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ADVANCED MICROWAVE SOIL MOISTURE STUDIES

Final Report
For
NASA-Goddard Space Flight Center
Grant NSG 5396
Greenbelt, Maryland
20771

SEPTEMBER 1983

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by
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Advanced Microwave Soil Moisture Studies

INTRODUCTION

Timely soil moisture information is needed for many existing and potential programs of agriculturists, foresters, hydrologists, climatologists, and others (NASA, 1980). Remote sensing technology offers a potentially powerful tool for obtaining these data, viz, multidate, region-wide estimations of soil water content (SWC). Numerous investigations have shown significant relationships between SWC and data collected with remote sensors responsive to the visible, near-infrared, thermal infrared, and microwave portions of the electromagnetic spectrum (Myers, 1975; Heilman et al., 1978).

This report will focus on two of the more promising remote sensing spectral regions--a thermal infrared window (8.5-11.1 µm) and passive L-band microwave (21 cm). The remote sensing data from these two regions have shown good prospects for the quantitative estimation of SWC (Heilman et al., 1978; Price, 1980; Schmugge, 1978; Schmugge et al., 1978).

A simplified basis for relating thermal-infrared (TIR) data to soil water estimations is dictated by the analysis of two major variables: diurnal heat capacity, or heat storing ability, and evaporation (Price, 1982). The correlation of thermal radiometric data, or apparent soil temperature, to SWC has shown a strong relationship to diurnal temperature measurements (Schmugge et al., 1978). Furthermore, satellite TIR data from the Heat Capacity Mapping Mission (HCMM) have shown a significant relationship between SWC (in the 0 to 4 cm soil depth) and the difference of apparent soil temperatures at 0230 and 1330 hours (Moore et al., 1981). Moore et al. (1981) also identified HCMM data as being useful in locating perched water tables. The complicating factors in relating TIR data to SWC have been widely identified as thermal inertia-heat sink interactions, vegetative cover, evapotranspiration, topography, soil variability, and atmospheric absorption, solar radiation, winds, and temperature.

Microwave emissivity at the earth's surface, assuming a bare, smooth surface, is largely related to the dielectric properties of the medium. The unique dielectric property of water at microwave wavelengths is the prime consideration used to differentiate a wet soil from a dry soil. The dielectric constant for water is an order of magnitude larger than that of a dry soil--80 vs. 3 or 4 (Schmugge et al., 1974). Concomitant changes are measurable in the emissivity of wet soil, 0.6, versus a dry soil, 0.9. Since brightness temperature (TB) is essentially defined as the product of emissivity (ε) and temperature, changes in ε will effect changes in the surficial thermal emissions at the microwave wavelengths.

Several L-band radiometer experiments have shown that the response of the sensor to SWC is sensitive to the top 5 cm of soil depth (Schmugge, 1980b). Analyses of L-band data have produced significant relationships to SWC in a controlled laboratory setting (Carver and Bush, 1979), in field trials on bare soils (Schmugge et al., 1974), and in field trials that included vegetative cover (Mo et al., 1981). The estimation of SWC using microwave sensors is complicated by other site variables, namely, vegetative cover, surface roughness, and soil type (Schmugge, 1980a). These variables are important insomuch as they cause direct or indirect changes in ε and/or dielectric properties in addition to those changes effected by soil water.

Several models have been devised to account for the complicating factors in estimating SWC with either thermal or microwave data (Schmugge and Choudhury, 1981; Camillo and Schmugge, 1981; Mo et al., 1981; Burke and Schmugge, 1982). Other manipulations to reduce confounding effects have included the use of soil water potential to normalize SWC in a TIR study (Idso et al., 1975), the use of SWC as a percentage of field capacity to normalize soil variation in an L-band study, (Theis et al., 1982), and the determination of upwelling radiation as it influences the measured temperature, or "effective temperature", for input in the TB calculation (Choudhury and Schmugge, 1982).

While a great deal is known about the driving forces and the variables within the soil-water continuum, much remains to be discerned about the inner working of this complex, dynamic system. After moisture enters the soil-water system, many variables may potentially exert force(s) in varying degrees and directions. These variables include texture (and mineralogy), organic matter, structure, antecedent moisture content, chemical content (e.g., level of salts), diffusion gradients, temperature gradients, soil water potentials, bulk density, porosity, and pore geometry (Nielsen et al., 1972; Rose, 1966).

A framework that groups soils by similar properties may provide a basis for reducing the complicating factors in analyzing TIR or L-band radiometer data. Detailed soil maps, produced by the USDA/Soil Conservation Service (SCS) at a 1:20,000 scale, may provide such a framework. A detailed soil map consists of soil units that are "alike in characteristics that are significant to the nature and functioning of the soil in the natural landscape" (p. 12, Soil Survey Staff, 1951). Soil phases, e.g., slope or stoniness, are also used in partitioning the landscape into relatively homogeneous soil units. Varying soil usages and managements can also add to the range of soil properties within a soil unit. Each soil unit is described and grouped by a characteristic set of interpretations based on observed, measured, or inferred features. Among the features of similarity within a soil map unit, assuming a single dominant soil (consociation), are slope, soil depth, structure, texture, soil temperature and moisture regime, organic matter, permeability, and degree of aggregation (Soil Survey Staff, 1951).

The major objectives of this project were to statistically evaluate the comparisons between remotely sensed data (low-level L-band TB and TIR data) and each of the following data sets: 1) soil map data and land cover data, 2) direct soil moisture measurements and 3) a computer-generated water table contour map.

THE STUDY AREA

The project was conducted in the Big Sioux River Basin in Brookings County (Fig. 1). The continental climate of this area is characterized by seasonal extremes. Mean annual precipitation is 56 cm (22 in), while mean annual air temperature is 6.7°C (44°F). Land use is dominantly agricultural; corn, spring wheat, barley, oats, soybeans, sunflowers, pasture and hayland are the major crops.

Brookings County is located in the Prairie Coteau, a physiographic unit of Pleistocene age. Several forms of glacial deposits dominate this region. Within the extent of the flight overpasses, outwash terraces and alluvium are prevalent. Sand and gravel lenses occur throughout this zone, and shallow groundwater is common, with recharge coming mainly from the spring snowmelt and rain (Moore et al., 1981).

Soils of this area are usually medium-textured or finer. Drainage is largely poor, and soil slopes are generally nearly level. A detailed soil survey, completed for Brookings County at a scale of 1:20,000 provides more in-depth soil and general information (Westin et al., 1958).

METHODS AND MATERIALS

Four data collection flights took place over the project area in 1981--20 May, 17 July, 20 July and 11 August. Climatological information prior to and including the data collection periods is listed in Table 1. Color infrared (CIR) photography, thermal infrared (TIR) imagery, and L-band radiometer data were collected during each flight at an altitude of 304 m above-ground level.

The analog L-band data were converted to brightness temperature (TB) via the following equation:

$$TB = 1.6684\ (\text{Normalized digital count-average hot load}) + 322.$$

This calibration equation was derived from measurements made with the complete radiometer system of three targets with well-known microwave properties--sky, water and thick pads of microwave blackbody material. The radiometer contains two temperature reference loads which are useful but bypass the antenna and so do not measure the entire radiometer system. Of the two internal references, the hot load is one which is temperature controlled and produces a constant output. It is this hot load that is used as the normalizing point in developing the calibration equation. The digitized values from the hot load output

