United States Department of Agriculture	Natural Resources Conservation Service	5 Radnor Corporate Center, Suite 200 Radnor, PA 19087-4585

Subject: SOI -- Site-Specific Farming; Electromagnetic Induction (EM) Assistance

Date: 20 May 1997

To: Janet Oertly
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Purpose:
The purpose of this study was to complete an electromagnetic induction (EM) survey of newly acquired land at the Pennsylvania State University's Rock Spring Agronomy Farm. The objective of this investigation was to prepare maps at a suitable scale for use with site-specific farming. The results of earlier work were reported in my trip report of 6 February 1997.

Participating Agencies:
Pennsylvania State University
USDA-Natural Resources Conservation Service

Participants:
Jim Doolittle, Research Soil Scientist, USDA-NRCS, Radnor, PA
Lynn Huffman, Farm Manager, PSU Agronomy Research Farm, Rock Spring, PA
Jake Eckenrode, Soil Scientist, USDA-NRCS, Bellefonte, PA

Activities:
All field activities were completed during the period of 28 April to 1 May 1997. The study was conducted at the Rock Spring Agronomy Research Farm, Centre County, Pennsylvania. This farm is owned and operated by Pennsylvania State University.

Equipment:
The electromagnetic induction meters used in this study were the EM38 and EM31 manufactured by Geonics Limited. * Each meter is portable and requires one person to operate. Principles of operation have been described by McNeill (1980a, 1986). No ground contact is required with either meter. Each meter provides limited vertical resolution and depth information. For each meter, lateral resolution is approximately equal to the intercoil spacing. The observation depth of an EM meter is dependent upon intercoil spacing, transmission frequency, and coil orientation. Table 1 lists the anticipated observation depths for the EM38 and EM31 meters with different coil orientations.

* Trade names are used to provide specific information.. Their mention does nor constitute endorsement by USDA-NRCS.

TABLE 1

Depth of Measurement
(All measurements are in feet)

Meter	Intercoil Spacing	Depth of Measurement Horizontal	Vertical
EM38	3.2	2.5	5.0
EM31	12.0	10.0	20.0

The EM38 meter has a fixed intercoil spacing of about 3.2 feet. It operates at a frequency of 13.2 kHz. The EM38 meter has theoretical observation depths of about 2.5 and 5 feet in the horizontal and vertical dipole orientations, respectively (McNeill, 1986). The EM31 meter has a fixed intercoil spacing of about 12 feet. It operates at a frequency of 9.8 kHz. The EM31 meter has theoretical observation depths of about 10 and 20 feet in the horizontal and vertical dipole orientations, respectively (McNeill, 1980a). Values of apparent conductivity are expressed in milliSiemens per meter (mS/m).

To help summarize the results of this survey, the SURFER for Windows program, developed by Golden Software, Inc.,* was used to construct two- and three-dimensional simulations. Grids were created using kriging methods with an octant search. All grids were smoothed using a cubic spline interpolation. Shadings and filled isolines have been used in most of the enclosed plots to help emphasize spatial patterns. Other than showing trends and patterns in values of apparent conductivity (i.e., zones of higher or lower electrical conductivity), no significance should be attached to the shades themselves.

Study Site

The study site covered an area of about 88.3 acres. The site was irregularly shaped with maximum dimensions of about 3500 by 1100 feet. Figure 1 shows the general dimensions of the study site and the locations of observation points. This computer-generated plot of the site assumes that the grid interval was 100 feet, and that lines were straight and parallel. This assumption is false and the actual locations of observation points or grid intersections must be corrected with a global positioning system (GPS).

The site had been cropped to corn. Soil delineations mapped within the site include phases of Murrill and Buchanan soils (Braker, 1981). Murrill soils are members of the fine-loamy, mixed, mesic Typic Hapludults family. Buchanan soils are members of the fine-loamy, mixed, mesic Aquic Fragiudults family. These soils formed in colluvium derived principally from materials weathered from sandstone or acid shale bedrock. Slopes ranged from 0 to 8 percent.

Field Procedures

An irregularly shaped grid was hastily paced-off across the site. The grid interval was about 100 feet. This provided 365 grid intersections or observation points. Distances between observation

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points and traverse lines varied. The coordinates of each of the grid intersections will be measured with GPS. These coordinates will be used to improve the spatial accuracy of the plotted data.

At each observation point, measurements were taken with an EM38 meter placed on the ground surface in the vertical dipole orientation. At each observation point, measurements were taken with an EM31 meter in both the horizontal and vertical dipole orientations. For each measurement, the EM31 meter was held at hip height (about 36 inches above the ground surface) with the long axis oriented in a northeast to southwest direction. This alignment approximated the strike of the bedrock.

Soil profiles were observed with a hydraulic probe at 16 grid intersections. At each of these observation sites, a brief profile description was prepared (see Addendum #1). These descriptions specified the depth and texture of soil horizons and the depth to bedrock or auger refusal. These data were used to confirm interpretations.

Results:
Basic statistics for the EM data collected in this survey are displayed in Table 1. For the shallower-sensing EM38 meter, values of apparent conductivity averaged 4.94 mS/m and ranged from 0.6 to 12.9 mS/m in the vertical dipole orientation. One-half of the observations had values of apparent conductivity between 3.4 and 6.2 mS/m. For the deeper-sensing EM31 meter, values of apparent conductivity averaged 6.48 mS/m and ranged from 3.0 to 10.4 mS/m in the horizontal dipole orientation. One-half of the observations had values of apparent conductivity between 5.4 and 7.4 mS/m. In the vertical dipole orientation, values of apparent conductivity averaged 8.5 mS/m and ranged from 3.8 to 15.2 mS/m. One-half of the observations had values of apparent conductivity between 7.0 and 9.6 mS/m.

