United States Department of Agriculture
Natural Resource Conservation Service **Chester, PA 19013**

Subject: Electromagnetic Induction Surveys of Sites in Monroe, St. Clair, and Clinton Counties, Illinois; 24 - 28 October 1994. **Date:** 1 December 1994

To: Tom Christensen
State Conservationist
USDA-NRCS
1902 Fox Drive
Champaign, Illinois 61820

Purpose:
To conduct geophysical assessments of various sites using electromagnetic induction (EM) techniques. The purpose of this study was to further assess the applicability of EM techniques for soil survey updates and site assessments in southern Illinois.

Participants:
Annette Butts, Resource Conservationist, Clinton County SWCD, Breese, IL
Mark Caldwell, GIS Specialist, NRCS, Belleville, IL
Jim Doolittle, Soil Specialist, NRCS, Chester, PA
Sam Indorante, MLRA Project Leader, NRCS, Belleville, IL
Paul Kremmel, Res. Conservationist, Monroe County, Waterloo, IL
Randy Leeper, Soil Scientist, NRCS, Belleville, IL
Matt McCauley, Soil Scientist, NRCS, Belleville, IL
Mike Stanfil, Soil Conservationist, NRCS, Breese, IL

Activities:
Traverses were completed at selected sites in Monroe, St. Clair, and Clinton counties during the week of 24 October 1994. At most sites, measurements were obtained with EM meters and an altimeter, and soils and geologic materials were observed with powered probes.

MATERIALS AND METHODS

Equipment

The electromagnetic induction meters were the EM38, EM31, and EM34-3, 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

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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.

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] The EM34-3 meter has intercoil spacing of 10, 20, or 40 m. A 10 m intercoil spacing was used in this investigation. With a 10 m intercoil spacing, the EM34-3 meter has effective observation depths of about 7.5 m and 15 m in the horizontal and vertical dipole orientations, respectively.[3] Measurements of conductivity are expressed as milliSiemens per meter (mS/m). Bar and line graphs of the EM data were prepared using LOTUS software.

As part of this study, the performance of a field altimeter was evaluated. A Micro, model M1-6 surveying altimeter, belonging to the Belleville MLRA Project Office, was used. This altimeter is suitable for use in areas having elevations of less than 6000 feet. The altimeter weighs about 4 pounds and has gradations expressed in one foot intervals.

Field Methods

Survey lines were established at each site. Along each line, survey flags were inserted in the ground at 50 foot intervals. These flags served as observation points. At most observation points, EM and altimeter measurements were obtained. At sites located in Monroe and St. Clair counties, a transit and stadia rod were used to confirm relative changes in surface elevations and to evaluate the performance of the altimeter.

RESULTS

Altimeter measurements

A comparison was made of topographic data obtained with the model M1-6 surveying altimeter and a rotating laser level at the Monroe and St. Clair County sites. For each survey site, the altimeter was calibrated before and after the survey at a nearby U.S. Geological Survey bench mark. Along each survey line, at each observation point, altimeter and laser level measurements were obtained. For each survey line, datum was the altimeter measurement at the first observation point. All subsequent stadia rod measurements were adjusted to the altimeter measurement of the first observation point.

The data set consisted of 61 altimeter and laser level measurements collected at study sites in Monroe and St. Clair counties. The average difference between the altimeter and corrected laser level measurements was +/- 3.7 feet with a range of 0 to +/- 11.3 feet (see Figure 1). At

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

3. McNeill, J. D. 1983. EM34-3 survey interpretation techniques. Technical Note TN-8. Geonics Limited, Mississauga, Ontario.

one-half of the observation points, the difference between altimeter and corrected level measurements was between +/- 0.9 to 6.3 feet.

The altimeter provided fairly accurate measurements of surface elevations. General trends in surface topography and elevations were closely approximated with the altimeter. At the Monroe County site, based on 49 altimeter measurements, relief was about 72 feet with elevations ranging from 438 to 510 feet (see figures 2 and 3). At the St. Clair county site, based on 12 altimeter measurements, relief was about 26 feet with elevations ranging from 430 to 464 feet (see Figure 7, upper).

The model M1-6 surveying altimeter is relatively easy and quick to use in the field. It appears to be a very appropriate tool for topographic, soil, and NRI surveys. As measurements were observed to vary slightly with operators, survey procedures should stress anticipated margins of equipment and operator errors. The reliability of data collection appears to increase slightly with the experience of the operator. Data collection should be suspended during periods of rapidly changing weather and barometric conditions.

EM survey of a site in Monroe County

The study site was located in the S 1/2, Section 36, T. 4 S., R. 9 W. Three survey lines were established across the study site. The approximate locations of these lines are shown in Figure 1A. The survey lines crossed areas of Blair silty clay loam, 10 to 15 percent slopes, severely eroded (5D3); Alford silt loam, 15 to 30 percent slopes, severely eroded (308E3); Muren silt loam, 2 to 5 percent slopes (453B); and Alford silt loam, karst, 12 to 25 percent slopes (5308E). Alford is a member of the fine-silty, mixed, mesic Typic Hapludalfs family. Blair and Muren soils are members of the fine-silty, mixed, mesic Aquic Hapludalfs family.

Interpretations of the EM data are based on the identification of spatial patterns within the data set. The EM data have been displayed as line graphs for each survey line (figures 4, 5, 6). Each of these figures consists of two graphs. The upper graph shows spatial variations in EM response as measured with the EM38 and EM31 meter in both horizontal and vertical dipole orientations. The lower graph shows spatial variations in EM response as measured with the EM34-3 meter using a 10 meter intercoil spacing in both horizontal and vertical dipole orientations.

Comparing figures 4, 5, and 6, values of apparent conductivity, as a rule, appear to increase and become slightly more variable with increasing observation depth (responses of the EM38 meter were typically less those of the EM31 meter, and, for each meter, responses in the horizontal dipole orientation were typically less than those in vertical dipole orientation). However, at greater depths (as measured with the EM34-3 meter) values tend to decrease with increasing observation depths. The first relationship was assumed to be related to the higher clay content of the fine-textured Illinoian drift which underlies the medium textured Peoria loess and Roxana silts. The second relationship was assumed to be related to the more resistive nature of the Salem limestone which underlies the more conductive Illinoian drift.

The basic statistics for each survey line of the Monroe County site are displayed in Table 1. The number of observation points were 24, 15, and 10 for survey lines 1, 2 and 3, respectively. Variations in each meters response can be related to differences in soil type, landscape position, and depth to contrasting materials.

Table 1
Site in Monroe County, Illinois

Line 1
(all values are in mS/m)

Meter	Orientation	Minimum	Maximum	Quartiles 1st	Median	3rd	Average
EM38	Horizontal	14	38	18	23	27	23
EM38	Vertical	20	41	24	28	30	29
EM31	Horizontal	28	60	32	35	41	39
EM31	Vertical	40	85	45	50	61	55
EM34-3	Horizontal	24	58	28	34	39	37
EM34-3	Vertical	32	65	38	42	52	46

Line 2
(all values are in mS/m)

Meter	Orientation	Minimum	Maximum	Quartiles 1st	Median	3rd	Average
EM38	Horizontal	13	35	16	24	27	24
EM38	Vertical	15	38	21	26	32	26
EM31	Horizontal	24	53	29	36	44	38
EM31	Vertical	30	62	36	48	58	48
EM34-3	Horizontal	25	54	28	34	41	36
EM34-3	Vertical	28	54	29	35	48	39

Line 3
(all values are in mS/m)

Meter	Orientation	Minimum	Maximum	Quartiles 1st	Median	3rd	Average
EM38	Horizontal	13	35	16	18	25	23
EM38	Vertical	13	38	18	19	25	23
EM31	Horizontal	17	46	25	26	33	30
EM31	Vertical	20	57	27	32	35	34
EM34-3	Horizontal	18	42	23	24	27	27
EM34-3	Vertical	16	34	22	26	28	26

Vertical variations in EM measurements conformed with the basic conceptual model of the site. For the purpose of this investigation, the site was assumed to consist of three layers: loess, till, and limestone bedrock. The medium and moderately-fine textured loess has a lower clay content and was presumed to have lower apparent conductivity values than the underlying fine-textured till. The underlying limestone bedrock is more resistive (less conductive) than the overlying, moderately-fine textured loess and fine-textured till deposits. The limestone bedrock was known to have lower values of apparent conductivity than the drift.

Thickness of loess varied across the site because of erosion, deposition, and landscape position. Because of the large difference in clay content between the loess and underlying Illinoian drift, significant vertical contrasts in electrical conductivity exist across this stratigraphic interface. It was assumed that variations in the magnitude of the EM response could provide an estimate of the thickness of the loess or the depth to Illinoian drift.

Soil probe and EM measurements collected at six observation points were compared. The depth to drift averaged 92 inches and ranged from 70 to 130 inches. Relatively high, negative, sample coefficients of correlation were found between soil probe and EM measurements taken with the EM38 meter in the vertical dipole orientation ($r = -0.739$) and with the EM31 meter in the horizontal dipole orientation ($r = -0.675$). The observation depths of these meters most closely approximated the observed range in depth to the Illinoian drift. The lack of stronger correlations were attributed to the small sample size and the complexity of soil patterns within the study area. Lower correlations were found between soil probe and EM measurements taken with the EM38 meter in the horizontal dipole orientation ($r = -0.651$) and with the EM31 meter in the vertical dipole orientation ($r = -0.647$).

<u>EM survey of a site in St. Clair County</u>
The study site was located in the N 1/2, Section 33, T. 2 S., R. 8 W. One survey lines was established across this study site. The approximate location of this line is shown in Figure 7A. The line crossed areas of Iva silt loam, 2 to 4 percent slopes (454B); Darmstadt silty clay loam, 4 to 10 percent slopes (620C3); and Wakeland silt loam (333). Iva is a member of the fine-silty, mixed, mesic Aeric Ochraqualfs family. Darmstadt is a member of the fine-silty, mixed, mesic Typic Natraqualfs family. Wakeland is a member of the course-silty, mixed, nonacid, mesic Aeric Fluvaquents family.

Topographic and EM data from the survey line in St. Clair County are displayed in Figure 7. The upper graph shows the general topography of the survey line and compares the topographic data obtained with the model M1-6 surveying altimeter and a rotating laser level. The lower graph shows spatial variations in EM response as measured with the EM38 and EM31 meter in both horizontal and vertical dipole orientations.