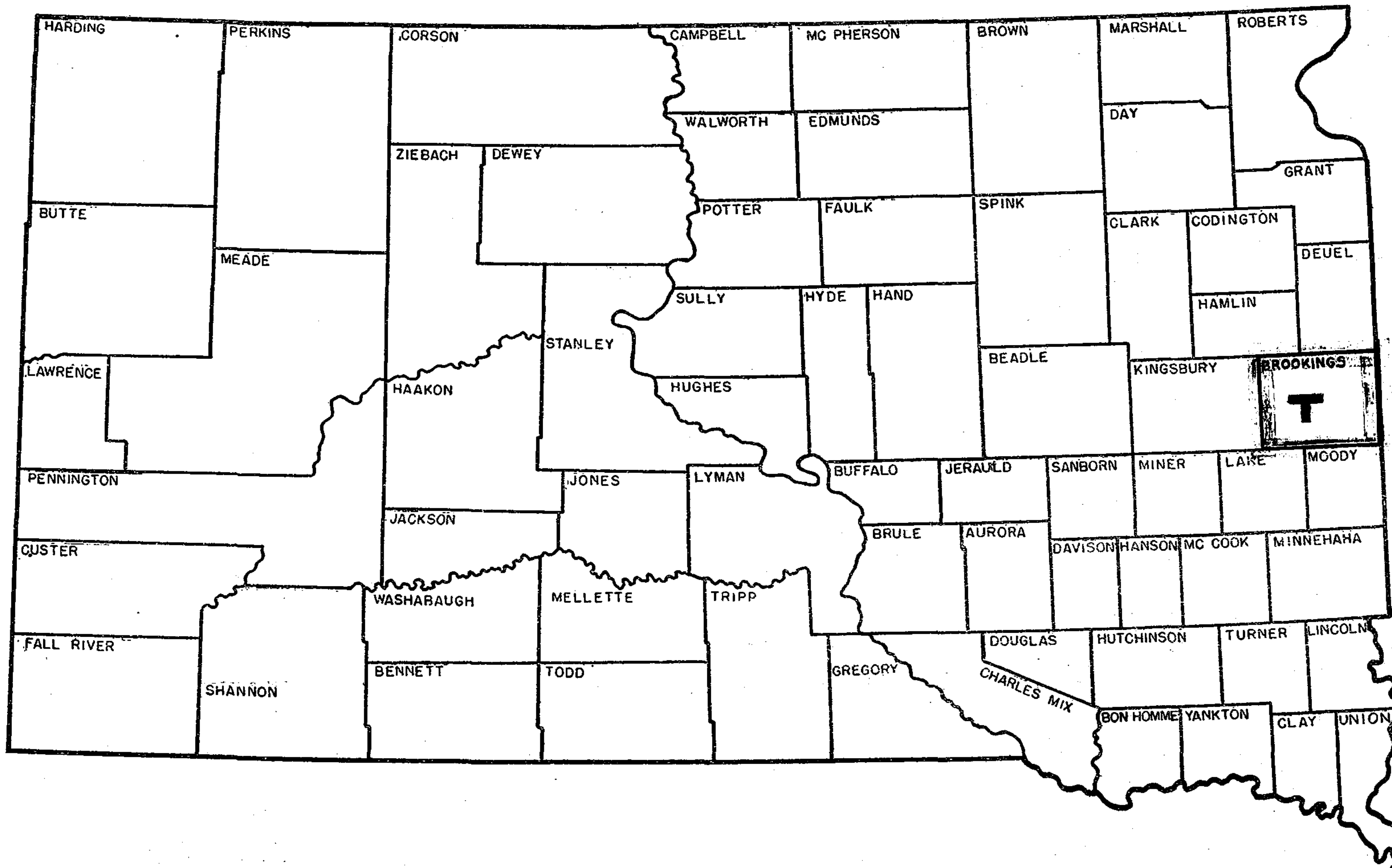

Fig. 1. Location of the project area in Brookings County, South Dakota. The 'T' shaped areas marks the approximate location of the flight lines.

Table 1. Climatological Data for May - August, 1981.

		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	Ave. Temp./ Total Precip
MAY	max (°F)	67	62	84	63	56	64	62	62	67	51	57	66	58	67	70	74	70	63	68	72*	76	77	81	73	52	56	65	75	70	71	71	66.8
	min (°F)	24	40	M	45	33	33	36	45	35	23	26	39	36	31	36	42	51	42	27	35	48	56	57	44	44	47	52	58	43	42	44	40.5
	precip (in)			.40		.03												.03						.05		.3			.17				0.71
JUNE	max (°F)	84	84	69	77	82	81	84	85	76	68	74	69	77	87	87	66	77	79	71	74	73	74	75	91	80	81	85	83	85	77		78.5
	min (°F)	56	55	54	48	50	42	58	54	56	47	55	51	64	64	53	49	49	54	50	46	51	49	53	58	45	45	58	63	61	47		52.8
	precip (in)	.05		.43				.26	.05	.01	.50		.08	.34	.65							.06	.15		.02				.19	.10			2.89
JULY	max (°F)	83	84	81	77	82	90	88	89	88	84	92	91	87	87	88	77	88*	89	83	87*	82	85	89	81	83	68	69	64	66	69	78	82.2
	min (°F)	52	58	65	66	50	58	61	70	42	50	67	69	69	67	63	56	56	59	59	60	57	58	56	58	57	56	50	52	49	59	68	58.6
	precip (in)			.16	.07							.34		.23							.90††		.95	1.17	.03			.04	.11		.01		4.01
AUGUST	max (°F)	79	83	87	84	81	85	79	80	79	73	76*	82	91	82	80	77	67	70	73	78	81	85	78	78	79	74	72	69	69	76	83	78.4
	min (°F)	67	62	64	63	65	60	58	56	54	45	48	51	57	63	60	53	43	45	47	51	58	54	58	58	59	57	61	55	55	58	63	56.4
	precip (in)	.02	.43	.20	.06					.10					1.78	.02								.05	.54	.34		.10	.05				3.69

† Data recorded at Brookings 2 NE weather station (lat. 44° 19' N, long. 96° 46' W; elev. 1642 ft.)
M Missing - data not recorded
* Overflight date
†† Early A.M. precipitation

are the highest amplitude digital values as well as being constant. Therefore, the normalization process consists of subtracting the digital values for each of the three targets from the hot load digital value. This produces negative normalized values since each of the targets has a lower amplitude than the hot load. The normalized values (normalized digital counts) for the three targets are plotted against the known values of microwave brightness temperature on graph paper and a straight line drawn to fit the target values. The slope and intercept of the straight line on the graph become the constants in the TB equation as given above and all subsequent flightline TB values are determined from that equation.

The TB's produced from the above equation were relative only within flight, not across flights. Microwave data were registered to ground locations using event markers, which correspond to aerial photo centers. At the altitude flown, the radiometers 'footprint' was 76 meters in diameter. Only footprints corresponding to aerial photo centers were used to compile data sets, thus insuring precision in registration and independence among TB samples. The footprint locations were plotted on a 1:20,000 soil map (Westin et al., 1958) corresponding to actual ground positioning. The soil map was also used as a base map for registration of all ground data and TIR data (Fig. 2).

The TIR data were converted to radiometric temperatures using film densities and the blackbody settings from each flight. The apparent temperature data were compiled on a field-by-field basis per flight date.

Ground data were also gathered on the day of each flight and included 0-15 cm soil moisture samples and land cover categories (Fig. 3). Twenty sites constituted the soil sampling area with 12 soil samples per site. Since a site often encompassed more than one field, the number of soil samples ranged from 3 to 12 per land cover category. Land cover categories for the remaining fields in the project area were identified by air photo interpretation.

The ground data consisted of 1) land cover categories--field boundaries delineated on the soil map and assigned land cover codes and identifier numbers, 2) five soil interpretations obtained from soil interpretative data and located according to the soil mapping units, 3) site data on a field basis--gravimetric moisture averaged for land cover category within site, and 4) a depth-to-water-table contour map generated from data of 34 Brookings County wells using the computer program SYMAP (Dongenik and Sheehan, 1979). Ground data and levels within the categories are listed in Table 2.

The soil interpretations used in the analysis were generated as map output products, after digitizing of the soil mapping units, using a geographic information system (Wehde et al., 1980) and assigning interpretation classes based on the Brookings County Soil Survey