Table 1
Basic Statistics
EM Survey
(All values are in mS/m)

				Quartiles			
Meter	Orientation	Minimum	Maximum	1st	Median	3rd	Average
EM38	Vertical	0.6	12.9	3.4	4.7	6.2	4.94
EM31	Horizontal	3.0	10.4	5.4	6.4	7.4	6.48
EM31	Vertical	3.8	15.2	7.0	8.2	9.6	8.50

In November, an electromagnetic induction survey was completed on fields to the north and northwest of the present site. The results of this survey have been summarized in my trip report of 6 February 1997. Soils were conspicuously drier in April than they were in November. Apparent conductivity increases with increases in moisture content. A line from the November survey was re-measured to better understand the temporal variations in apparent conductivity caused by changes in moisture content. The comparison was based on measurements taken at 36 observation points with an EM31 meter. Table 3 shows the results of this comparison. Measurements were consistently lower at each observation point in April than they were in December. Measurements made with the shallower-sensing EM31 meter in the horizontal dipole orientation averaged 13 percent lower in April than in

December. Measurements made in the deeper-sensing vertical dipole orientation averaged 19 percent lower in April than in December.

Table 3
Comparison of Apparent Conductivity Measurements made at the same observation points in December and April
(All values are in mS/m)

Month	Meter	Orientation	Minimum	Maximum	Quartiles 1st	Quartiles 3rd	Average
December	EM31	Horizontal	5.6	9.6	7.0	8.6	7.77
April	EM31	Horizontal	4.8	9.0	6.0	7.0	6.69
December	EM31	Vertical	7.5	13.6	9.2	12.0	10.66
April	EM31	Vertical	5.8	10.8	7.6	9.6	8.62

Figure 2 is a two-dimensional plot of data collected with the EM38 meter in the vertical dipole orientation. Figures 3 and 4 are two-dimensional plots of data collected with the EM31 meter in the horizontal and vertical dipole orientations, respectively. Each plot shows the spatial distribution of apparent conductivity for a different depth interval. In each plot, the isoline interval is 2 mS/m.

Soils and soil patterns are exceedingly complex in the study site. Soils formed in highly stratified and variable layers of colluvium. The texture, thickness, and coarse fragment content of these layers are highly variable. The patterns appearing in figures 2, 3, and 4 testify to the variability of soils and soil properties within the site. The complex patterns are an endorsement for precision farming and variable rate applications.

The plot shown in Figure 3 represents apparent conductivity data collected with the EM31 meter in the horizontal dipole orientation. In this orientation, the meter is highly sensitive to the conductivity of materials nearest to the meter. As the meter was held at hip height, in the horizontal orientation, the meter disproportionately weighed the included air column in its average of apparent conductivity. The effects of the air column on measurements are reflected in the lower and less variable values of apparent conductivity plotted in Figure 3.

Generalized spatial patterns appearing in Figures 2 and 4 are similar. In Figures 2 and 4, fingers of materials with lower conductivity appear to extend across the study site in an east to west direction. This orientation approximates the slope that descends from east to west across the site. The fingers of lower conductivity are interpreted to represent areas of thicker deposits of coarser textured and more channery soil materials. These materials are believed to represent colluvium derived from the sandstone bedrock that forms the adjoining ridge to the East of the site. Areas of higher apparent conductivity are evident in the northwest corner of the site. In this lower-lying area, soils were finer-textured and/or more moist. Two nodes of high apparent conductivity extend outward from the unsurveyed area in the southern and north-central portions of the study site. These nodes adjoined a homesite (southern) and a barn (north-central). These features are believed to represent "cultural noise" associated with use and management of the land.

The spatial patterns appearing in the enclosed figures are of value for decision-making. The maps have identified spatial variability. The patterns shown in these plots are large enough to be addresses with variable management practices. However, factors producing this variability need to be identified.

At sixteen observation points, depths to Bt horizon and bedrock were measured with a hydraulic probe (see Addendum #1). One soil profile lacked a Bt horizon. At fifteen observation points, the depth to argillic (Bt) horizon averaged 12 inches and ranged from 8 to 24 inches. The thickness and sequence of Bt horizons were variable. Textures of the Bt horizon included silt loam, loam, clay loam, silty clay loam, silty clay, gravelly silt loam, gravelly loam, and gravelly silty clay loam.

Depths to bedrock were exceedingly difficult to determine at the time of this investigation. At seven of the sixteen observations, augering was halted by either rock fragments or bedrock. At nine observation points, augering was halted by the extremely dry soil conditions before the underlying bedrock was met. These factors caused uncertainty as to the actual depth to bedrock.

In this study, the use of electromagnetic induction did not result in any clear interpretations. Soils and subsurface materials were heterogeneous within the site. The soils formed in colluvium derived from materials weathered from sandstone, acid shale, and limestone bedrock. The colluvium consists of multiple, dissimilar layers. These layers vary in sequence, thickness, and texture. This variability obscured relationships with apparent conductivity and produced unclear interpretations. Variations in apparent conductivity could not be clearly related to changes in the observed soil properties. Relationships between apparent conductivity and depth to argillic horizon or bedrock were exceedingly weak (r^2 ranged from 0.002 to 0.34). The strongest relationship was between apparent conductivity measured with the EM38 meter in the vertical dipole orientation and the depth to the argillic horizon. Because of the weaknesses of these relationships and the observed variability of soils and soil properties, no attempt was made to develop predictive equations for the study site.

Conclusions:

1. This study provided a great wealth of data: apparent conductivity (at three separate depth intervals) at 365 observation points. The data have been summarized in Addendum #2. Simple contouring of the data was used to display the areal extent of similar and dissimilar areas at the three separate depth intervals (figures 2, 3, and 4).