Areas of Darmstadt and Iva soils were on higher-lying positions of the landscape. In areas of Darmstadt and Iva soils (observation points 0 to 350), values of apparent conductivity, as a rule, increase with increasing observation depth (responses of the EM38 meter were typically less those of the EM31 meter, and, for each meter, responses in the horizontal dipole orientation were typically less than those in vertical dipole orientation). Once again, this relationship was assumed to be related to the higher clay content of the fine-textured Illinoian drift which underlies the medium textured Peoria loess and Roxana silts. In addition, in areas of Darmstadt and Iva soils, depths to bedrock were very deep and deep.

Areas of Wakeland soils were on lower-lying positions along a drainage channel. In areas of Wakeland soils (Figure 7 lower, observation points 400 to 550), values of apparent conductivity are conspicuously lower, less variable, and do not necessarily increase with increasing observation depths. In areas of Wakeland soils, depths to shale bedrock were moderately deep.

The basic statistics for this survey line are displayed in Table 2. The number of observation points was 12.

Table 2
Site in St. Clair County, Illinois

(all values are in mS/m)

				Quartiles			
Meter	Orientation	Minimum	Maximum	1st	Median	3rd	Average
EM38	Horizontal	18	57	21	30	34	31
EM38	Vertical	26	63	30	42	46	42
EM31	Horizontal	46	84	50	58	65	61
EM31	Vertical	55	90	64	72	81	73

In areas of Darmstadt and Iva soils, vertical variations in EM measurements conform with the basic conceptual model of the site. As was the case in the St. Clair County site, the Monroe County site was assumed to consist of three layers: loess, till, and limestone bedrock. The medium and moderately-fine textured loess has a lower clay content and was presumed to have lower apparent conductivity values than the underlying fine-textured till.

The underlying bedrock consisted of inter-bedded layers of limestone and shale. Shale is relatively conductive; limestone is relatively resistive. These layers display dissimilar EM responses and variations in the depth to and thickness of these layers complicated interpretations and lowered the interpretative power of the model. As depths to bedrock were moderately deep and because Illinoian drift was thin or absence, soil probe and EM measurements were not compared in areas of Wakeland soils.

In areas of Darmstadt and Iva soils, the thickness of loess varied across the site because of erosion, deposition, and landscape position. Because of the large differences in clay content between the loess and underlying Illinoian drift, significant vertical contrasts in electrical conductivity were assumed to exist. It was assumed that variations in the magnitude of the EM response would provide an estimate of the thickness of the loess or the depth to Illinoian drift.

Soil probe and EM measurements collected at eight observation points were compared. The depth to Illinoian drift averaged 32 inches and ranged from 0 to 85 inches. Relatively high, negative correlations were found between soil probe and EM measurements taken with the EM31 meter in the horizontal dipole orientation (r = -0.872) and with the EM38 meter in the vertical and horizontal dipole orientations (r = -0.768 and -0.760, respectively). The observation depths of these meters most closely approximated the range in observed depths to the Illinoian drift. No correlation was found between soil probe and EM measurements taken with the EM31 meter in the vertical dipole orientation (r = -0.225).

Increasing the sample size to include the fourteen observation points collected in St. Clair and Monroe counties improves the correlation between soil probe and EM measurements. The depth to Illinoian drift averaged 62 inches and ranged from 0 to 130 inches. Relatively high, negative correlations were found between soil probe and EM measurements taken with the EM31 meter in the horizontal dipole orientation (r = -0.892) and with the EM38 meter in the vertical dipole orientations (r = -0.892). Variations in soil type existing between the two sites appear to be of low significance when compared with the thickness of loess and the depth to Illinoian drift.

EM survey of Sites in Clinton County

Area of Oconee, Darmstadt, and Cowden Soils

One survey line was established in an area of Oconee (fine, montmorillonitic, mesic Udollic Ochraqualfs) Darmstadt (fine-silty, mixed, mesic Typic Natraqualfs), and Cowden (fine, montmorillonitic, mesic Mollic Albaqualfs) soils. The survey line was located in the NW 1/4, Section 4, T. 3 N., R. 3 W.

The basic statistics for this survey line are displayed in Table 3. The number of observation points was 16.

Table 3
Site in Clinton County, Illinois

Area of Oconee, Darmstadt, and Cowden Soils
(all values are in mS/m)

Meter	Orientation	Minimum	Maximum	Quartiles 1st	Median	3rd	Average
EM38	Horizontal	12	19	14	16	16	15
EM38	Vertical	15	31	17	25	27	24
EM31	Horizontal	23	47	26	39	41	36
EM31	Vertical	28	56	31	46	48	43

Topographic and EM data from this survey line are displayed in Figure 8. The upper graph shows the general topography of the survey line (data obtained with the model M1-6 surveying altimeter). The lower graph shows spatial variations in EM response as measured with the EM38 and EM31 meter in both horizontal and vertical dipole orientations.

Along the transect line, areas of Oconee soils were on the higher-lying positions. Compared with Darmstadt and Cowden soils, Oconee soils are better drained and have a lower clay content. As a result, areas of Oconee soils could be differentiated from areas of Cowden and Darmstadt soils on the basis of their lower EM responses at lower soil depths (see Figure 8, lower). Darmstadt and Cowden soils could not be distinguished on the basis of their EM responses. As the taxonomic identity of these soils were not verified in the field, it is unclear whether one or both soils, or inclusions or intergrades were present at this site.

Area of Cowden and Piasa Soils
One survey lines were established across the study site. A survey line was established in an area of Cowden-Piasa complex, 0 to 2 percent slopes (993). The transect line was located in the E 1/2 Section 27, T. 2 N., R. 3 W. Cowden is a member of the fine, montmorillonitic, mesic Mollic Albaqualfs family. Piasa is a member of the fine, montmorillonitic, mesic Mollic Natraqualfs family.

The basic statistics for this survey line are displayed in Table 4. The number of observation points was 10.

Table 4
Site in Clinton County, Illinois

Area of Cowden-Piasa Complex
(all values are in mS/m)

				Quartiles			
Meter	Orientation	Minimum	Maximum	1st	Median	3rd	Average
EM38	Horizontal	27	60	32	38	52	43
EM38	Vertical	38	79	50	54	71	60
EM31	Horizontal	51	86	62	65	77	70
EM31	Vertical	61	87	68	74	81	76

Electromagnetic data from this survey line are displayed in the upper graph of Figure 9. This graph shows spatial variations in EM response as measured with the EM38 and EM31 meter in both horizontal and vertical dipole orientations.

Values of apparent conductivity were noticeably higher along this transect line than along other lines surveyed. The high responses were believed to reflect the high soluble salt and clay contents of Cowden and Piasa soils. Variations in EM response along this line are believed to principally reflect variations in the concentration of soluble salts.

Area of Zook, Ridgway, and Lakaskia Soils
A survey line was established in an area of Zook (fine, montmorillonitic, mesic Cumulic Haplaquolls) Ridgway (fine-silty, mixed, mesic Typic Hapludalfs), and Lakaskia (fine, mixed, mesic Typic Argiaquolls) soils. The site was located in the E 1/2, Section 26, T. 1 N., R. 4 W.

The basic statistics for this survey line are displayed in Table 5. The number of observation points was 10.

Table 5
Site in Clinton County, Illinois

Area of Zook, Ridgway, and Lakaskia Soils
(all values are in mS/m)

Meter	Orientation	Minimum	Maximum	Quartiles 1st	Median	3rd	Average
EM38	Horizontal	11	46	12	20	29	24
EM38	Vertical	15	59	17	32	45	34
EM31	Horizontal	19	66	22	26	45	38
EM31	Vertical	28	67	30	45	55	46

Electromagnetic data from this survey line are displayed in the lower graph of Figure 9. This graph shows spatial variations in EM response as measured with the EM38 and EM31 meter in both horizontal and vertical dipole orientations.

A prominent ridge of coarser-textured soil materials produced the conspicuously lower EM responses in the area of the Ridgway soils (see Figure 9). Values of apparent conductivity were noticeably higher on adjacent, lower-lying areas of Lakaskia and Zook soils. These relatively high EM responses were believed to reflect the higher soil moisture and clay contents of Lakaskia and Zook soils.

RESULTS:

1. A Magellan NAVPRO 500 GPS receiver (serial number 3A 003038) was loaned to Sam Indorante and the soil survey project. The period of this loan is five months.

2. Results from this study indicate that EM techniques can be used to increase the quantity and quality of data and to extend the depths of interpretation. These techniques are quick, easy to use, and can produce large quantities of spatial information in a relatively short period of time. The use of electromagnetic induction techniques are suitable for estimating the depths to contrasting materials (i.e. finer-textured Illinoian drift). In many areas, knowledge of the depths to these layers is significant to land use, management, or site assessments. In Monroe and St. Clair counties, EM techniques can be used to estimate the depths to Illinoian drift or the thickness of loess. As the depth to the Illinoian drift influences water movement through this landscape, the techniques used in this study can be used to create a conceptual model of how and where water moves through the landscape.

I wish to recommend that these uses of EM techniques be more fully explored through a systematic survey of a representative area of karst in Monroe County. The purpose of this survey will be to produce a landscape model suitable for delivery to customers which will help to explain how hydrologic processes are interconnected from one part of the landscape to another. I wish to propose consideration of this project for my field assist visit scheduled for late March 1995.

It has been my pleasure to assist in this project.