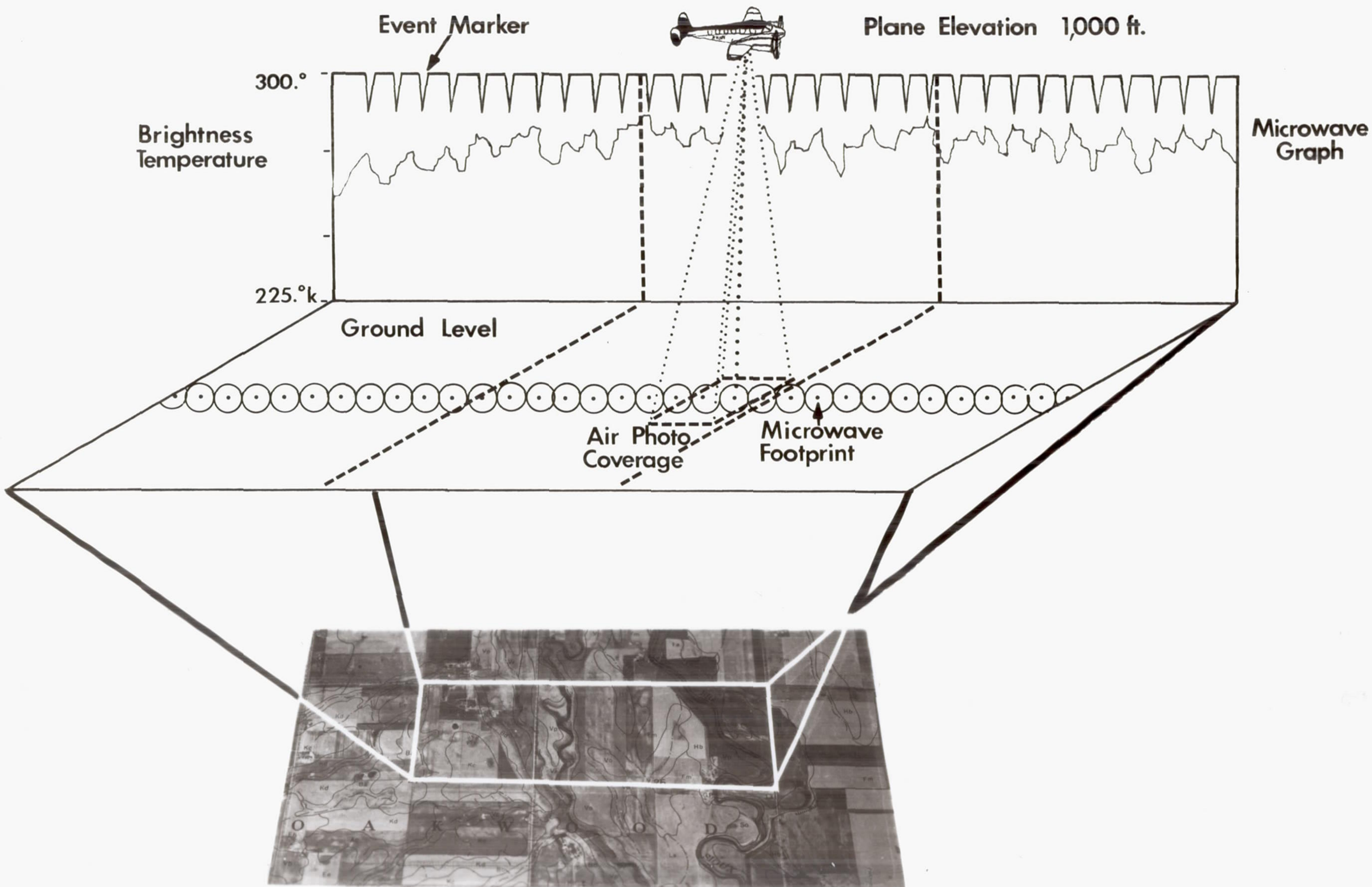

Fig. 2. The registration of aerial photography to the soil base map showing the use of event markers (localizing a footprint by a photo center) to register microwave data.

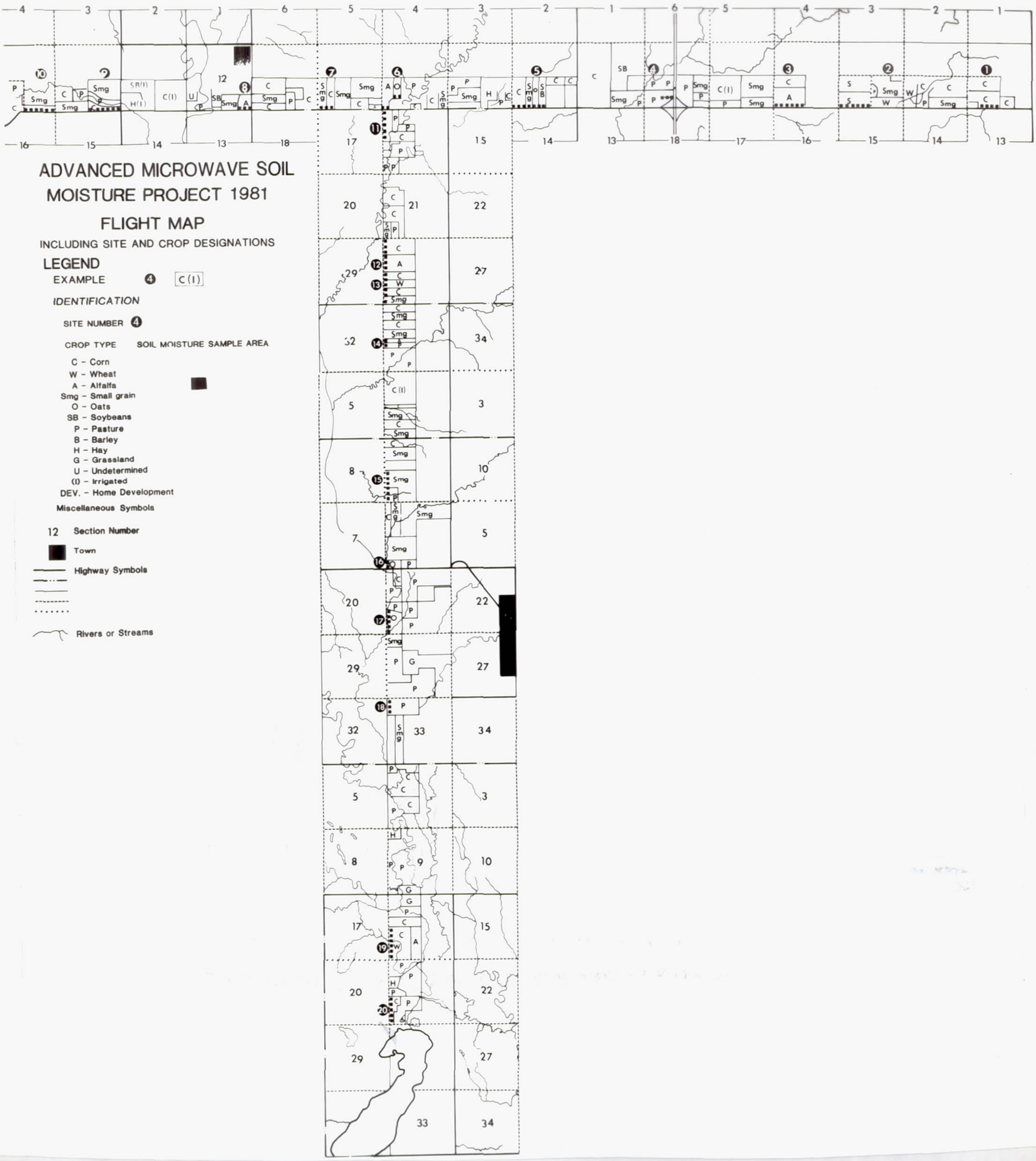

Fig. 3. Land cover categories and gravimetric sample sites for the flight lines in Brookings County. The flights took place within the one-half-mile wide corridor where land cover and field boundaries are identified.

Table 2. Ground data and levels within category.

Ground Data		Levels Within
Land Cover		1. Alfalfa 2. Soybeans 3. Corn 4. Farmstead 5. Pasture or Hayland 6. Small Grains
Soil Interpretations:	Slope Class:	1. 0-4% 2. 5-9% 3. >9%
	Soil Texture (Surface):	1. Sandy Loam 2. Loam 3. Silt Loam 4. Silty Clay Loam 5. Clay
	General Soil Area:	1. Bottomlands 2. Terraces 3. Central Uplands 4. Western Uplands 5. Northeast Upland 6. Depressions 7. Hilly or Steep
	Management Group:	1. Nearly level, moderately well drained, loamy soils 2. Nearly level, sloping or gently gently undulating well-drained, loamy soils 3. Undulating or sloping loamy soils 4. Rolling, thin, loamy soils 6. Soils with gravel substrata 7. Sandy soils 8. Poorly drained soils
	Hydrologic Group:	1. A (rapid infiltration) 2. B 3. C 4. D (slow infiltration)
Water Table Contours		1. 2-5 feet 2. 5-8 feet 3. 8-11 feet 4. 11-14 feet 5. 14-17 feet
Soil Moisture Data		Averaged within land cover category (by field)

(Westin et al., 1958). While the flight lines were in an area only a 1/2-section wide, each interpretation was digitized in one-section-wide parcels encompassing the sensor swath widths and in length corresponding to the flight overpasses. The selection of the soil interpretations was based on soil properties or phases that were most likely to influence the infiltration, percolation, and retention of soil water in the topsoil of this area.

An area larger than the actual flight coverage was used in construction of a water table elevation contour map, or depth-to-water-table map. The 34 wells and and other geographic information used in this process are shown in Fig. 4. Table 3 lists the water table readings taken during the day of each overflight. An example of the SYMAP product is shown in Fig. 5; Appendix A contains the remaining SYMAP outputs.

Only L-band data from two flights were analyzed. The 17 July and 20 July flights were used since these flights took place under dry and wet conditions, respectively (See Table 1). The footprint data and field-averaged footprint data are in Appendix B and Appendix C, respectively. The TIR data (on a field basis) were analyzed from each flight with the available ground data.

Three data files were established, each having the common base map. The first data set comprised two dates, 17 and 20 July data, on a footprint basis, i.e., each footprint, or TB sample, had a corresponding land cover class, each of the five soil interpretation classes, and the water table contour class The second data set comprised two to four dates on a field basis, i.e., TIR and TB values averaged per field (2 dates only), TIR values on all dates, land-cover classes, soil interpretation classes, and depth-to-water-table classes. The final data set was constructed on a site basis using TB and TIR data averaged per land cover category within site. Land cover class, water table class, and the average gravimetric moisture by field constituted the ground data at each site.

