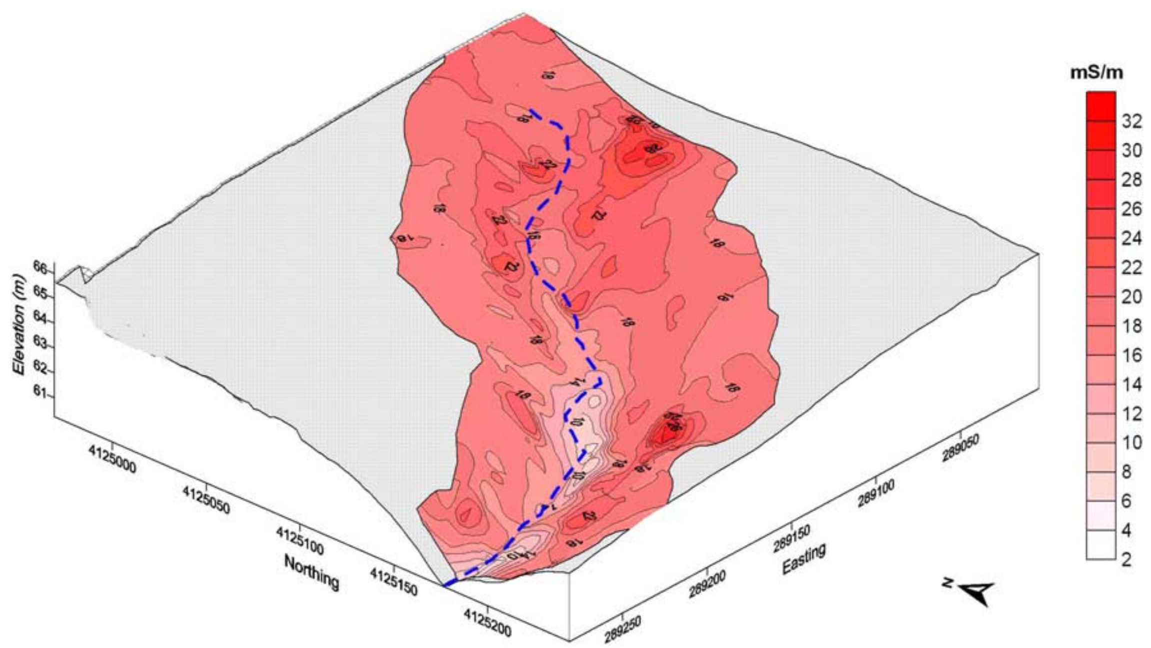

Figure 8. Plot of EC_a collected with the EM31 meter in the vertical dipole orientation at the Bean Ridge Road Site.

Discussion:

At both sites, EC_a increases with depth (measurements obtained with the deeper-sensing EM31 meter are typically higher than those obtained with the shallower sensing EM38 meter). The regolith is anisotropic with layers of loess, overlying till, overlying limestone bedrock. These anisotropic materials, each with different permeability, restrict and redirect the flow of water and foster the development of perched water tables. Ground water is believed to flow laterally along these interfaces and to reappear as seepage on lower back slopes adjacent to drainage channels. Plots of EMI data shown in this report support this idea.

In most studies, the highest EC_a is typically recorded on lower-lying areas adjacent to stream channels where the depth to the water table is shallowest and the volumetric soil moisture content is the highest. This relationship was not evident within the two investigated drainage basins. At the Morgan Ride Site, compared with soils on other slope components, soils adjacent to the stream were observed to be equally moist (at time of EMI survey), but to contain less clay. These properties resulted in a ribbon of lower EC_a adjacent to the stream channel. At the Bean Ridge Road Site, electrically resistive limestone bedrock outcrops along the lower reaches of the intermittent and entrenched stream channel. The comparatively shallow depths to electrically resistive limestone are believed responsible for the lower EC_a measured along portions of this stream channel.

In order to help clarify EMI interpretations, a short transect consisting of five flagged points was established across different slope components at the Morgan Pond Site. Apparent conductivity was measured and the soils were described at each of these points. Initially, it was assumed that variations in clay and/or moisture contents would explain the measured differences in EC_a. It was assumed that higher values of EC_a would be associated with soils having higher clay and/or moisture contents.