With kind regards

James A. Doolittle
Soil Specialist

cc:
J. Culver, Assistant Director, Soil Survey Division, NSSC, NRCS, Lincoln, NE
J. Dondero, Area Conservationist, USDA-NRCS, Room 204 G, Federal Bldg., 250 W. Cherry Street, Carbondale, IL 62901
S. Holzhey, Assistant Director, Soil Survey Division, NSSC, NRCS, Lincoln, NE
S. Indorante, MLRA Project Leader, USDA-NRCS, 25B Center Plaza Dr., Belleville, IL 62220
R. Mcleese, State Soil Scientist, USDA-NRCS, 1902 Fox Drive, Champaign, Illinois 61820

COMPARISON OF TOPOGRAPHIC DATA

VARIATION BETWEEN ALTIMETER AND ADJUSTED STADIA MEASUREMENT

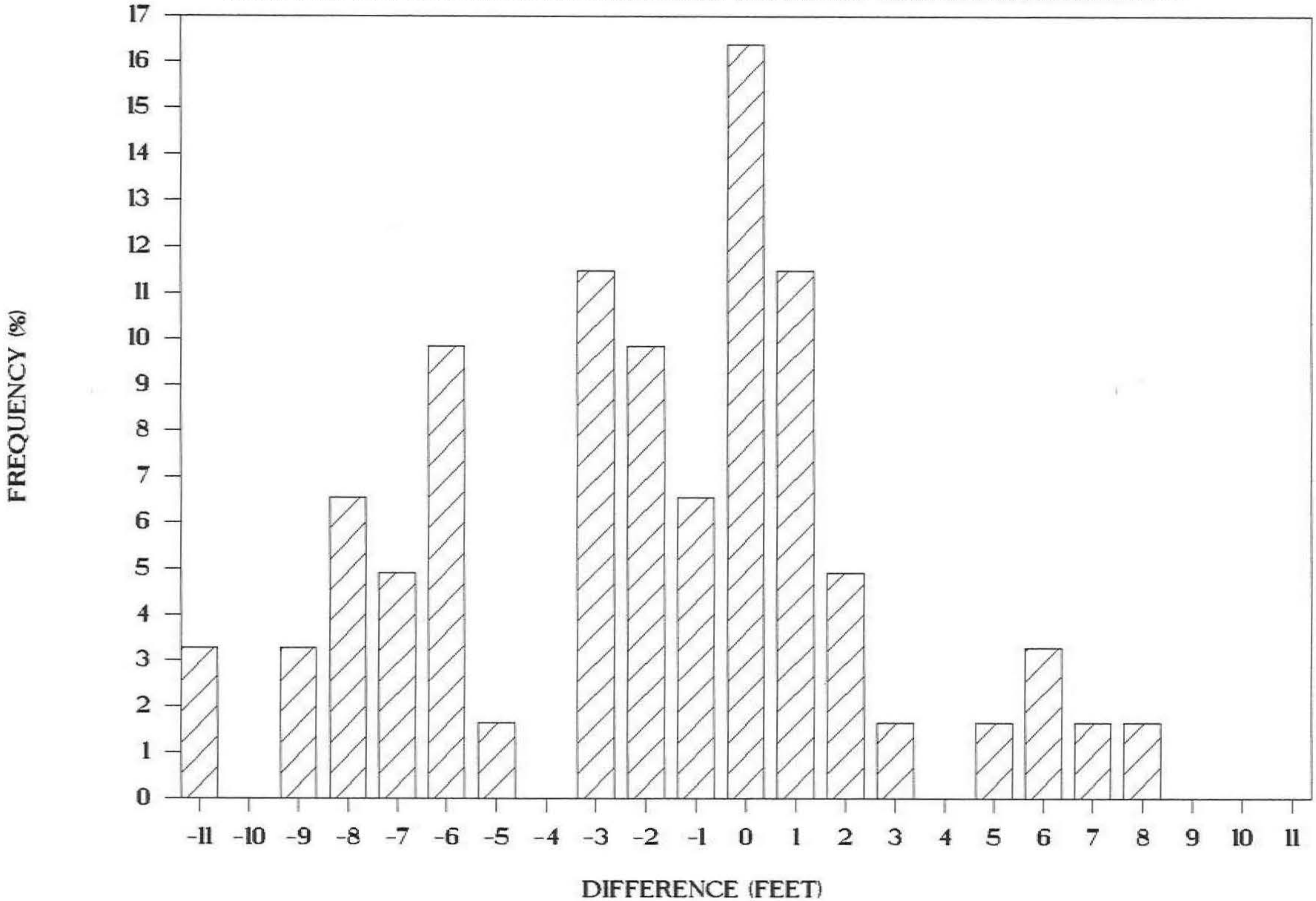
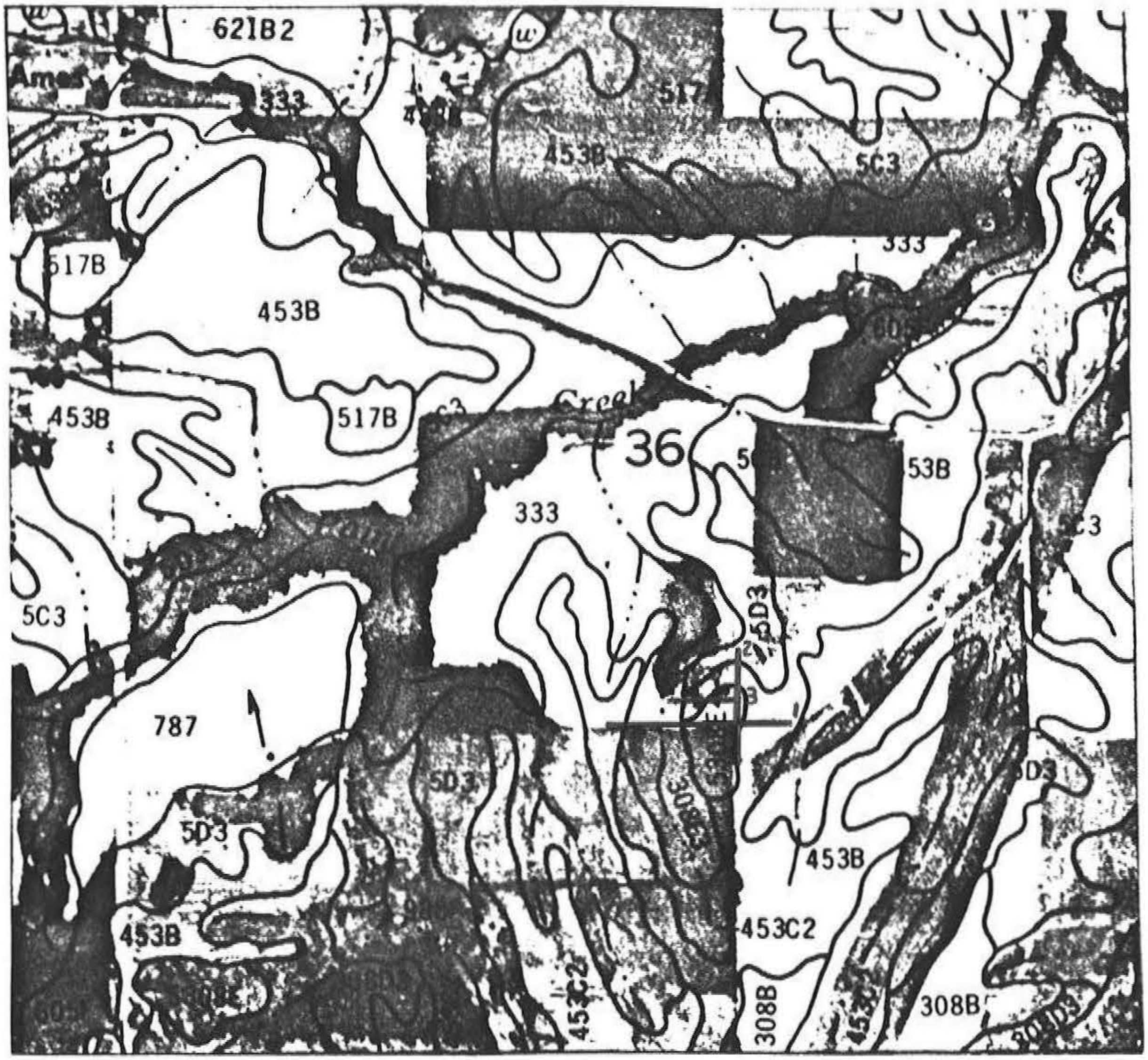


Figure 1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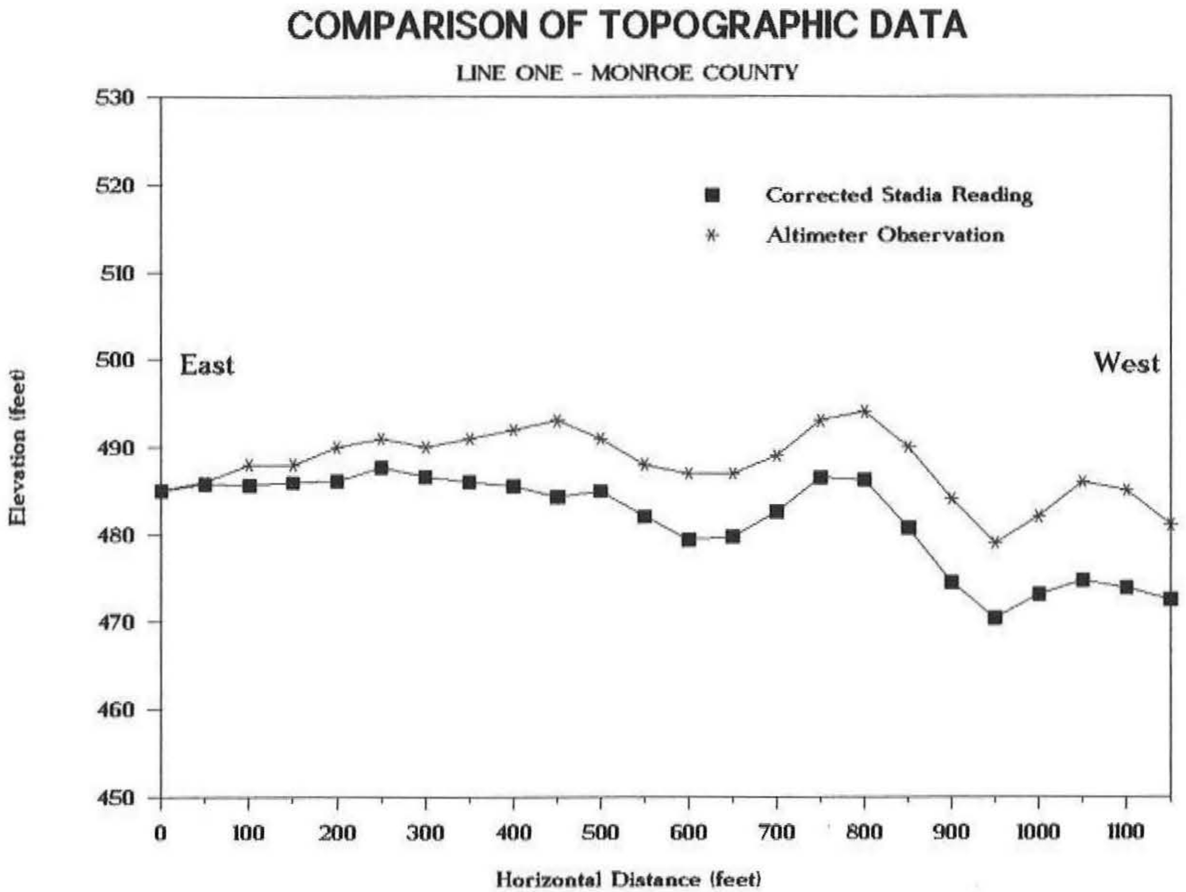
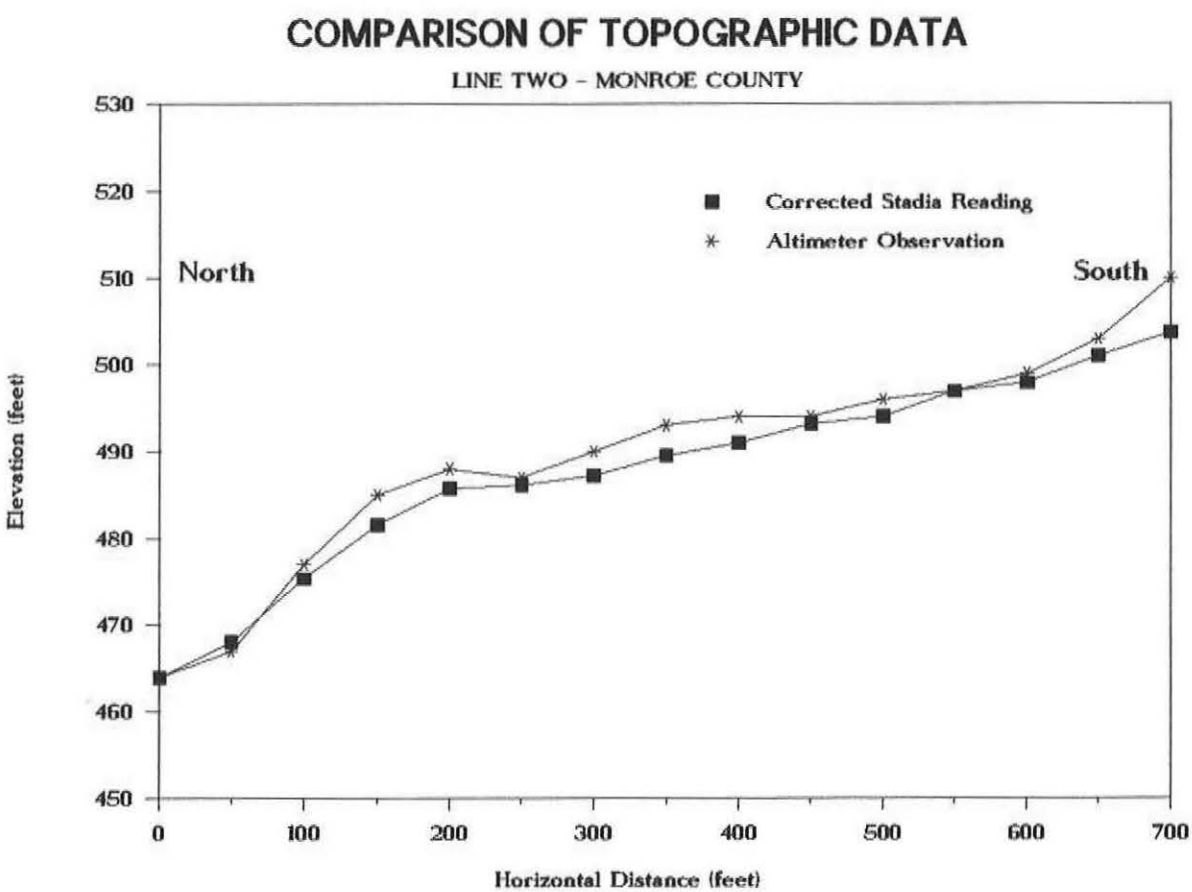