2. Within the study site, EM methods failed to produced unambiguous results and interpretations. Soils and subsurface materials were relatively heterogeneous. The soils formed in colluvium and consisted of multiple, dissimilar layers. The number and variability of these layers obscured relationships and produced unclear interpretations. Variations in apparent conductivity were not strongly related to changes in selected soil properties.

3. Slight temporal variations in apparent conductivity were observed between measurements collected in November and April. Apparent conductivity was lower in April because of drier soil conditions. Because of this difference, it may be difficult to correlate the results of the two surveys. To correct this dilemma, all areas should be surveys at the same time in the future.

4. The study is not complete. Staff from Penn State University should obtain a more accurate positioning of the observation points with GPS. The plots shown in this report have assumed parallel grid lines and a uniform grid interval. The locations of the observation points within the study site conform to very crude grid lines having variable intervals and spacings. As a consequence, the patterns shown in the enclosed plots are inaccurate.

5. Results of this survey have been stored on disc and have been enclosed in Addendum #2. This information must be integrated with yield data in a geographical information system. Yield data should

be compared with EM data. The successful integration and analysis of these data sets can increase our understanding of the variability of soils within soil map units.

Once again, it was my pleasure to work with and to be of assistance to members of your fine staff.

With kind regards,

James A. Doolittle
Research Soil Scientist

cc:

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References

McNeill, J. D. 1980a. Electromagnetic terrain conductivity measurement at low induction numbers. Technical Note TN-6. Geonics Limited, Mississauga, Ontario. 15 p.

McNeill, J. D. 1980b. Electrical Conductivity of soils and rocks. Technical Note TN-5. Geonics Ltd., Mississauga, Ontario. p. 22.