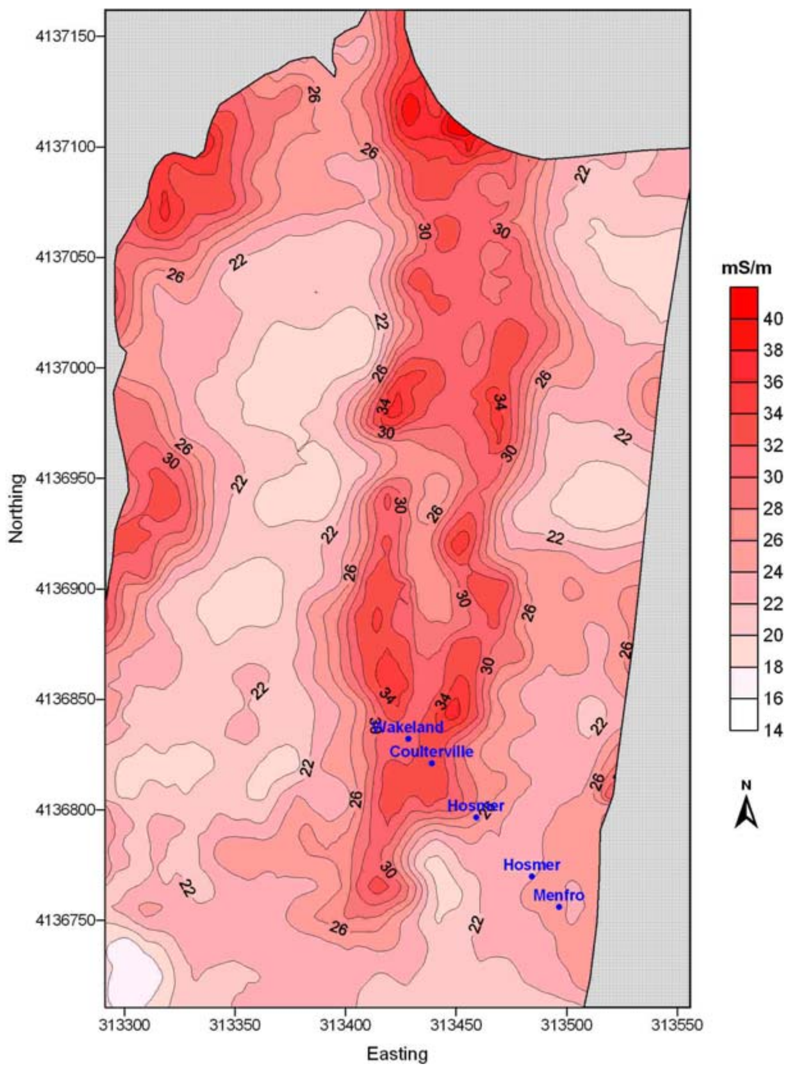

Figure 9. Plot of EC_a collected with the EM31 meter in the vertical dipole orientation at the Morgan Pond Site.

Figure 9 is a plot of EC_a data collected with the EM31 meter in the vertical dipole orientation at the Morgan Pond Site. Also shown in Figure 9 are the locations and names of the soils that were cored and described following the

EMI survey. The soils at the five observation points were identified (from top of divide to stream channel) as Menfro, Hosmer, Hosmer, Coulterville and Wakeland. The EC_a measured at these observation points were: 12 mS/m (Menfro), 11 mS/m (Hosmer), 18 mS/m (Hosmer), 28 mS/m (Coulterville) and 14 mS/m (Wakeland). All soils were observed to be equally moist throughout. With the exception of Wakeland soil, all soils had closely similar depths to the argillic horizon (8 to 15 cm) and averaged clay contents. Wakeland soil is coarse-silty; all other soils have a fine-silty textural control section. The thickness of the Peoria loess is greater than 160 cm for the two soils (Menfro and Hosmer) observed on the summit and shoulder slopes. The thickness of the Peoria loess thinned to 80 cm for the Hosmer and Coulterville soils described on the lower-lying back slope.

The soil identified along the lower back slope and in an area of high (>28 mS/m) EC_a is Coulterville. Coulterville soil contains concentrations (5 to 15 %) of exchangeable sodium in one or more subhorizon between depths of 25 to 100 cm. Once this sodium-affected soil was identified, several slickspots were recognized by soil scientists along other lower back slopes within this drainage basin. It is believed that lateral flow, seepage and evaporative discharge are responsible for the occurrence of sodium-affected soils on these lower back slopes. Areas of evaporative-discharge and sodium-affected soils form the conspicuous band of higher EC_a on the plots of EMI data.

Bands of higher EC_a rim the lower back slopes of both drainage basins. These areas are associated with seeps, higher concentrations of soluble salts and sodium-affected soils. In humid regions, sodium-affected soils occur in area where leaching is restricted (Indorante, 2002). The main factors responsible for the development of sodium-affected soils in humid regions include a source of sodium, high water tables (perched or apparent), impeded drainage, textural discontinuities between geologic strata (loess, till, bedrock), and seasonal periods of high evapotranspiration (Indorante, 2002). In Southern Illinois, the source of the sodium is the in-situ weathering of the Na-rich feldspar in the loess (Wilding et al., 1963). Wilding and others (1963) postulated that soluble products of weathering are translocated and concentrated in the lower part of loess deposits near the contact with the underlying Illinoian till or Pennsylvanian bedrock. The presence of these strata (till, bedrock) restricts the flow of water and redirects its movement laterally. As a consequence, excess water moves down slope and is discharged in seepage zones at the heads of shallow drainageways, in slight depressions and on slopes where lateral movement of water occurs (Fehrenbacker et al., 1963). Lateral flow and the evaporative discharge of ground water in seep areas is responsible for the accumulation of sodium and other bases and the development of sodium-affected soils along lower back slopes. The concentration of salts on lower back slopes undoubtedly affects the mineralogical, chemical and physical properties of soils and makes them different from similarly named soils mapped on adjoining, but different, landscape components.   On lower back slopes, the concentrations of soluble salts should vary with slope forms and gradients.

Reference:

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