COMPARISON OF TOPOGRAPHIC DATA
LINE ONE - MONROE COUNTY
Corrected Stadia Reading
Altimeter Observation
East
West
Elevation (feet)
Horizontal Distance (feet)
530
520
510
500
490
480
470
460
450
0
100
200
300
400
500
600
700
800
900
1000
1100


COMPARISON OF TOPOGRAPHIC DATA
LINE TWO - MONROE COUNTY
Corrected Stadia Reading
Altimeter Observation
North
South
Elevation (feet)
Horizontal Distance (feet)
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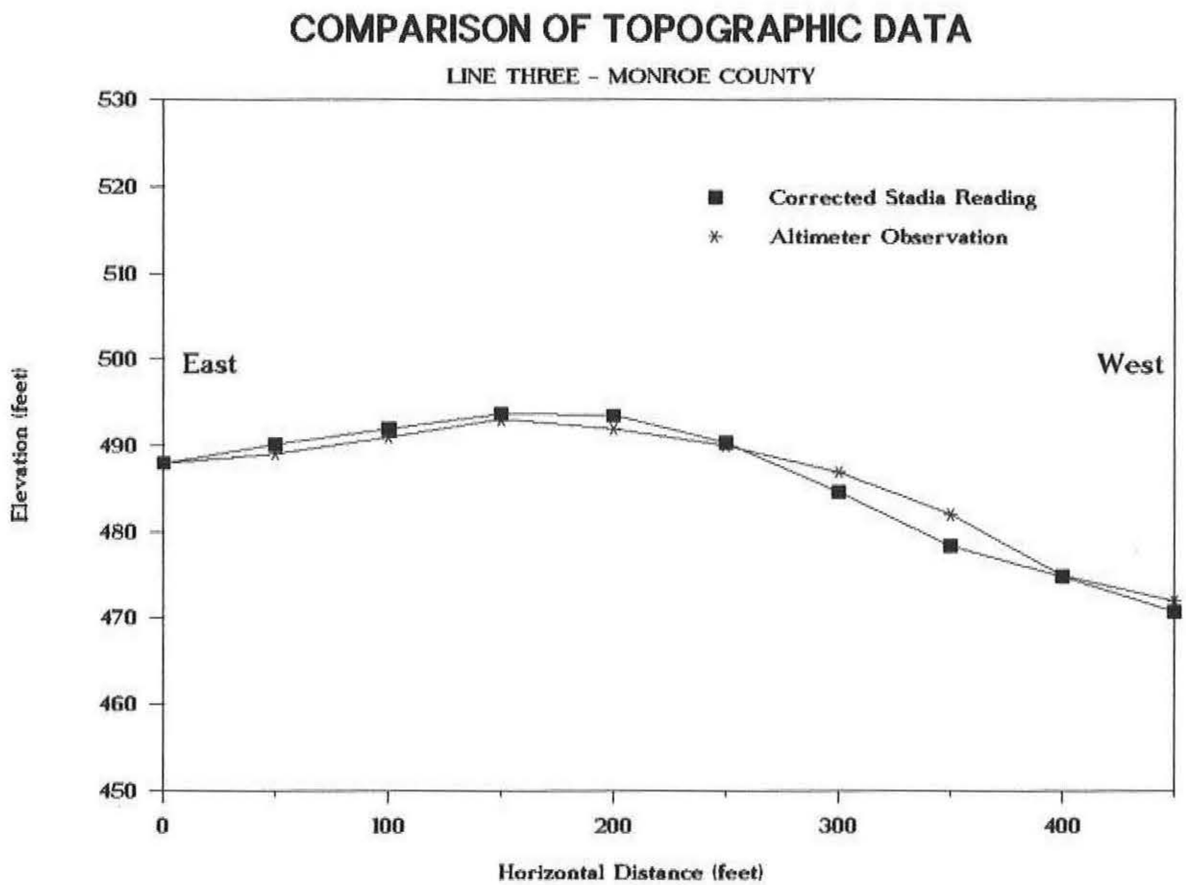
520
510
500
490
480
470
460
450
0
100
200
300
400
500
600
700