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

EM SURVEY
ROCK SPRING AGRONOMY FARM

LOCATION OF OBSERVATION POINTS

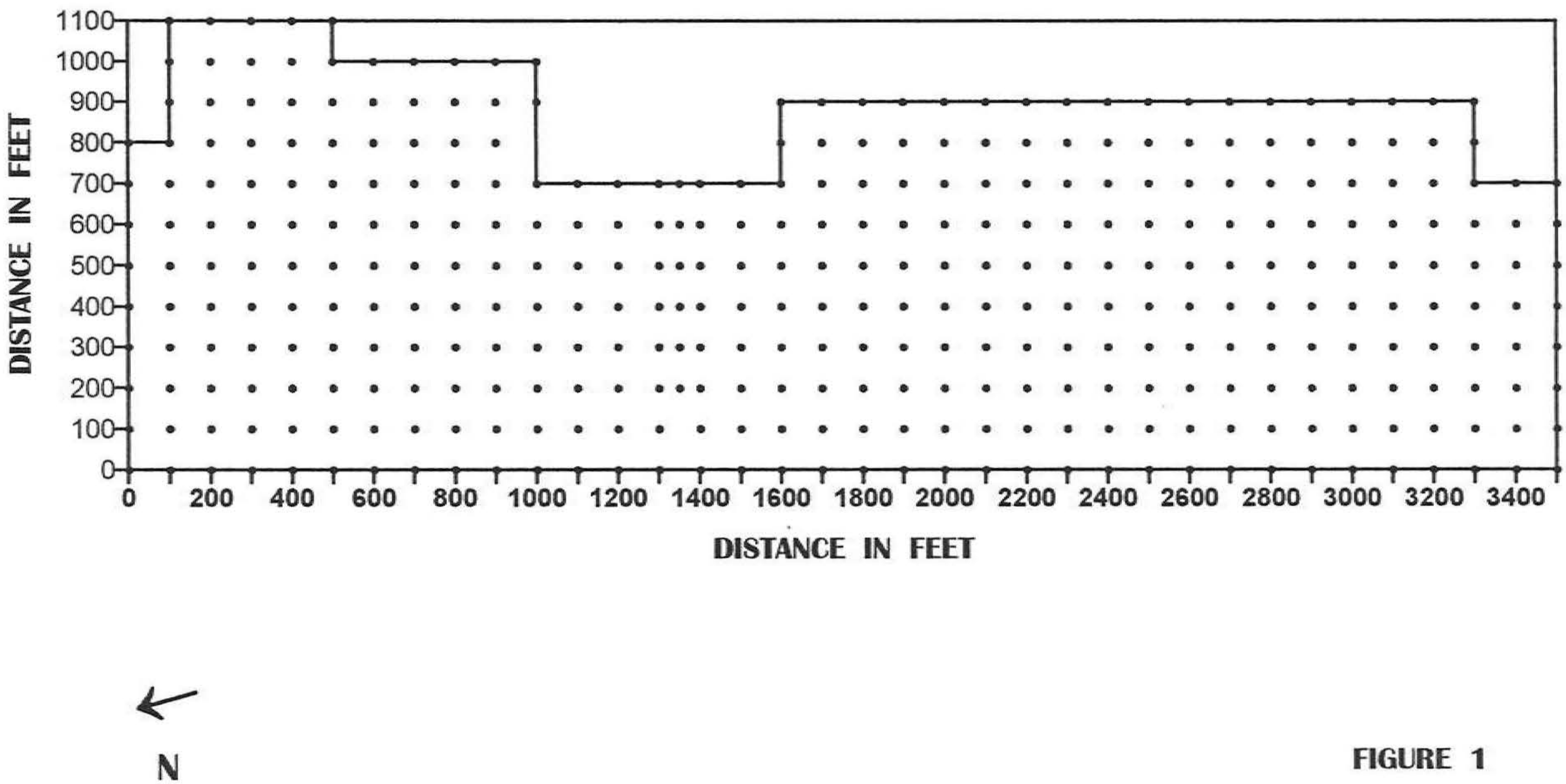

FIGURE 1

EM SURVEY
ROCK SPRING AGRONOMY FARM

EM38 METER
VERTICAL DIPOLE ORIENTATION

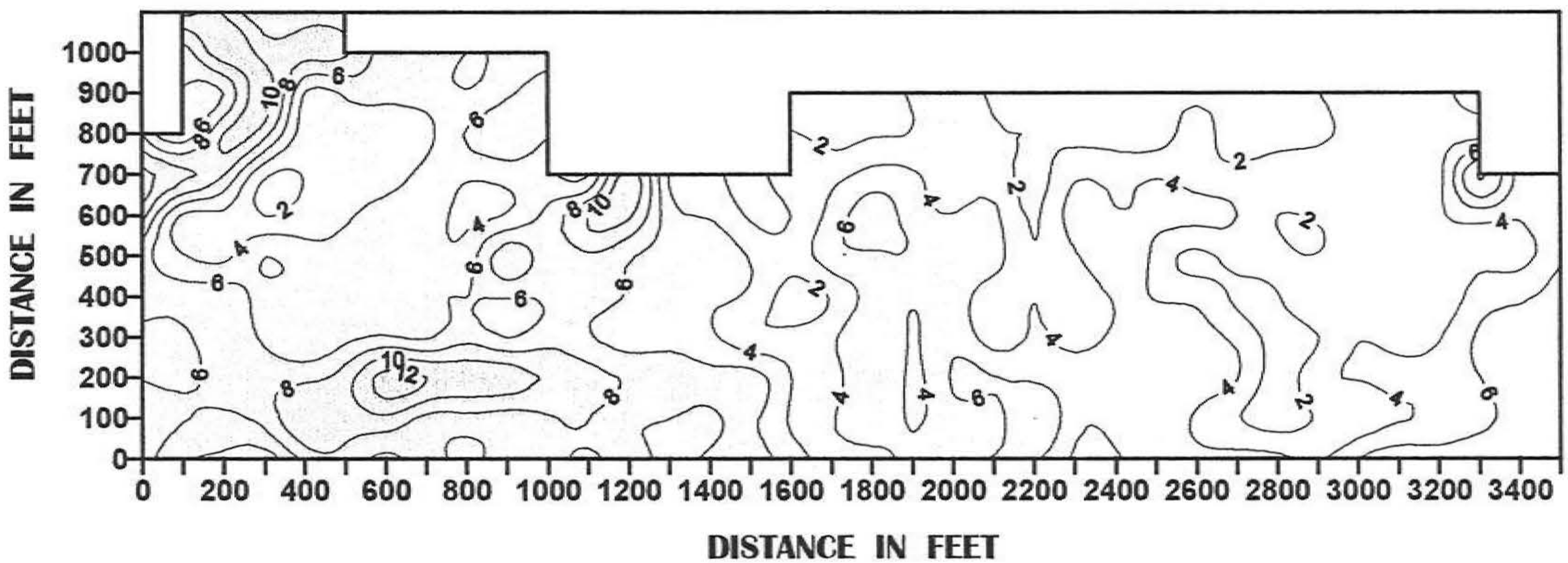

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FIGURE 2

EM SURVEY
ROCK SPRING AGRONOMY FARM

EM31 METER
HORIZONTAL DIPOLE ORIENTATION

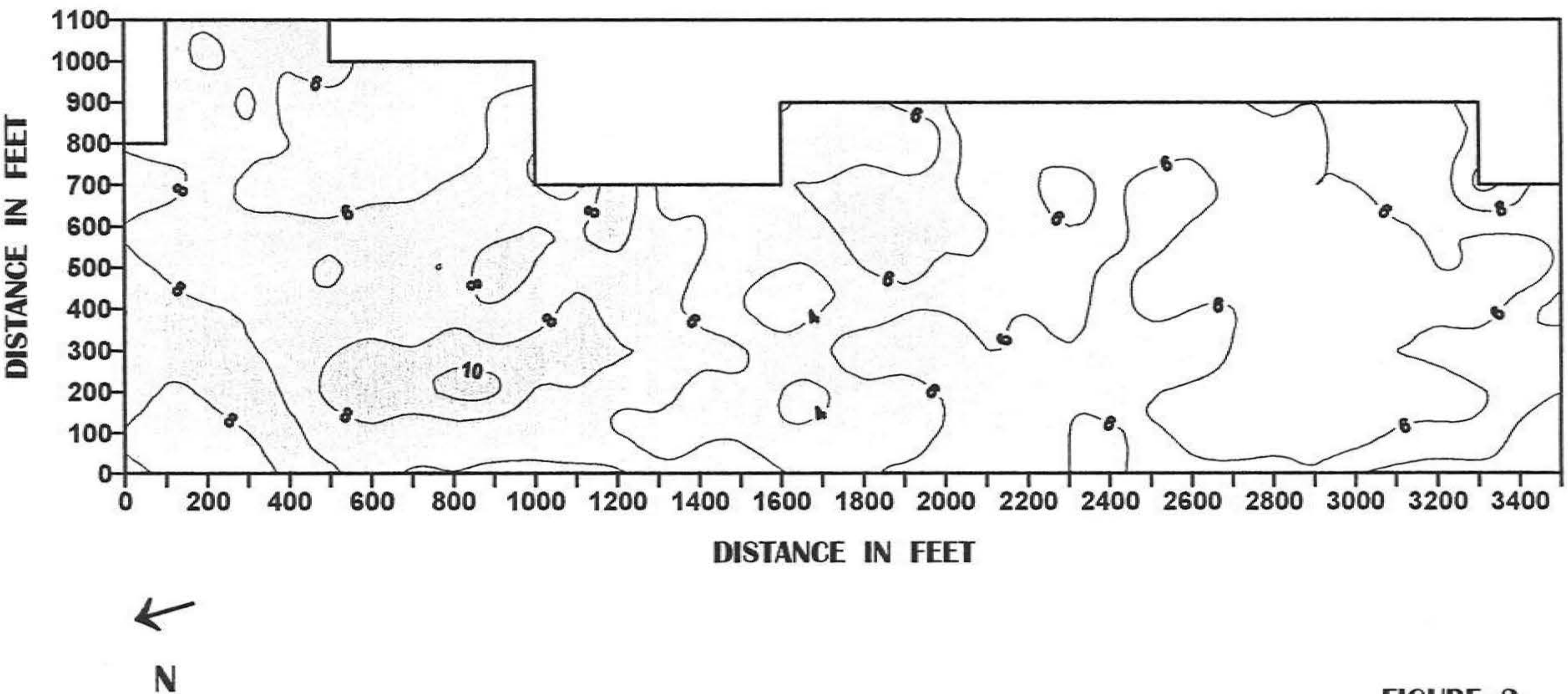

FIGURE 3

EM SURVEY
ROCK SPRING AGRONOMY FARM

EM31 METER
VERTICAL DIPOLE ORIENTATION

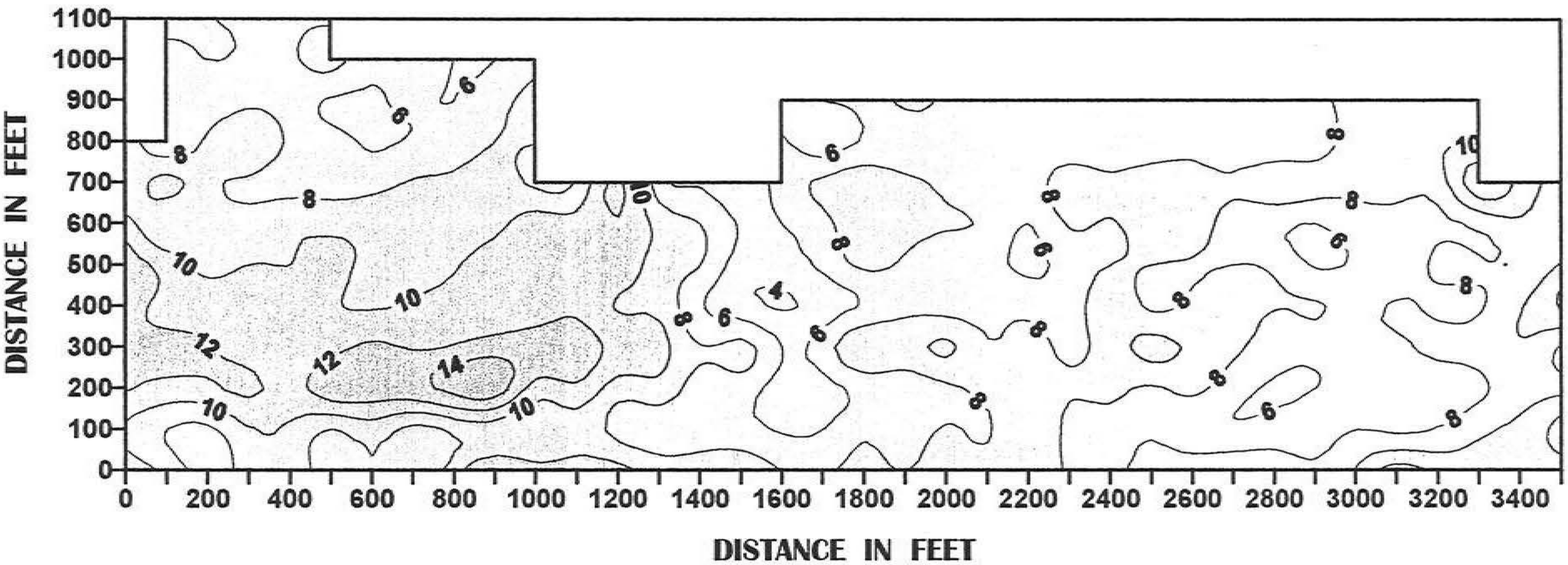

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FIGURE 4

Addendum #1

Soil Observations

Site	Horizon	Depth	Texture	Soil Series
Line 100				
100	Ap	0-18	silt loam	Timbersville
	Bt	18-30	silty clay loam	
	Bt	30-80	silty clay	
	C	80-96	gravelly loam	