Consequently, three separate statistical analyses were carried out on the three data sets. All analyses were directed toward analyzing the relationships of TB and TIR data, to the various ground data, where appropriate. The Statistical Analysis System, SAS, (SAS, 1979) was used in all phases of statistical determinations, namely, means and standard deviations, plots, discriminant analysis, and stepwise regression analysis. Dummy variables were used when class data were entered into regression analyses.

RESULTS AND DISCUSSION

The results and discussion are organized into two major divisions with three and two subdivisions, respectively. The divisions are made according to the type of analysis: I. regression analysis and II. discriminant analysis. The subdivisions are made according to the

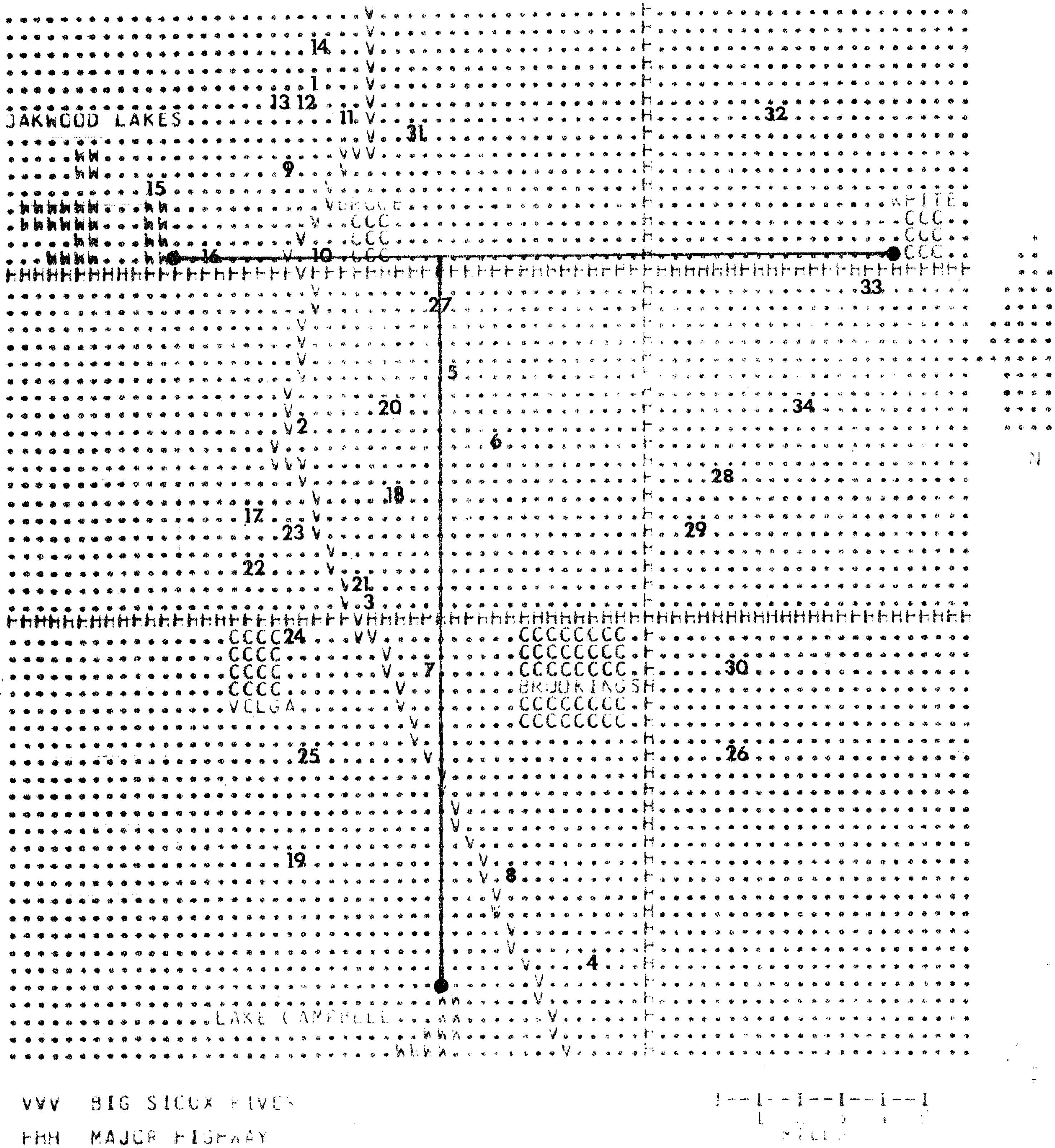

Fig. 4. Location of the 34 wells used in the computer-generated water table contour maps. The wells are identified by number.

Table 3. Water table readings (in feet) by date for the 34 wells used in SYMAP. Refer to figure 3 for well locations.

Well Number	20 May	17 July	20 July	11 Aug
1	7.93	8.13	8.13	8.13
2	6.64	6.64	6.64	6.74
3	5.67	5.67	6.27	6.27
4	2.77	3.27	3.27	2.97
5	13.87	12.87	12.87	12.77
6	4.42	3.82	3.82	4.22
7	4.73	4.63	4.63	4.63
8	9.21	9.71	9.21	9.21
9	15.78	16.48	16.48	16.28
10	9.08	9.38	9.38	8.68
11	5.57	5.98	5.98	4.98
12	11.71	12.21	12.21	12.01
13	11.18	11.68	11.68	11.68
14	6.20	6.40	6.40	6.40
15	3.58	3.88	3.98	3.98
16	7.92	8.12	7.82	7.82
17	40.99	41.29	41.29	41.49
18	6.46	6.96	6.96	6.26
19	14.70	14.80	14.80	14.90
20	5.74	6.14	6.14	5.34
21	6.13	6.53	6.53	6.03
22	10.31	10.41	10.41	10.51
23	4.40	5.00	5.00	4.80
24	12.55	12.65	12.65	12.65
25	14.65	14.95	14.95	15.15
26	5.71	6.51	6.51	6.81
27	6.69	4.79	4.79	2.79
28	7.70	9.20	9.20	7.50
29	7.60	8.40	8.40	7.90
30	4.15	5.25	5.25	5.65
31	--	19.22	19.22	18.22
32	14.11	16.31	16.31	14.91
33	14.92	15.13	14.82	14.82
34	19.63	20.83	20.83	20.33