COMPARISON OF TOPOGRAPHIC DATA
LINE THREE - MONROE COUNTY
Corrected Stadia Reading
Altimeter Observation
East
West
Elevation (feet)
Horizontal Distance (feet)
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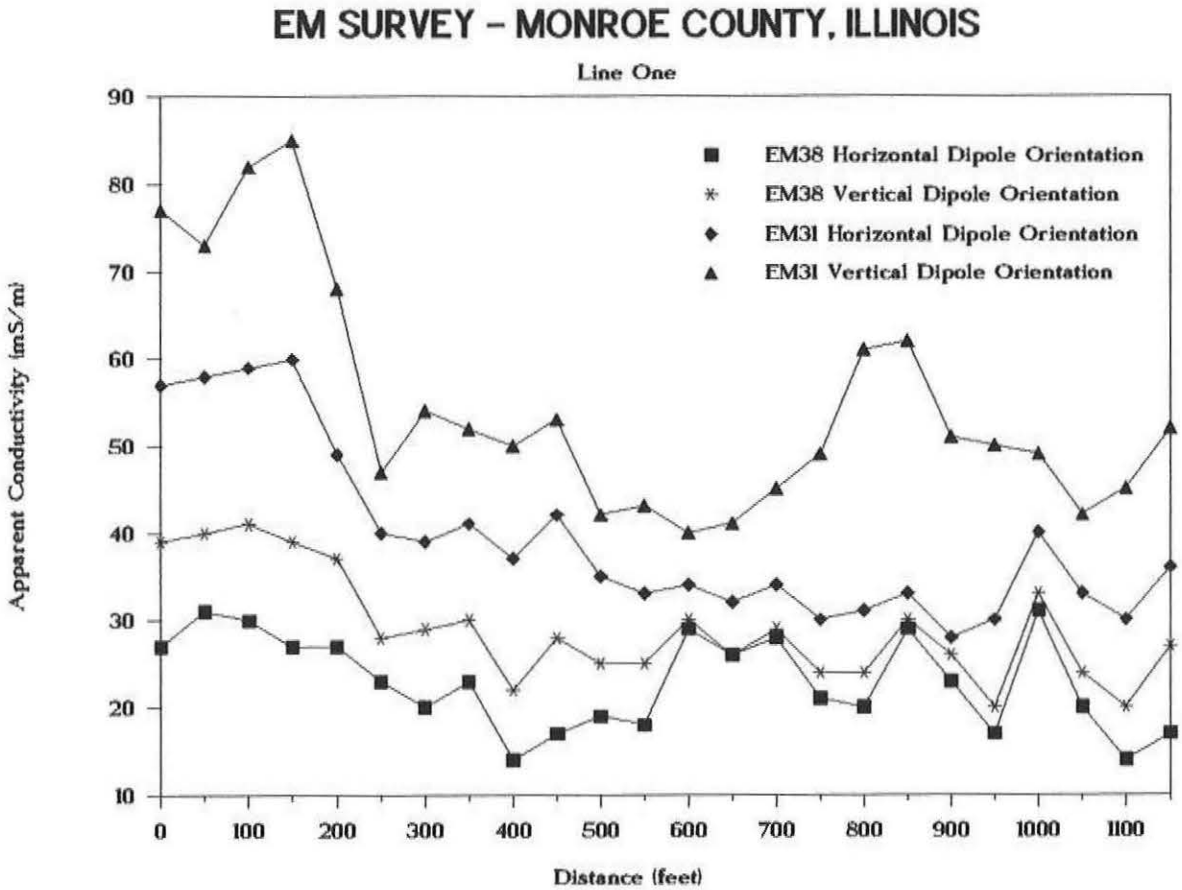
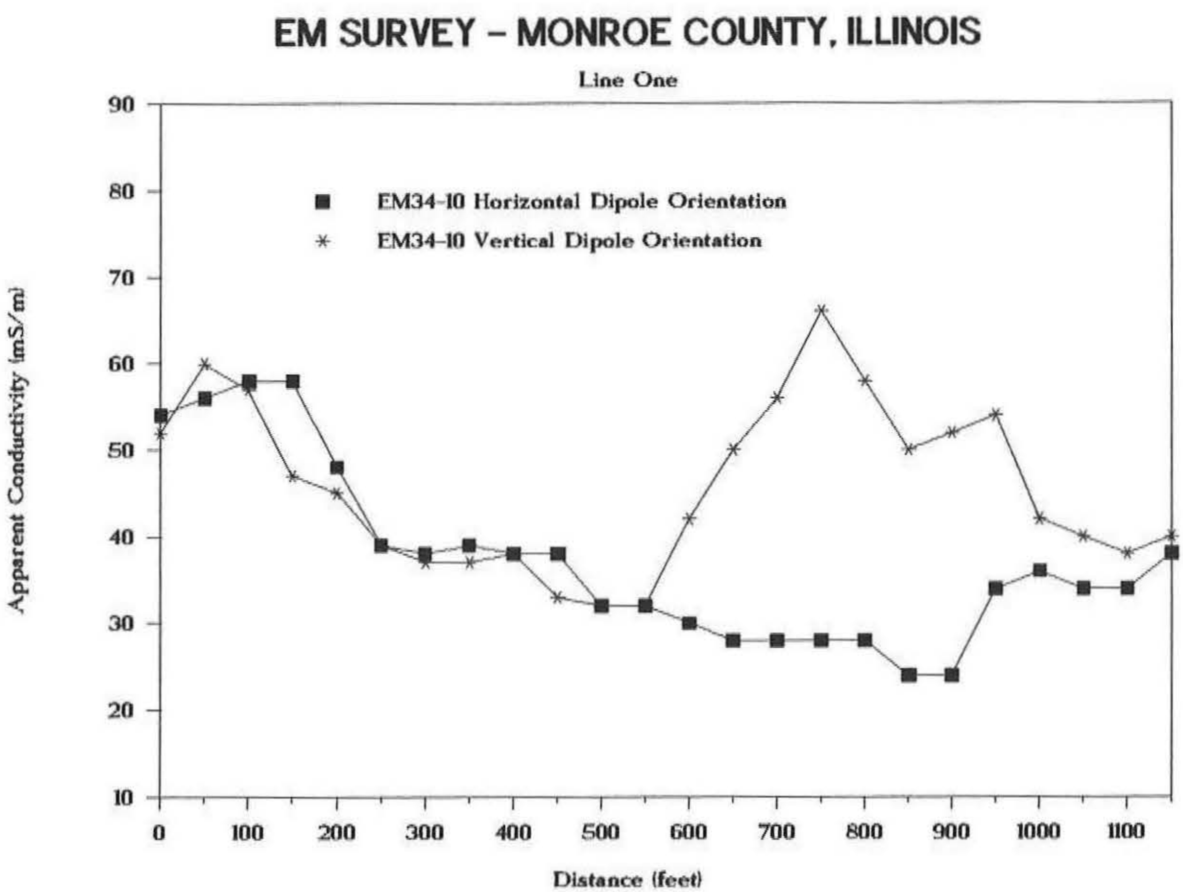
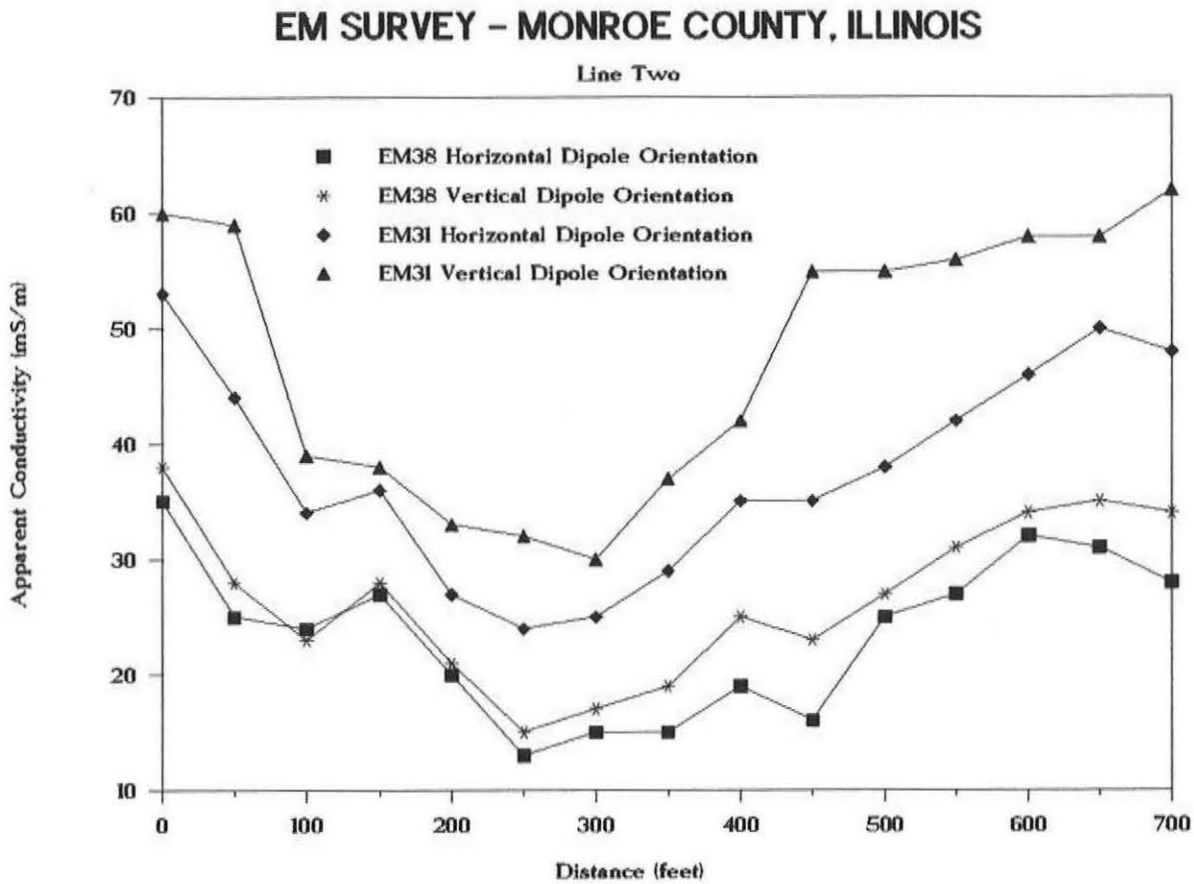
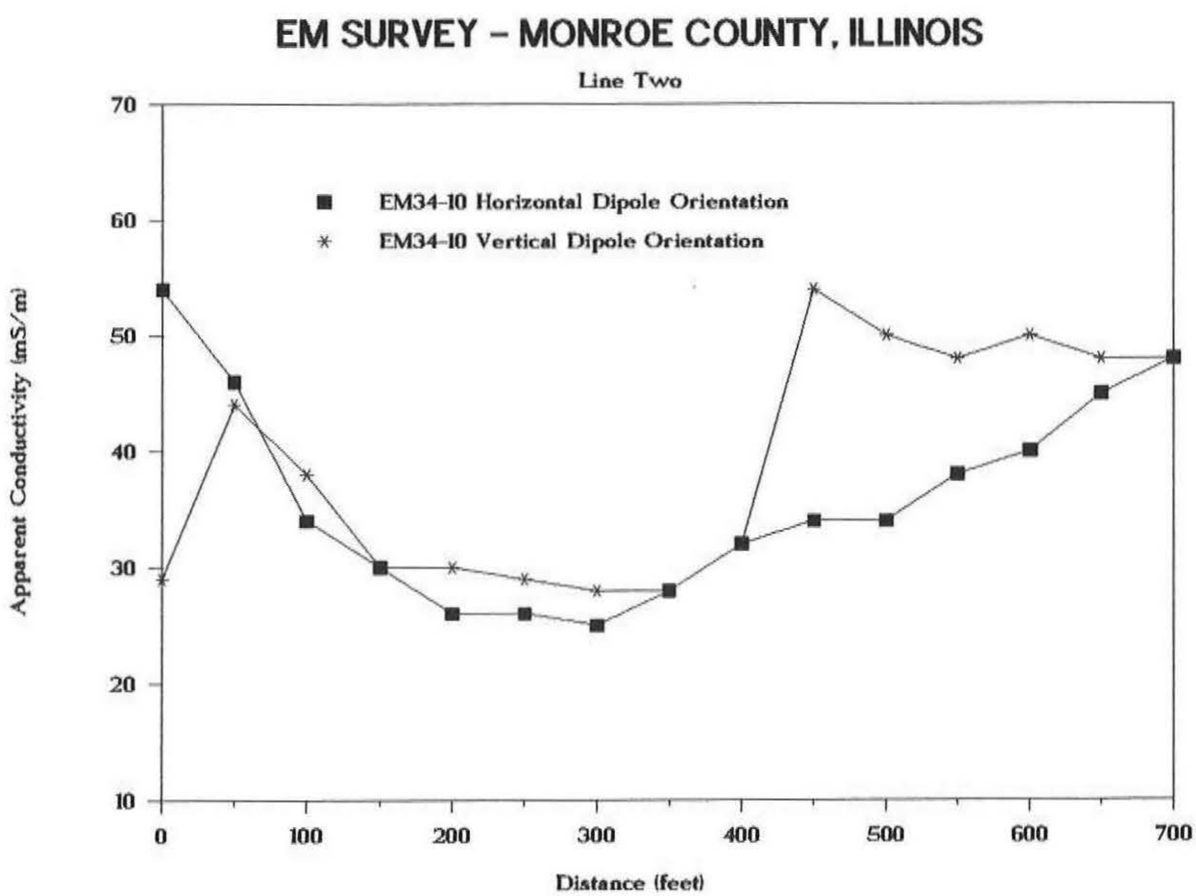
520
510
500
490
480
470
460
450
0
100
200
300
400