Line 200				
200	Ap	0-10	silt loam	Clarksburg
	Bt	10-16	silt loam	
	Bt	16-24	silty clay loam (with redox features)	
	Bt	24-34	clay loam (with redox features)	
	C	34-66	loam	
600	Ap	0-10	silt loam	Clarksburg
	Bt	10-16	silt loam	
	Bt	16-32	silt loam (with redox features)	
	Bt	32-56	silt loam	
800	Ap	0-10	silt loam	Clarksburg
	Bw	10-14	silt loam	
	Bt	14-34	silty clay loam (with redox features)	
	Bt	34-44	silty clay loam	
	C	44-54	silt loam	
900	Ap	0-10	silt loam	Clarksburg
	Bt	10-16	loam	
	Bt	16-44	silty clay loam (with redox features)	
	Bt	44-50	silt loam (with redox features)	
	Bt	50-70	silty clay loam (with redox features)	
Line 500				
3400	Ap	0-8	gravelly loam	Murrill
	Bt	8-60	loam	
	Bt	60-102	silt loam	
3300				
	Ap	0-9	gravelly loam	Murrill
	Bw	9-15	silt loam	
	Bt	15-30	loam	
	Bt	30-40	loam (with redox features)	
	Bt	40-65	loam	
	Bt	65-72	clay loam	