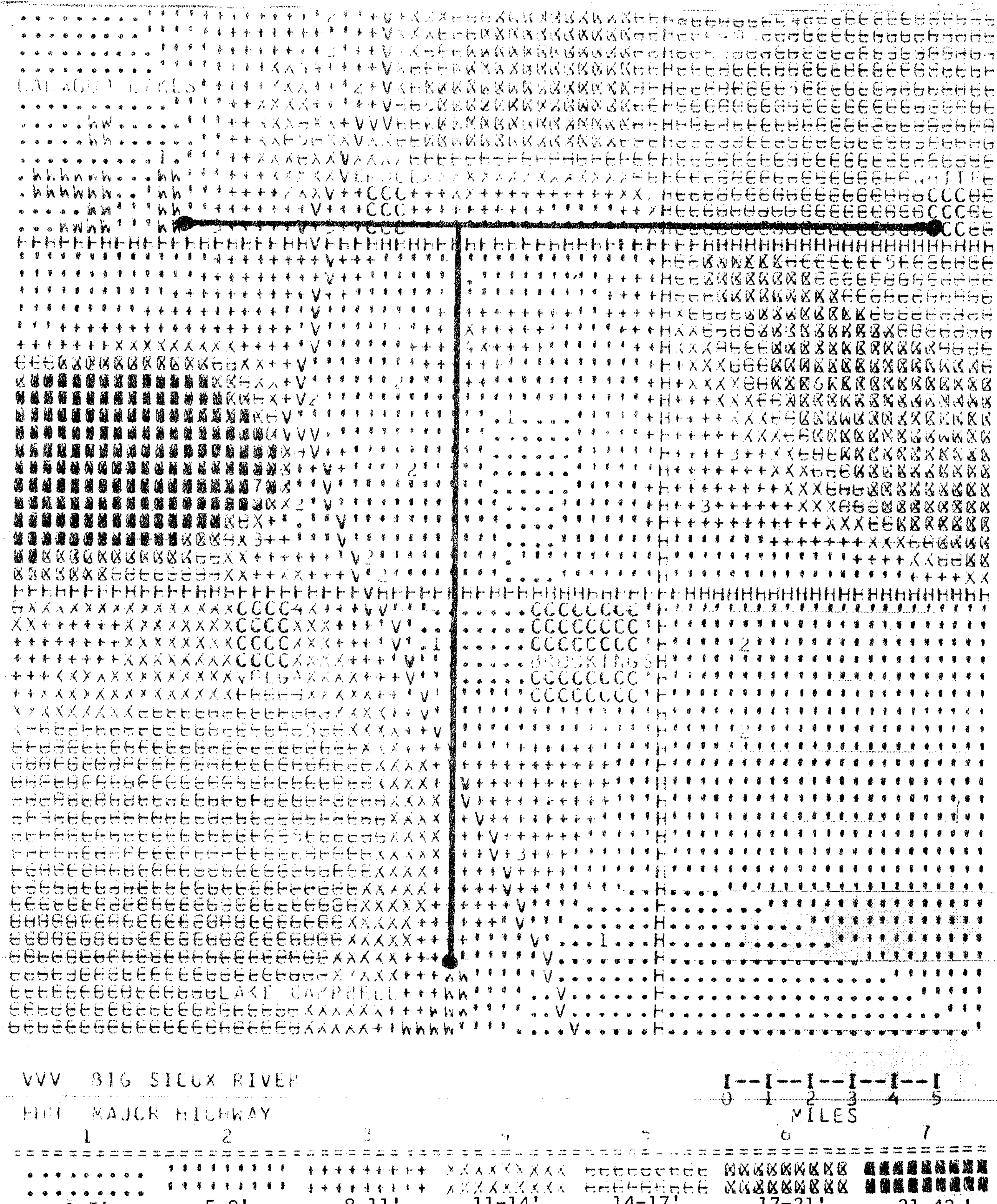

Fig. 5. Example of computer-generated water table contour map from 17 July data. (See Table 3 and Fig. 4 for well depths and well locations, respectively.)

three data sets: footprints, fields, and sites (soil moisture data were used only in regression). The 17 and 20 July flight data are included in all the analyses. The 20 May and 11 August flight data are included in the analyses of thermal data. Site data also include the 11 August flight data, but not the 20 May data.

I. Regression Analysis

Footprint Basis

This analysis examined the relationship of the July L-band data to the various ground variables, excluding gravimetric moisture. Five to six registered footprints, or footprints corresponding to photo centers, were common per section of land. The direction of flight and wind velocity caused some variations in number of footprints within and across dates.

The TB values per land cover, soil interpretation, and water table contour are given by date in Table 4 and Table 5. The differences in total number of observations and observations per level vary according to the factors mentioned above. Assuming a degree of similarity across dates in absolute TB determination, a marked difference in means and standard deviations is evident between dates. The rainfall received early in the morning prior to the 20 July flight was the major factor in these across-date differences.

The more uniformly dry conditions of the 17 July data produced anticipated mean values. For example, in the land cover category, corn should be a good emitter since it has a relatively dense vegetative cover (Fig. 6). The corn TB is substantially higher than the other levels of land cover, which are probably, for the most part, attenuators rather than emitters (Theis, et al, 1982).

The hilly or steep lands (also management group 4 and slopes greater than 9 percent) recorded cool TB's from only two observations on the 17 July flight. Inspection of the aerial photographs revealed that these two footprints were located on northwest- and west northwest-facing slopes. Aspect and slope, especially for the noontime flights, are probably the controlling factors contributing to a cool TB for this situation within the project area. A decrease in ε is also associated with an increase in the effective incidence angle. Steep slopes were, however, insignificant over the entire flight line.

The following general hypothesis covers the relative rankings of TB from the 17 July data: coarse-textured soils, more rapid infiltration rates of hydrologic groups A and B, and excessively to well-drained management groups had warmer TB than fine-textured soils, hydrologic groups C and D, and poorly drained management groups. The influence of land cover categories, especially corn, does cause some bias, but, generally, the land cover categories did occur across most soil-based groupings.

Table 4. July 17 means and standard deviations of the brightness temperatures for the ground variables less gravimetric moisture

Category	Level	Observ. (N)	TB Mean (deg. K)	St.Dev.	TB Range
Land Cover	Alfalfa	7	271.0	11.2	257.6-287.5
	Soybeans	7	275.1	5.9	266.4-285.5
	Corn	38	285.3	5.1	272.4-295.3
	Farmstead	6	274.1	13.6	255.2-291.3
	Pasture or Hayland	47	271.8	9.6	254.7-292.6
	Small Grains	41	277.4	7.7	261.9-293.6
General Soil	Bottomlands	39	271.4	8.1	256.6-290.3
	Terraces	39	277.4	8.8	255.2-293.4
	Central Uplands	61	281.9	8.2	257.6-295.3
	Western Uplands	5	265.0	10.8	254.2-282.6
	Hilly or Steep Lands	2	261.6	3.6	258.0-265.1
Hydrologic Grouping	A	3	273.0	9.8	259.2-281.1
	B	102	279.3	9.7	254.7-295.3
	C	6	268.3	5.8	260.8-275.3
	D	35	272.3	8.3	256.6-290.3
Management Group¶	1	11	274.1	11.7	254.7-288.1
	2	34	282.6	8.0	257.6-293.6

Table 4. (cont'd)

Category	Level	Observ. (N)	TB Mean (deg. K)	St.Dev.	TB Range
Management Group (cont'd)	3	12	283.0	9.8	263.6-295.3
	4	2	261.6	3.6	258.0-265.1
	6	34	276.4	8.4	255.2-291.8
	7	12	282.3	6.6	266.9-291.04
	8	41	271.3	8.0	256.6-290.3
Slope	0-4%	128	276.5	9.6	254.7-293.6
	5-9%	16	283.7	8.8	263.6-295.3
	>9%	2	261.6	3.6	258.0-265.1
Soil Texture (Surface)	Sandy Loam	12	279.1	8.4	259.2-291.0
	Loam	27	283.2	9.4	257.6-293.6
	Silt Loam	54	278.2	8.8	255.2-295.3
	Silty Clay Loam	30	272.6	10.4	254.7-291.8
	Clay	23	272.0	7.1	260.6-290.3
Depth to Water Table	2-5'	7	269.5	8.3	258.6-287.9
	5-8'	71	278.3	10.0	255.2-293.6
	8-11'	41	275.5	10.3	257.6-295.3
	11-14'	3	280.2	7.4	269.7-285.9
	14-17'	24	278.0	8.1	254.7-288.7

¶ See Table 2 for descriptions.

Table 5. July 20 means and standard deviations of the brightness temperatures for all ground variables less gravimetric moisture

Category	Level	Observ. (N)	TB Mean (deg. K)	St.Dev.	TB Range
Land Cover	Alfalfa	9	245.0	7.8	231.8-257.0
	Soybeans	3	234.1	13.9	222.7-253.7
	Corn	47	248.8	12.2	220.8-271.7
	Farmstead	4	252.1	7.9	239.4-260.4
	Pasture or Hayland	56	250.3	13.6	212.4-281.0
	Small Grains	56	243.1	13.7	210.5-271.8
General Soils	Bottomlands	51	252.2	11.9	230.5-278.0
	Terraces	44	242.4	14.7	210.5-271.7
	Central Uplands	76	245.7	12.2	220.8-271.8
	Western Uplands	2	267.4	13.6	253.7-281.0
	Hilly or Steep Lands	2	251.7	3.4	248.3-255.0
Hydrologic Group	A	1	261.2	-	-
	B	121	244.7	13.5	210.5-281.0
	C	7	245.4	13.0	232.9-264.0
	D	46	253.7	11.2	230.5-278.0
Management Group	1	12	240.9	11.1	221.3-260.7
	2	38	244.6	13.1	220.8-271.8

Table 5. (cont'd)

Category	Level	Observ. (N)	TB Mean (deg. K)	St.Dev.	TB Range
Management Group (cont'd)	3	17	245.7	12.5	229.5-281.0
	4	2	251.7	3.4	248.3-255.0
	6	37	242.3	15.9	210.5-271.2
	7	13	253.3	7.1	241.8-263.3
	8	56	252.0	11.6	230.5-278.0
Slope	0-4%	150	247.0	13.8	210.5-278.0
	5-9%	24	247.2	11.4	229.5-281.0
	>9%	1	248.3	-	-
Soil Texture (Surface)	Sandy Loam	10	257.1	3.6	250.3-262.5
	Loam	31	246.0	12.1	220.8-271.8
	Silt Loam	71	243.0	14.1	210.5-281.0
	Silty Clay Loam	29	243.6	11.6	221.3-263.3
	Clay	34	256.4	10.1	236.3-278.0
Depth to Water Table	2-5'	9	260.6	10.4	244.5-278.0
	5-8'	85	247.0	11.5	221.2-271.8
	8-11'	50	251.9	11.4	229.5-281.0
	11-14'	5	235.6	15.6	212.4-254.2
	14-17'	26	235.6	13.3	210.5-260.4