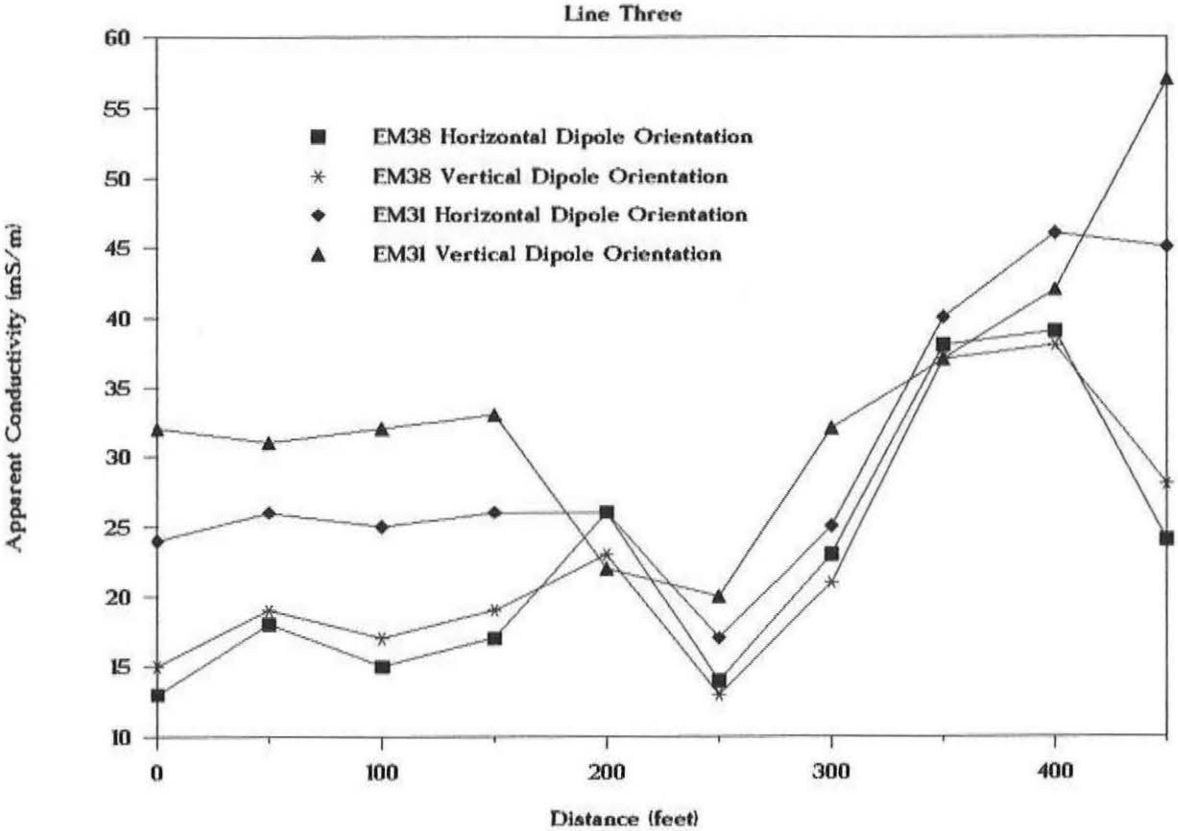

EM SURVEY - MONROE COUNTY, ILLINOIS
Line One
EM38 Horizontal Dipole Orientation
EM38 Vertical Dipole Orientation
EM31 Horizontal Dipole Orientation
EM31 Vertical Dipole Orientation
Apparent Conductivity (mS/m)
Distance (feet)
90
80
70
60
50
40
30
20
10
0
100
200
300
400
500
600
700
800
900
1000
1100


EM SURVEY - MONROE COUNTY, ILLINOIS
Line One
EM34-10 Horizontal Dipole Orientation
EM34-10 Vertical Dipole Orientation
Apparent Conductivity (mS/m)
Distance (feet)
90
80
70
60
50
40
30
20
10
0
100
200
300
400
500
600
700
800
900
1000
1100

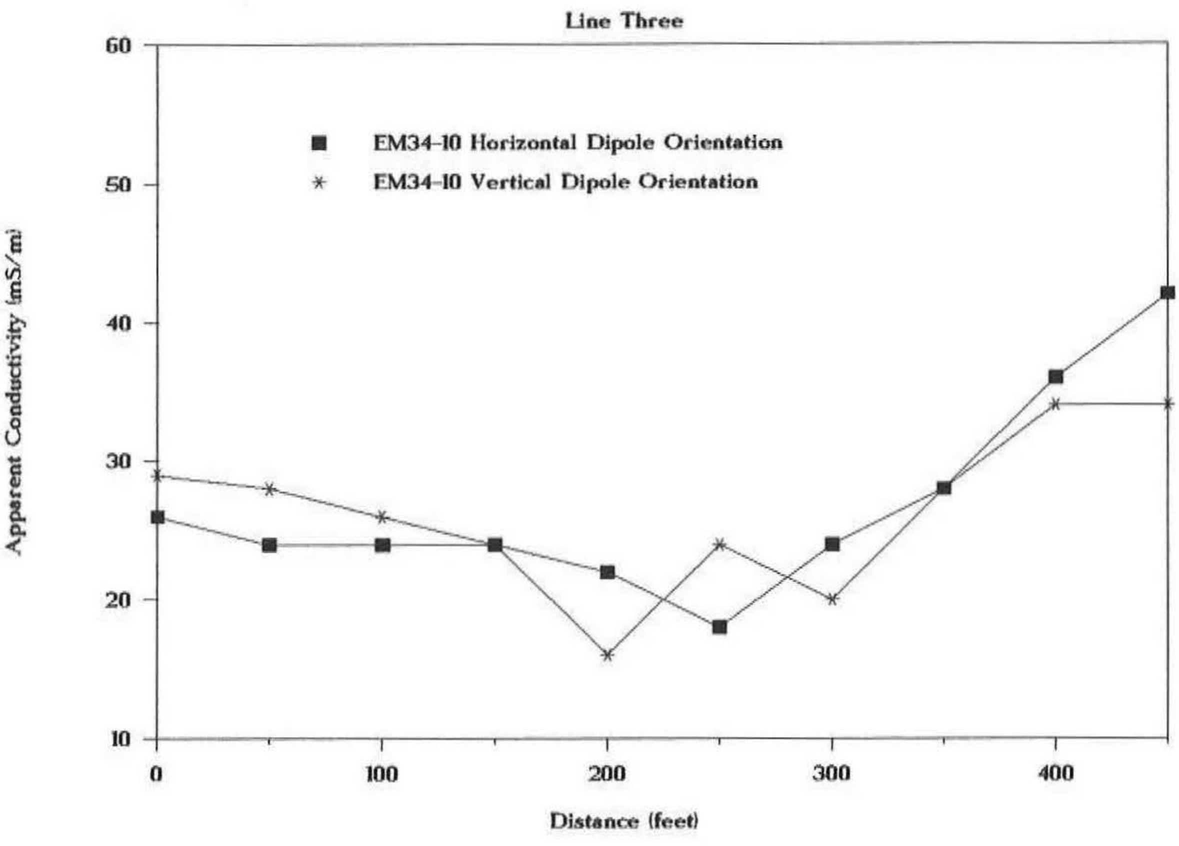

EM SURVEY - MONROE COUNTY, ILLINOIS
Line Two
EM38 Horizontal Dipole Orientation
EM38 Vertical Dipole Orientation
EM31 Horizontal Dipole Orientation
EM31 Vertical Dipole Orientation
Apparent Conductivity (mS/m)
Distance (feet)
70
60
50
40
30
20
10
0
100
200
300
400
500
600
700


EM SURVEY - MONROE COUNTY, ILLINOIS
Line Two
EM34-10 Horizontal Dipole Orientation
EM34-10 Vertical Dipole Orientation
Apparent Conductivity (mS/m)
Distance (feet)
70
60
50
40
30
20
10
0
100
200
300
400
500
600
700