Soil Observations

Site	Horizon	Depth	Texture	Soil Series
Line 500				
3200				
	Ap	0-8	gravelly silt loam	
	Bw	8-24	gravelly loam	
	C	24-42	gravelly sandy loam	
3100				
	Ap	0-9	gravelly silt loam	
	Bt	9-72	silt loam	
	R	72+	rock	
3000				
	Ap	0-8	gravelly silt loam	Clarksburg
	Bt	8-30	silt loam	
	Bt	30-40	loam (with redox features)	
	Bt	40-65	loam	
	C	65-85	sandy loam	
	2Btb	85-95	silt loam	
	2Btb2	95-102	clay	
2900				
	Ap	0-8	gravelly silt loam	
	Bt	8-40	loam	
	Bt	40-48	gravelly loam	
		48	auger refusal (stones)	
2800				
	Ap	0-10	silt loam	Clarksburg
	Bw	10-24	gravelly loam	
	Bt	24-52	gravelly silty clay loam (with redox features)	
		52	auger refusal (stones)	
2700				
	Ap	0-9	silt loam	Clarksburg
	Bt	9-15	silt loam	
	Bt	15-30	gravelly clay loam (with redox features)	
	Bt	30-40	gravelly loam	
		40	auger refusal (bedrock)	
2600				
	Ap	0-9	gravelly silt loam	
	Bt	9-30	gravelly loam	
	C	30-56	very gravelly sandy loam	
		56	auger refusal (stones)	

Soil Observations

Site	Horizon	Depth	Texture	Soil Series
Line 500				
2500				
	Ap	0-8	gravelly silt loam	
	Bt	8-20	gravelly loam	
	C	20-44	gravelly sandy loam	
		44	auger refusal (stones)	
2400				
	Ap	0-8	gravelly silt loam	
	Bw	8-15	gravelly silt loam	
	Bt	15-24	gravelly silty clay loam	
	2Bt	24-70	clay	
		70	auger refusal (stones)	

Addendum #2

X	Y	EM38V	EM31H	EM31V
0	0	6.9	8.8	11.4
100	0	4.2	7.6	9.4
200	0	3.4	6.8	7.2
300	0	2.8	7.2	9.0
400	0	6.6	8.4	9.8
500	0	7.3	8.6	6.6
600	0	5.4	6.6	8.0
700	0	7.0	8.6	6.6
800	0	5.3	8.2	9.2
900	0	7.8	9.4	12.2
1000	0	7.8	8.8	10.8
1100	0	8.2	8.8	11.2
1200	0	7.0	8.4	10.8
1300	0	5.6	6.8	9.2
1400	0	6.4	7.0	9.4
1500	0	7.1	7.8	9.8
1600	0	4.9	6.2	8.0
1700	0	3.3	5.6	7.8
1800	0	3.0	5.8	8.4
1900	0	4.8	6.4	8.0
2000	0	5.5	6.8	8.8
2100	0	6.2	7.0	9.0
2200	0	5.8	6.8	9.0
2300	0	3.6	6.0	7.8
2400	0	3.8	5.8	7.8
2500	0	4.8	6.4	8.4
2600	0	4.6	6.6	9.2
2700	0	5.0	7.0	10.2
2800	0	4.6	6.8	9.4
2900	0	3.9	6.2	8.4
3000	0	6.1	7.8	10.2
3100	0	7.8	8.6	13.0
3200	0	7.3	8.8	11.4
3300	0	8.4	8.6	10.6
3400	0	6.9	8.2	10.6
3500	0	7.6	8.4	10.8
0	100	7.1	7.8	9.6
100	100	6.1	6.8	8.0
200	100	5.7	6.6	7.6
300	100	6.8	8.0	9.8
400	100	9.8	8.4	9.6
500	100	7.5	7.2	8.0
600	100	9.5	7.4	9.0
700	100	7.3	6.6	7.4
800	100	7.3	7.0	8.4
900	100	7.0	6.6	8.8
1000	100	7.8	7.0	8.2
1100	100	8.0	6.6	9.0
1200	100	6.4	6.0	7.4
1300	100	6.0	5.4	7.0

X	Y	EM38V	EM31H	EM31V
1400	100	5.7	5.6	6.8
1500	100	6.4	5.6	6.6
1600	100	3.7	4.4	5.8
1700	100	3.8	4.8	6.0
1800	100	5.6	5.8	7.6
1900	100	3.7	5.0	7.0
2000	100	5.4	6.2	8.2
2100	100	5.2	5.8	7.8
2200	100	8.0	7.6	9.8
2300	100	4.6	6.0	7.4
2400	100	4.8	5.8	7.4
2500	100	5.1	6.2	7.8
2600	100	3.7	5.4	7.0
2700	100	2.1	4.6	6.2
2800	100	1.2	5.2	6.8
2900	100	2.2	5.2	7.0
3000	100	2.9	5.2	8.0
3100	100	3.8	6.2	7.6
3200	100	4.4	6.6	8.2
3300	100	5.4	6.8	9.6
3400	100	7.0	8.4	10.6
3500	100	8.2	9.2	12.8
0	200	5.9	9.4	12.2
100	200	5.7	7.8	11.4
200	200	6.6	8.4	11.6
300	200	7.3	9.4	12.4
400	200	7.6	7.6	11.4
500	200	9.1	8.4	13.2
600	200	12.9	9.6	13.2
700	200	12.0	9.6	13.4
800	200	11.3	10.4	14.8
900	200	11.1	10.2	15.2
1000	200	9.7	7.8	11.2
1100	200	8.9	7.8	11.6
1200	200	7.7	6.6	9.0
1300	200	7.1	6.8	9.2
1350	200	8.8	6.4	8.6
1400	200	6.5	5.2	7.0
1500	200	6.9	5.4	7.0
1600	200	4.0	4.0	5.0
1700	200	3.1	3.8	5.2
1800	200	6.6	5.2	6.6
1900	200	3.6	4.8	6.8
2000	200	6.3	6.4	7.6
2100	200	6.1	6.6	8.4
2200	200	5.7	6.4	8.4
2300	200	5.0	6.2	8.2
2400	200	5.6	6.8	8.4
2500	200	5.7	6.2	7.8
2600	200	5.1	5.4	8.4
2700	200	4.0	5.0	6.8
2800	200	1.2	4.8	5.8
2900	200	3.4	4.4	6.0
3000	200	4.1	4.8	6.4