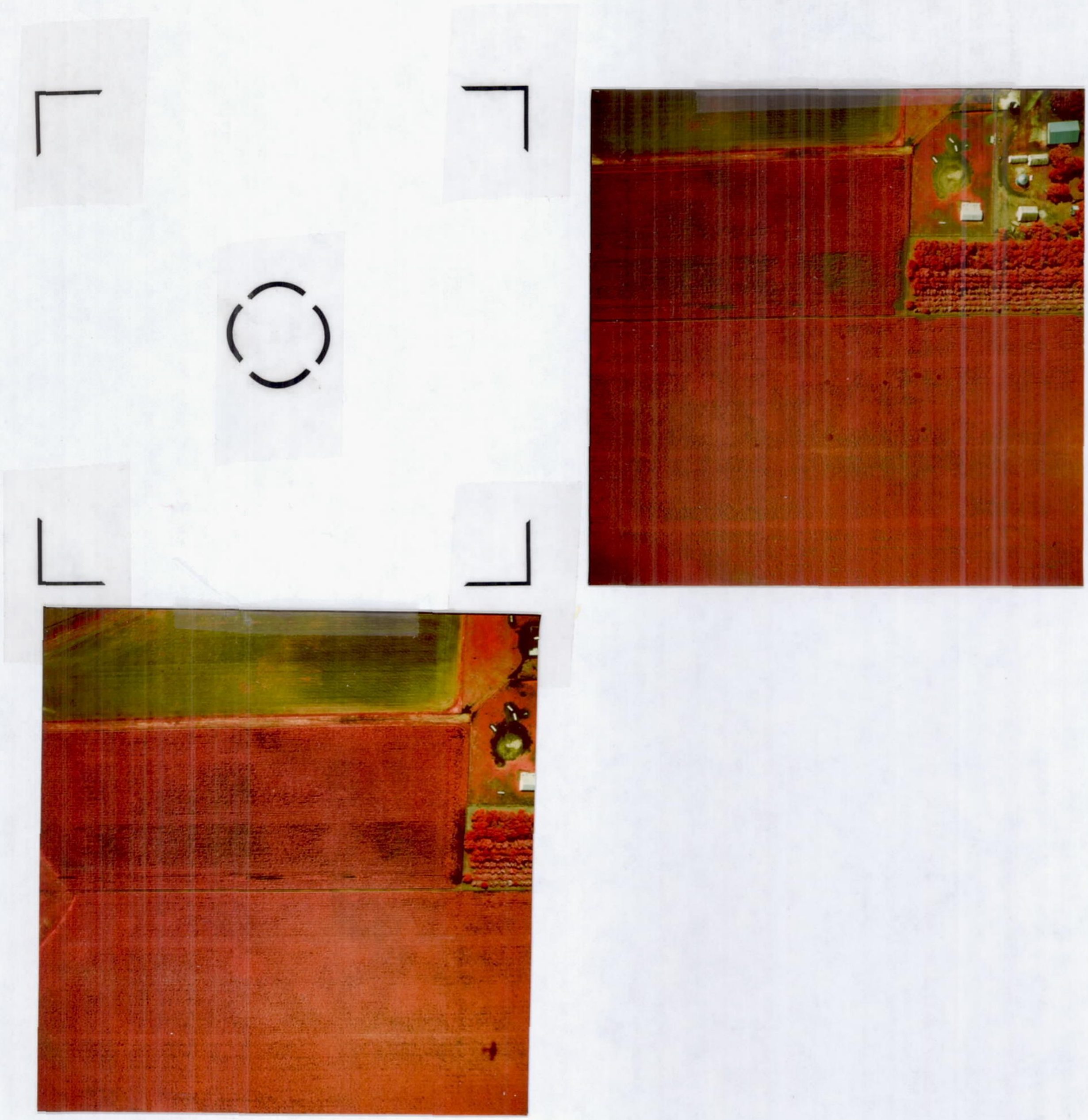

Fig. 6. Color infrared frames show a corn field where L-band TB's were recorded on 17 July, 283°K (above), and on 20 July, 261°K (below). Exact footprint registration within the photo frame is shown in the graphic. The TB's were expected given the dry conditions on 17 July and the 20 July rainfall. The soils in this area have gravelly substrata. Standing water or wet soil is especially noticeable as the dark colors in the upper one-half of the 20 July photo. Location is NW 1/4 of SW 1/4, Section 10, R 51 W, T 111 N. Scale is approximately 1:5500.

The water table contour means indicate that the shallowest level is cooler than the other categories on 17 July. We do have, however reservations about the accuracy of the computer-derived isoline map. The complexity of land surfaces and aquifer boundaries and an assumption of horizontal flow (Daly, 1982) are among the problems that may cause inaccuracies. The poorly drained, fine-textured soils contained most of the shallow water tables. This was anticipated because these soils are located in the lowest landscape position.

The 20 July TB means are most strongly influenced by the distribution of surface wetness from an early morning rain. The variability of this rainfall across the flight lines is unknown. Factors that influence runoff or infiltration, slope, texture and microtopography, appear to be the major influences in TB variations: the greater the runoff or the higher the infiltration rate, the higher the TB. A possible exception is the nearly level, clayey textures, which we would expect to have standing surface water; however, the mean TB's are relatively warm rather than the anticipated cool. Microtopography is probably the overriding feature in this situation, funneling excess surface moisture, due to slow infiltration rates, from slightly convex rises into shallow depressions (Fig. 7 and Fig. 8).

Since most of the shallow water tables are associated with fine-textured rangeland, it is not surprising that the mean TB for the shallow water table class on 20 July was substantially higher than that of the deeper water table levels. The small number of observations for some intermediate levels may also be influential.

Stepwise regression results (Table 6) reveal that the variance associated with the 17 July TB is well-explained (48%) with the given variables. Corn enters the regression first, accenting the notion of corn as an emitter according to the discussion of the TB means (See Table 4). No category of independent variables (i.e., levels within land use, soil texture, etc.) seems to dominate input into the regression. Conversely, one category, management groups, was not a significant contributor, though by definition they appeared to have promising characteristics for partitioning TB. Since this category embodies several features of the other categories, it should not be dropped from any further evaluations.

Stepwise regression results for the data of 20 July (Table 7) indicate a somewhat lower R^2 than the 17 July results. The usefulness of the 14-17' water table contour as a significant variable is dubious at best. However, since this level occurs exclusively on the east end of the east-west flight (Fig. 4), a relationship to another factor is possible, e.g., rainfall distribution over the project area. The clayey soil texture (warm TB's) is the other early-entry variable in this model. Overall, it is difficult to assess the value of these results because of the inclusion of three water table variables that include depths greater than 5 feet. The rank of the mean TB per water table level is reversed from the 17 July data.