EM SURVEY - MONROE COUNTY, ILLINOIS

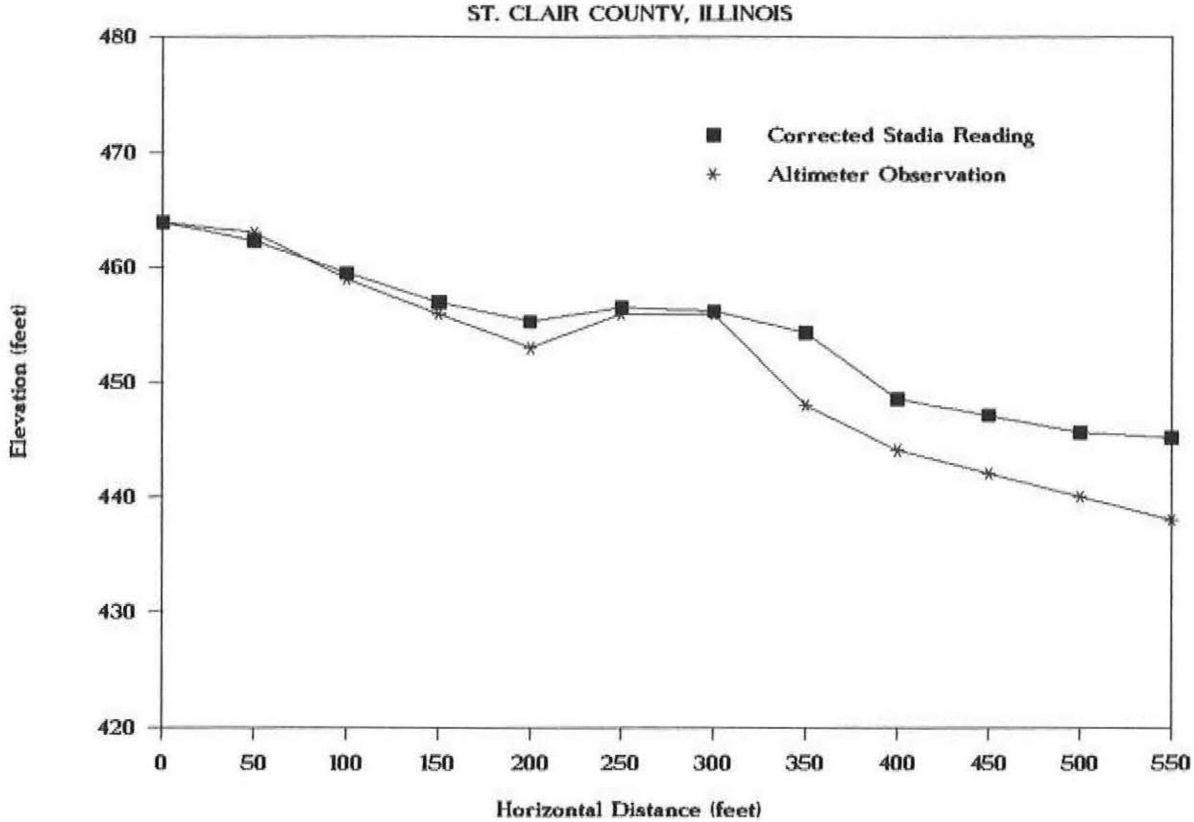


EM SURVEY - MONROE COUNTY, ILLINOIS



COMPARISON OF TOPOGRAPHIC DATA

ST. CLAIR COUNTY, ILLINOIS



EM SURVEY - ST. CLAIR COUNTY, ILLINOIS

AREA OF IVA, ALFORD, AND WAKELAND SOILS

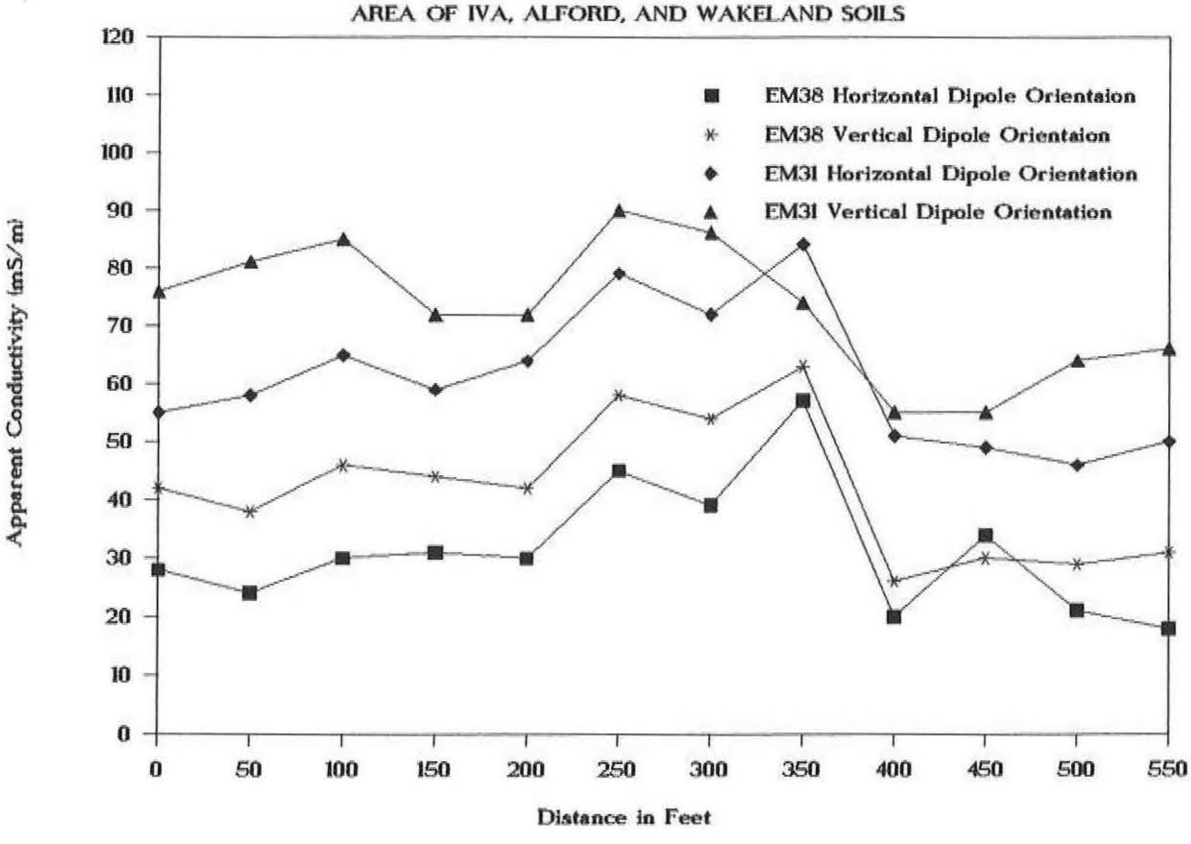
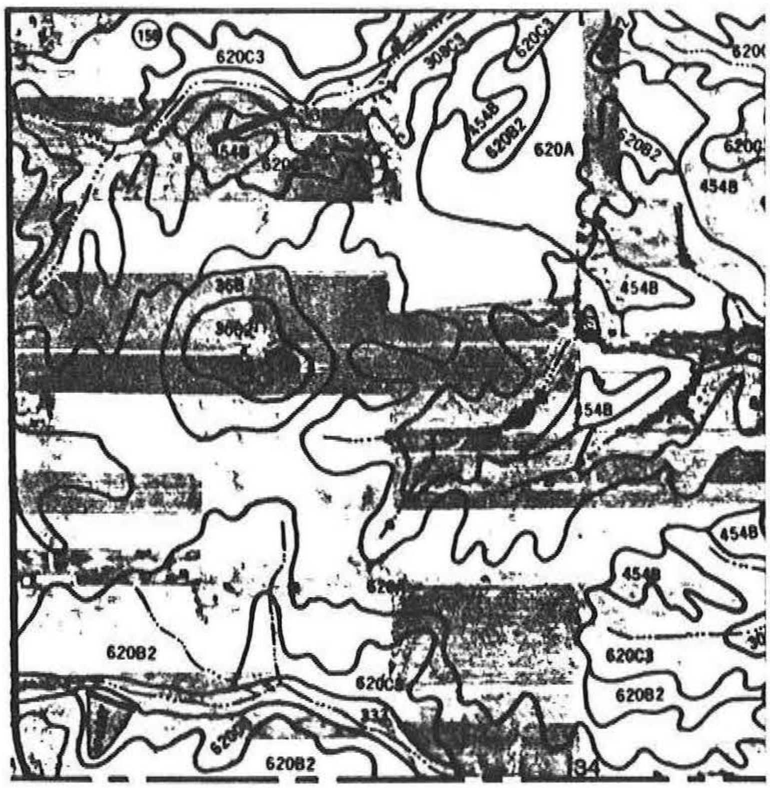
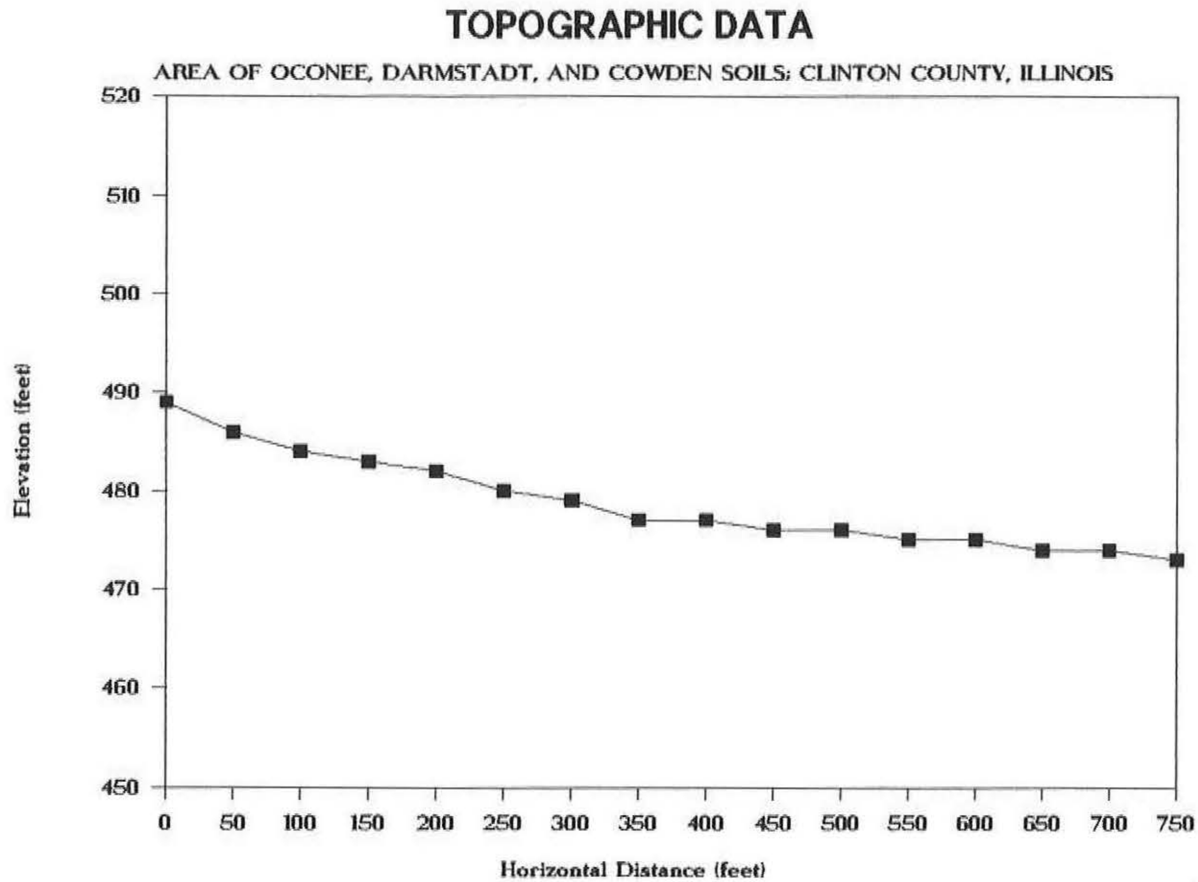
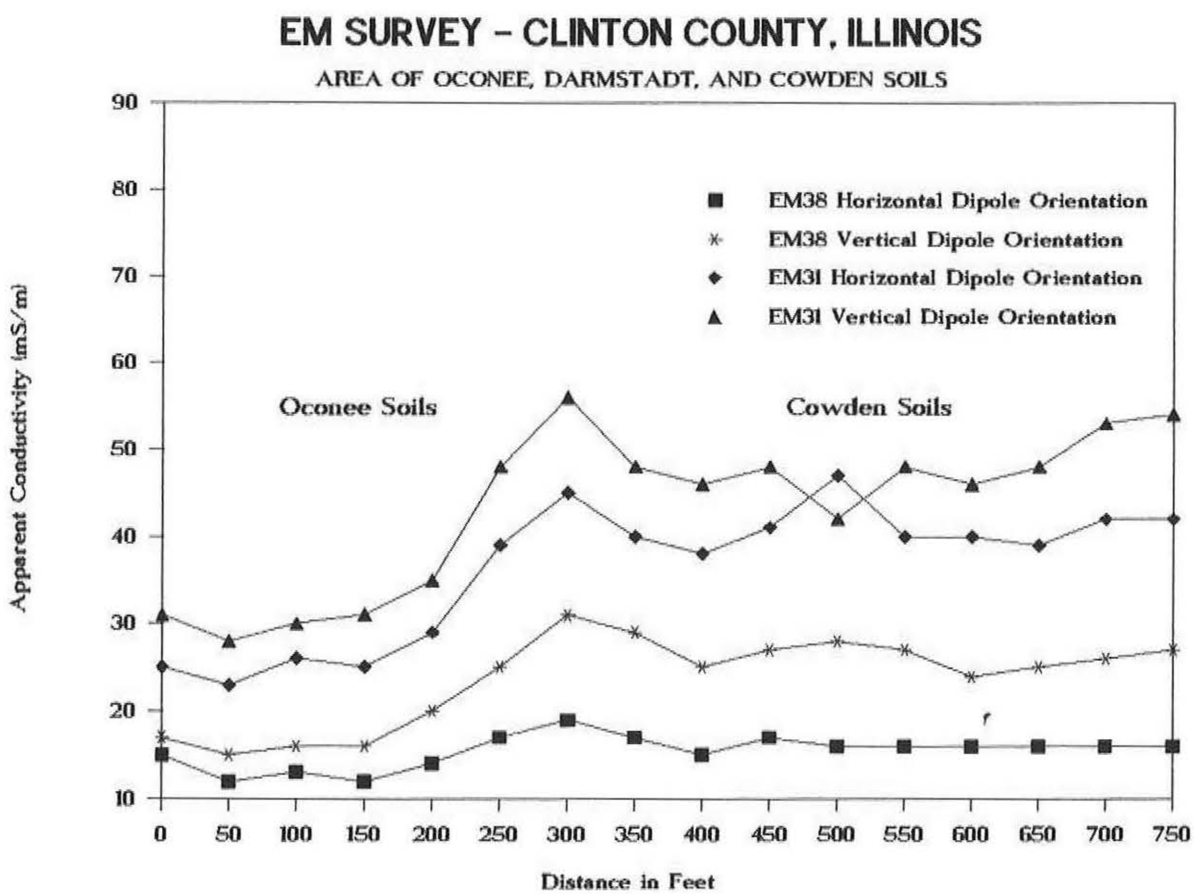
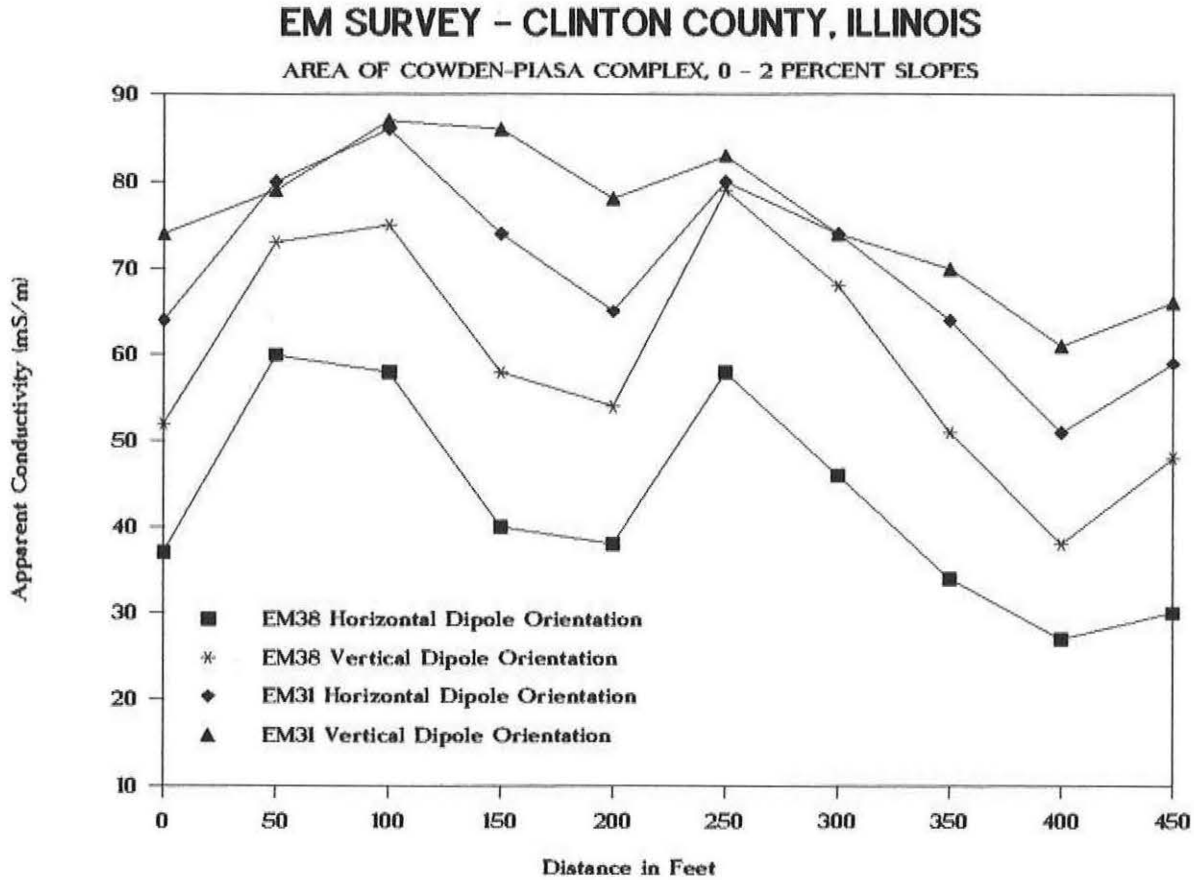