X	Y	EM38V	EM31H	EM31V
3100	200	4.6	5.4	6.8
3200	200	4.7	5.2	6.4
3300	200	6.0	5.8	7.6
3400	200	7.4	7.0	9.0
3500	200	7.6	8.0	9.2
0	300	5.4	8.8	12.2
100	300	5.6	8.4	12.4
200	300	7.2	8.6	12.0
300	300	5.6	8.2	11.2
400	300	3.6	7.4	10.2
500	300	5.5	7.8	11.2
600	300	6.3	8.6	12.4
700	300	5.8	8.2	11.8
800	300	7.3	9.0	12.2
900	300	5.9	8.4	13.0
1000	300	7.2	8.8	13.2
1100	300	6.2	8.8	13.2
1200	300	5.1	8.2	11.4
1300	300	5.3	7.6	10.8
1350	300	4.5	7.0	8.4
1400	300	4.4	6.6	7.8
1500	300	2.6	6.2	8.6
1600	300	2.6	4.8	6.2
1700	300	3.6	5.6	7.0
1800	300	5.8	7.4	9.8
1900	300	3.8	7.4	9.2
2000	300	5.4	7.8	10.4
2100	300	3.0	6.0	8.2
2200	300	4.3	6.6	8.6
2300	300	3.2	6.2	7.6
2400	300	4.6	7.2	9.0
2500	300	5.5	8.0	10.6
2600	300	4.8	7.6	9.6
2700	300	3.4	5.8	8.4
2800	300	1.2	5.0	7.0
2900	300	2.0	5.6	6.6
3000	300	3.9	5.8	7.4
3100	300	3.2	6.0	7.6
3200	300	3.9	6.4	8.6
3300	300	6.4	7.2	8.8
3400	300	6.8	7.2	9.8
3500	300	5.8	6.8	7.8
0	400	6.8	8.0	12.6
100	400	6.6	8.4	11.6
200	400	7.2	8.2	11.4
300	400	5.3	7.8	11.6
400	400	5.6	7.6	11.2
500	400	4.4	7.2	10.2
600	400	4.0	6.8	9.8
700	400	5.7	6.8	10.2
800	400	6.0	7.4	10.6
900	400	6.1	7.6	11.0
1000	400	6.1	7.0	10.6
1100	400	6.6	8.6	11.4
1200	400	5.8	7.0	9.8

X	Y	EM38V	EM31H	EM31V
1300	400	4.7	6.6	9.4
1350	400	5.1	5.2	6.4
1400	400	4.4	5.4	6.2
1500	400	3.5	4.2	4.8
1600	400	1.2	3.0	3.8
1700	400	2.2	4.0	4.8
1800	400	4.6	4.6	6.2
1900	400	4.3	5.8	7.4
2000	400	4.8	5.8	7.0
2100	400	3.1	5.4	7.2
2200	400	3.9	5.8	7.4
2300	400	1.8	5.0	7.0
2400	400	4.4	7.0	9.4
2500	400	3.8	5.2	7.6
2600	400	3.4	6.0	8.6
2700	400	1.6	6.0	8.8
2800	400	1.9	5.6	8.0
2900	400	4.1	5.2	8.2
3000	400	3.1	5.8	7.4
3100	400	2.5	5.2	8.2
3200	400	2.7	5.6	7.6
3300	400	4.9	5.0	7.8
3500	400	6.9	8.6	12.2
0	500	6.6	9.0	13.0
100	500	4.2	7.6	11.2
200	500	3.5	6.8	9.4
300	500	6.1	6.6	10.0
400	500	4.8	6.8	10.0
500	500	4.7	8.4	10.6
600	500	5.2	6.4	9.4
700	500	4.8	6.2	9.4
800	500	5.0	6.4	9.8
900	500	9.3	9.6	11.2
1000	500	6.9	7.8	10.8
1100	500	7.6	7.4	10.8
1200	500	6.2	7.6	11.4
1300	500	5.4	7.4	9.0
1350	500	5.4	6.2	8.0
1400	500	5.4	5.8	8.0
1500	500	3.8	4.6	5.0
1600	500	2.7	4.0	5.2
1700	500	5.2	4.2	6.4
1800	500	5.7	6.0	8.4
1900	500	6.2	6.4	7.6
2000	500	5.2	5.8	6.6
2100	500	4.6	5.6	6.6
2200	500	2.3	4.2	5.6
2300	500	3.7	5.0	6.8
2400	500	6.1	6.2	8.0
2500	500	3.3	5.8	8.0
2600	500	1.5	5.2	7.8
2700	500	2.8	5.2	8.0
2800	500	2.6	5.2	7.6
2900	500	2.1	4.2	5.8
3000	500	3.3	5.4	6.2