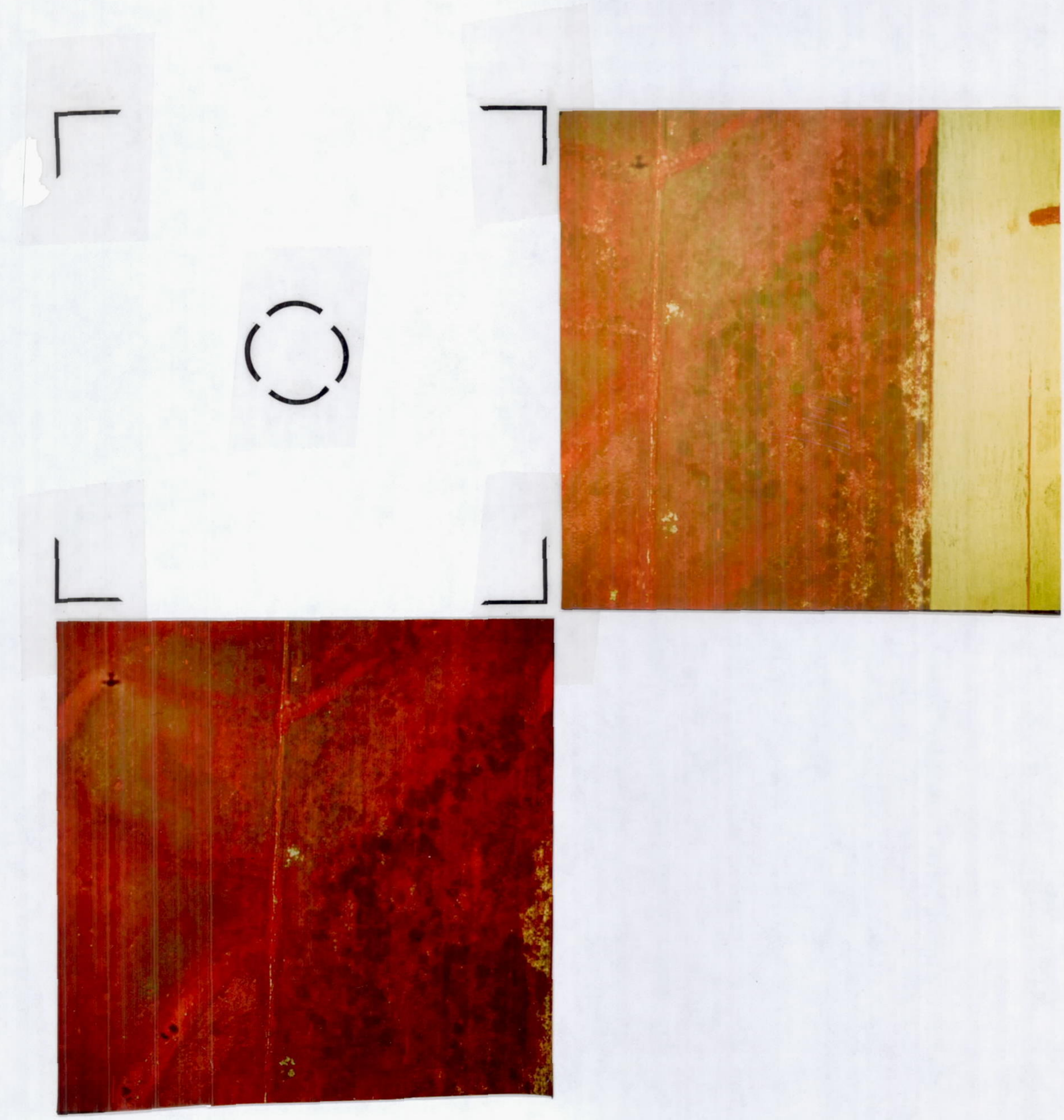

Fig. 7. The footprints within a clayey, pasture area, as localized with the CIR photography, where TB's were 267°K on 17 July (above) and 248 °K on 20 July (below). Exact footprint registration within the photo frame is shown in the graphic. This field is characterized by patchy growth and subtle topographic changes. Location is NW 1/4, Section 289, R 50 W, T 110 N. Photo scale is approximately 1:5500.

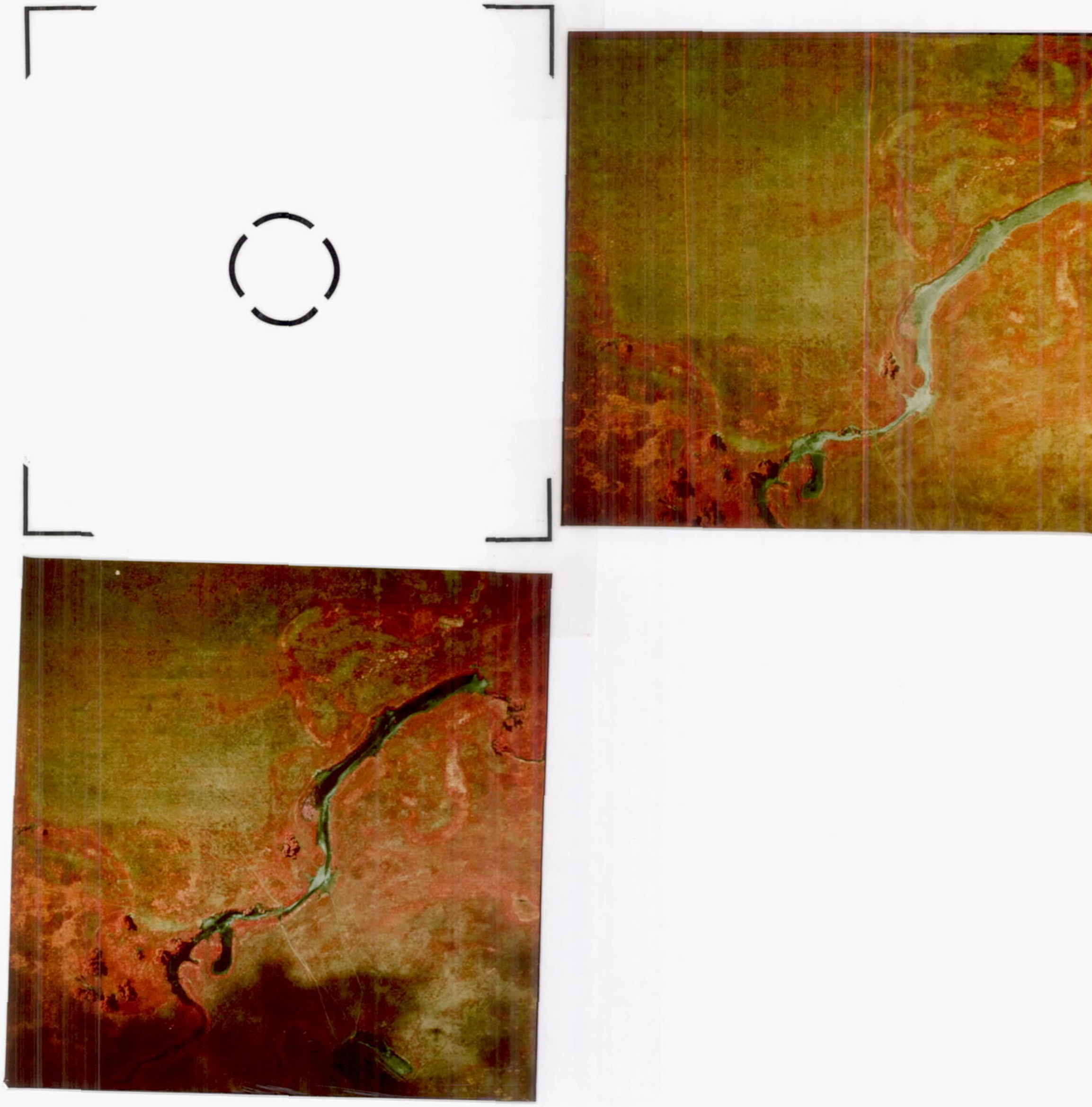

Fig. 8. As localized on CIR photography, the footprints sampled within a clayey, pasture area where TB's were 265°K on 17 July (above) and 264 $^{\circ}$K on 20 July (below). Exact footprint registration within the photo frame is shown in the graphic. The addition of water to the stream channel between dates is dramatic. The location is SW 1/4, Section 33, R 50 W, T 111 N. Scale is approximately 1:5500. Cloud shadows are located on the edge of the 20 July photo.

Table 6. Stepwise linear regression results for the 17 July TB data on a footprint basis. Only significant variables are included in the linear model.

Dependent Variable	Independent Variable	B Value¶	Standard Error	F Value	R^2	DF¶¶
TB	Land Cover 3 (Corn)	10.51	1.61	42.18	0.48	145
	Slope 2 (5-9%)	6.41	2.02	10.03		
	Gen. Soil 4 (Western Uplands)	-10.27	3.44	8.89		
	Texture 2 (Loam)	4.86	1.77	7.5		
	Slope 3 (>9%)	-15.16	5.60	7.32		
	Land Cover 6 (Small grain)	3.13	1.54	4.14		
	Hydrologic Group 3 (C)	-6.35	3.12	4.13		
	Gen. Soil 3 (Central Uplands)	1.89	1.46	1.68		

¶ y Intercept = 271.93

¶¶Total Degrees of Freedom

Table 7. Stepwise linear regraession results for the 20 July TB data on a footprint basis. Only significant variables are included in the model.

Dependent Variable	Independent Variable	B Value¶	Standard Error	F Value	R^2	DF¶¶
TB	Water Table 5 (14-17')	-13.82	2.86	23.30	0.32	174
	Texture 5 (Clay)	10.50	2.39	19.22		
	Water Table 4 (11-14')	-13.45	5.35	6.30		
	Gen. Soil 4 (Western Upland)	20.11	8.22	5.97		
	Land Cover 5 (Pasture)	13.96	5.84	5.71		
	Land Cover 3 (Corn)	4.62	2.03	5.19		
	Water Table 2 (5-8')	-4.28	2.01	4.53		
	Management Group 6 (Gravelly Substrata)	6.82	3.39	4.05		

¶ y Intercept = 247.28

¶¶Total Degrees of Freedom

There is little correspondence between across-date, stepwise regression variables although corn and the western uplands soil group (less than 5 observations per date) are in both sets of independent significant variables. It does appear that the land cover of corn is influential in the determination of L-band radiometer TB's--more so when dry than wet.

Field Basis

The next stage of analysis employed fields as the lowest denominator in order to assess both TIR and TB data at the same level. Since it is fields, not footprints, that form this data set, the soil interpretations cannot be used due to variability within fields. One to three footprints were registered within most fields and were averaged to produce one value per field. Pasture lands occasionally had greater numbers of footprints per field.

The means and standard deviations of TIR and TB by land cover for the various flights are listed in Table 8. As may be expected, the TB means when averaged within fields and then by land cover class do not vary much from the means averaged per land cover by the footprint data. The 20 July data are, however, somewhat more variable within the footprint data set than the field-averaged (smoothed) data set.

The TIR means show higher values on dates 1 and 2 corresponding, in general, to amount of bare soil and dryness, respectively. Alfalfa and pasture are the only two early land cover categories that would have any substantial vegetative growth and ground cover. The first two dates also have the largest standard deviations. The difference in apparent ground temperature between dates 2 and 3 is consistently 5 to 7°C, corresponding to the 20 July rain. The spread of apparent ground temperatures across land cover categories is quite small for dates 3 and 4, indicating a similar situation on both dates (without regard to differing sun angles or solar insolation).