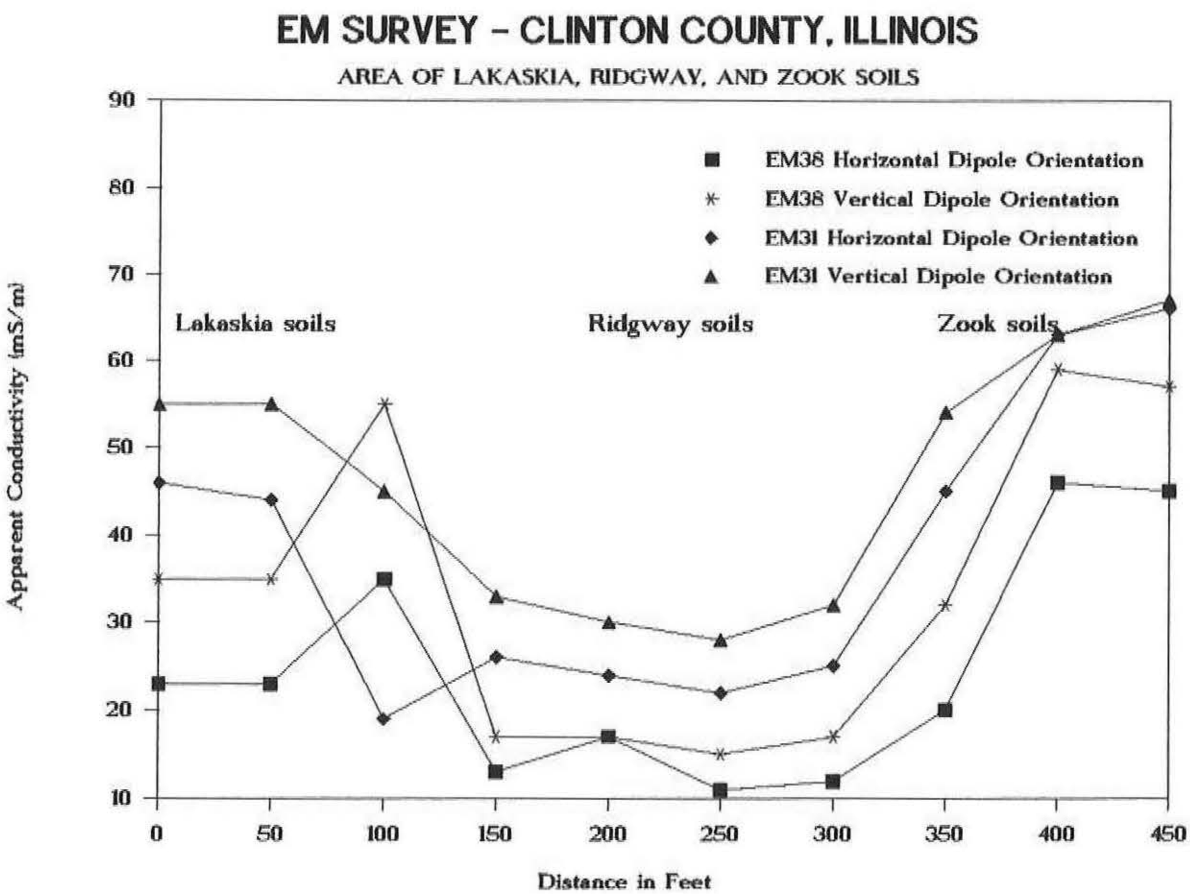
Figure 7A


620C3
308C3
620C3
454B
620B2
620A
620B2
454B
454B
36B
454B
454B
620B2
620C3
620B2
620B2
620C3


TOPOGRAPHIC DATA
AREA OF OCONEE, DARMSTADT, AND COWDEN SOILS; CLINTON COUNTY, ILLINOIS
Elevation (feet)
520
510
500
490
480
470
460
450
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
Horizontal Distance (feet)


EM SURVEY - CLINTON COUNTY, ILLINOIS
AREA OF OCONEE, DARMSTADT, AND COWDEN SOILS
Apparent Conductivity (mS/m)
90
80
70
60
50
40
30
20
10
EM38 Horizontal Dipole Orientation
EM38 Vertical Dipole Orientation
EM31 Horizontal Dipole Orientation
EM31 Vertical Dipole Orientation
Oconee Soils
Cowden Soils
0
50
100
150
200
250
300
350
400
450
500
550
600
650
700
750
Distance in Feet


EM SURVEY - CLINTON COUNTY, ILLINOIS
AREA OF COWDEN-PIASA COMPLEX, 0 - 2 PERCENT SLOPES
Apparent Conductivity (mS/m)
90
80
70
60
50
40
30
20
10
0
50
100
150
200
250
300
350
400
450
Distance in Feet
EM38 Horizontal Dipole Orientation
EM38 Vertical Dipole Orientation
EM31 Horizontal Dipole Orientation
EM31 Vertical Dipole Orientation


EM SURVEY - CLINTON COUNTY, ILLINOIS
AREA OF LAKASKIA, RIDGWAY, AND ZOOK SOILS
Apparent Conductivity (mS/m)
90
80
70
60
50
40
30
20
10
0
50
100
150
200
250
300
350
400
450
Distance in Feet
EM38 Horizontal Dipole Orientation
EM38 Vertical Dipole Orientation
EM31 Horizontal Dipole Orientation
EM31 Vertical Dipole Orientation
Lakaskia soils
Ridgway soils
Zook soils