X	Y	EM38V	EM31H	EM31V
3100	500	4.1	5.4	6.6
3200	500	3.1	6.0	8.4
3300	500	3.5	5.6	8.2
3400	500	3.4	4.6	8.2
3500	500	5.8	6.8	10.2
0	600	10.8	7.8	10.8
100	600	3.6	6.4	8.2
200	600	3.5	6.6	8.8
300	600	2.0	6.2	9.0
400	600	3.0	6.4	9.6
500	600	3.7	6.4	9.4
600	600	5.1	6.8	9.6
700	600	4.7	6.6	9.4
800	600	3.6	6.4	8.8
900	600	4.2	6.8	9.4
1000	600	6.7	8.0	11.0
1100	600	10.0	7.8	10.8
1200	600	10.3	8.6	11.8
1300	600	4.9	6.4	9.4
1350	600	4.9	6.6	8.8
1400	600	3.8	6.2	8.0
1500	600	1.7	4.2	5.8
1600	600	2.0	4.4	6.0
1700	600	4.7	5.6	7.2
1800	600	7.0	7.0	9.8
1900	600	5.1	6.6	9.0
2000	600	4.1	6.2	8.2
2100	600	4.4	6.0	7.6
2200	600	1.7	5.0	6.0
2300	600	5.0	6.0	8.2
2400	600	4.0	5.6	7.8
2500	600	4.6	6.6	9.4
2600	600	4.7	5.8	9.2
2700	600	4.0	5.2	7.0
2800	600	1.8	5.2	6.4
2900	600	2.4	4.8	6.0
3000	600	3.4	4.8	7.0
3100	600	3.4	5.8	7.0
3200	600	3.8	6.2	7.6
3300	600	4.8	6.4	8.4
3400	600	4.2	6.6	9.6
3500	600	5.8	6.8	8.0
0	700	12.8	10.4	8.2
100	700	10.6	9.0	10.6
200	700	5.8	6.8	8.6
300	700	2.3	5.8	7.6
400	700	2.1	5.4	7.2
500	700	3.0	5.2	7.2
600	700	2.9	5.2	7.2
700	700	4.6	5.6	8.2
800	700	4.3	6.2	8.4
900	700	4.9	6.4	8.8
1000	700	4.6	6.0	7.6
1100	700	4.0	5.6	8.2
1200	700	11.0	9.2	12.4

X	Y	EM38V	EM31H	EM31V
1300	700	3.8	5.8	6.8
1350	700	4.0	6.0	6.8
1400	700	2.4	5.2	5.8
1500	700	1.3	4.4	4.8
1600	700	3.3	5.8	6.8
1700	700	3.4	6.2	8.4
1800	700	4.7	7.2	9.4
1900	700	4.3	6.6	8.6
2000	700	3.0	6.2	7.6
2100	700	3.1	5.4	7.0
2200	700	1.3	5.6	7.0
2300	700	3.6	6.8	9.0
2400	700	3.4	5.6	8.6
2500	700	3.8	7.0	9.8
2600	700	2.9	6.8	9.0
2700	700	2.7	5.6	8.4
2800	700	3.5	6.0	9.4
2900	700	4.2	6.0	8.8
3000	700	3.6	6.0	8.6
3100	700	4.3	7.0	8.8
3200	700	3.4	6.8	9.0
3300	700	10.4	10.4	13.4
3400	700	5.0	8.4	11.4
3500	700	6.2	7.6	9.0
0	800	8.0	7.4	9.4
100	800	4.6	6.8	6.4
200	800	10.1	7.8	8.4
300	800	8.7	6.8	10.0
400	800	2.9	6.0	7.6
500	800	3.0	4.8	6.6
600	800	2.8	4.6	5.8
700	800	3.5	5.4	6.2
800	800	6.2	5.0	6.8
900	800	7.2	6.2	8.0
1600	800	2.2	5.2	6.2
1700	800	1.2	4.0	4.8
1800	800	1.8	4.8	6.2
1900	800	2.1	4.4	6.4
2000	800	3.7	6.2	7.6
2100	800	2.3	5.2	7.6
2200	800	2.8	5.6	6.8
2300	800	1.8	4.8	6.6
2400	800	1.2	5.0	6.0
2500	800	1.1	4.6	6.2
2600	800	2.7	5.4	7.2
2700	800	0.8	4.0	6.4
2800	800	0.8	5.0	6.4
2900	800	1.2	5.4	7.0
3000	800	3.2	7.2	8.8
3100	800	2.8	6.2	8.8
3200	800	3.4	6.8	9.8
3300	800	3.2	8.6	9.8
100	900	5.8	7.8	7.4
200	900	6.0	6.2	6.6
300	900	11.2	8.4	7.4

X	Y	EM38V	EM31H	EM31V
400	900	3.9	5.0	7.0
500	900	4.3	5.0	5.8
600	900	4.4	4.6	5.8
700	900	4.6	5.2	6.2
800	900	4.1	4.6	6.0
900	900	5.7	6.2	7.2
1000	900	6.7	6.4	8.6
1600	900	0.6	3.8	5.4
1700	900	0.8	4.8	6.0
1800	900	1.1	5.2	6.6
1900	900	2.2	6.4	8.4
2000	900	2.8	6.0	7.6
2100	900	1.7	5.2	6.6
2200	900	1.1	4.8	6.4
2300	900	1.6	5.2	6.4
2400	900	1.8	5.0	6.8
2500	900	1.8	6.0	7.8
2600	900	1.7	5.4	6.8
2700	900	1.8	5.6	7.4
2800	900	1.9	6.6	7.8
2900	900	1.9	6.0	7.6
3000	900	4.0	7.4	8.8
3100	900	2.6	6.6	9.4
3200	900	2.8	7.4	9.0
3300	900	6.4	8.6	9.6
100	1000	7.0	6.8	7.2
200	1000	11.3	8.4	8.0
300	1000	8.9	6.8	7.6
400	1000	8.8	6.4	7.6
500	1000	8.3	7.6	8.8
600	1000	5.1	4.8	6.4
700	1000	4.6	5.2	6.4
800	1000	3.9	5.4	6.0
900	1000	4.3	4.4	6.0
100	1000	5.4	5.4	7.4
100	1100	12.6	7.8	9.4
200	1100	9.7	7.4	8.2
300	1100	6.4	6.8	7.6
400	1100	6.4	6.6	7.4
500	1100	6.4	6.6	7.6