Regression results for the dependent variable TB are shown in Table 9. Considering that the soil interpretations were not used, the R^2 results are relative to the footprint regression analysis. The 17 July data produced a explanation of more variance than did the 20 July data, and corn was an important independent variable. Apparently the lower degrees of freedom (i.e., by including field data) kept corn out of the 20 July list. Overall, the regression results from the individual footprint data with soil interpretations provide more information than the smoothed, field-averaged TB's without soil interpretations, although lower degrees of freedom may be cause for some of the difference.

Table 8. Means and standard deviations of TIR and TB data on a field basis by land cover and date

Land Cover	Date¶	TIR $\bar{X}$ (deg C)	TIR s	TIR n	TB $\bar{X}$ (deg K)	TB s	TB n
Alfalfa	1	24.0	3.8	7	--	--	--
	2	32.1	2.6	8	271.6	11.4	7
	3	23.7	0.9	8	247.1	7.6	6
	4	20.1	0.9	8	--	--	--
Soybeans	1	29.8	2.4	6	--	--	--
	2	29.2	2.1	6	275.7	8.3	4
	3	22.1	1.2	6	239.0	20.8	2
	4	21.8	3.0	6	--	--	--
Corn	1	30.3	4.2	26	--	--	--
	2	26.5	2.1	38	285.5	5.2	25
	3	21.3	1.8	38	247.7	11.9	27
	4	20.0	1.8	39	--	--	--
Pasture or Hay	1	25.1	4.2	26	--	--	--
	2	29.2	4.8	46	271.9	8.8	29
	3	23.6	2.3	45	250.3	12.8	32
	4	22.0	2.6	43	--	--	--
Small Grain	1	27.1	4.3	37	--	--	--
	2	28.7	4.6	49	279.2	7.2	24
	3	23.6	2.5	47	245.0	13.4	33
	4	23.3	4.1	47	--	--	--

¶Date 1 = 20 May flight
Date 2 = 17 July flight
Date 3 = 20 July flight
Date 4 = 11 August flight

L-Band data were collected on 20 May and 11 August, but not registered to ground data.

Table 9. Stepwise linear regression results for 17 and 20 July TB data on a field basis. Only significant variables are included in this linear model.

Dependent Variable	Independent Variable	B Value¶	Standard Error	F Value	R^2	DF¶¶
TB (17 July)	Land Cover 3 (Corn)	13.31	1.96	45.87	0.35	88
	Land Cover 6 (Small Grain)	6.97	1.99	12.27		
TB (20 July)	Water Table 5 (14-17')	-12.94	3.72	12.09	0.17	99
	Water Table 4 (11-14')	-18.71	5.94	9.92		

¶ y Intercept = 272.22 for 17 July data

y Intercept = 249.60 for 20 July data

¶¶Total Degrees of Freedom

The four dates of TIR data in the regression analysis are shown in Table 10. The 20 May data offer the best explanation of variance, relating ground cover density to apparent ground temperature, i.e., dense covers have lower apparent temperatures. Corn is the most persistent variable across date, appearing in all lists of significant variable but that of date 4. Small grains are important in May and in August. Both dates are most likely related to minimum ground cover: the August crop being ripe, windrowed, or harvested.

Site Basis

This analysis also used a field as the smallest terrain divisor. Due to sampling of narrow fields and variability in aircraft alignment along flight lines, some sites were not represented in the aerial data. Table 11 lists the gravimetric data used in the statistical analysis. The mean values of the samples vary according to the climatic data discussed previously, i.e., dry on the 17th and wet on the 20th of July. Land cover is not a large influence on the magnitude of the gravimetric values. Soil texture and landscape position are reflected in the gravimetric values; however, since the data are assembled on a field basis, these characteristics are not specified.

The stepwise regression analysis used the following model for 17 and 20 July data:

$$\text{Gravimetric moisture} = \text{TB, TIR}$$

The TIR data were also used alone in the model for 17 July, 20 July, and 11 August. The results did not produce any significant variables or R^2's. Scatter plots were inspected to detect any curvilinear tendencies, but, as indicated within Table 11 by the standard deviation values, an inconsistent and extremely variable situation exists.

The site basis analysis was limited severely by degrees of freedom (df): 12 and 16 for the 17 and 20 July data, respectively. For the TIR independent variable alone on 17 July, 20 July, and 11 August, the df were 21, 20, and 30, respectively. Consequently, this analysis would have probably benefitted from 1) more fields, 2) observations averaged on a footprint basis, 3) inclusion of soil factors in partitioning the gravimetric values and expressing moisture as percent of field capacity, 4) selection of more uniform fields (i.e., bare ground) with regard to soil moisture, or 5) sampling to 5 cm rather than 15 cm. The factors causing the most variability between fields, as listed in Jones et al. (1981), were confirmed as causing variability in these soil moisture samples, viz., pasture land cover, soil type, and poor drainage, etc.

II. Linear Discriminant Analysis

This technique was employed to analyze the data with the continuous variables and several classification variables, i.e., ground

Table 10. Stepwise linear regression results for the four TIR data sets on a field basis. All aerial overflights are overflights represented, and only significant variables are included.

Dependent Variable	Independent Variable	B Value¶	Standard Error	F Value	R^2	DF¶¶
TIR (20 May)	Land Cover 3 (Corn)	5.40	1.08	24.81	0.21	101
	Land Cover 2 (Soybeans)	4.84	1.83	6.97		
	Land Cover 6 (Small Grain)	2.26	0.99	5.24		
TIR (17 July)	Land Cover 3 (Corn)	-2.68	0.75	12.67	0.10	146
	Water Table 4 (11-14')	3.24	1.82	3.18		
TIR (20 July)	Land Cover 3 (Corn)	-2.26	0.41	30.18	0.18	143
TIR (11 Aug)	Land Cover 6 (Small Grain)	3.05	0.62	24.19	0.15	142
	Land Cover 5 (Pasture)	1.76	0.63	7.71		

¶ y Intercept = 24.90 for 20 May

y Intercept = 29.06 for 17 July

y Intercept = 23.54 for 20 July

y Intercept = 20.21 for 11 Aug

¶¶Total Degrees of Freedom

Note: Land Cover 3 provided the best one-variable model; however, Land Cover 5 replaced Land Cover 3 in best two-variable model.

Table 11. Means and standard deviations of gravimetric moisture samples by field for data used in stepwise linear regression analysis.

Date	Land Cover¶	Site No.	Samples Per Field	$\overline{X}$ Grav.	Stand Dev.	Data Used in Analysis of TB	TIR
2	3	1	12	16.4	6.0	x	x
3	3	1	12	29.3	9.2	x	x
4	3	1	12	16.6	4.3		x
2	6	2	12	11.8	3.3		x
3	6	2	12	24.3	9.2	x	x
4	6	2	12	16.6	4.3		x
2	1	3	12	7.9	1.8	x	x
3	1	3	12	12.1	4.4	x	x
4	1	3	12	11.2	3.2		x
2	6	4	6	12.4	2.0		x
3	6	4	6	20.6	5.2	x	
4¶¶	6	4	6	17.4	5.8		x
4	6	4	6	16.9	5.5		x
2	6	5	12	11.9	2.4	x	x
3	6	5	12	22.8	4.4	x	x
4	6	5	12	11.9	2.4		x
2	6	6	3	8.3	1.7	x	x
3	6	6	3	16.7	2.2	x	x
4	6	6	3	7.5	0.6		x
4	6	6	3	9.1	1.7		x
2	1	6	6	9.7	1.1	x	x
3	1	6	6	14.5	2.3	x	x
4	1	6	6	9.7	2.1		x
2	3	6	12	8.2	1.7	x	x
3	3	7	12	13.5	3.4	x	x
4	3	7	12	8.2	1.7		x
2	1	8	9	9.8	1.8	x	x
3	1	8	9	15.9	2.0	x	x
4	1	8	9	8.8	2.3		x
2	1	6	3	11.5	2.4	x	x
3	1	8	3	15.4	2.2	x	x
4	1	8	3	13.7	2.6		x
2	3	9	6	11.4	2.3		x
3	3	9	6	18.7	2.9		x
4	3	9	6	19.4	8.0		x
4	3	9	3	14.6	8.5		x
4	3	9	3	11.5	1.1		x
2	3	10	12	11.7	2.4		x
3	3	10	12	24.4	3.3	x	x

Table 11. (Cont'd)

Date	Land Cover	Site No.	Samples Per Field	$\bar{X}$ Grav.	Stand Dev.	Data Used in Analysis of TB	TIR
4	3	10	12	18.0	2.4		x
2	3	11	12	10.9	3.1		x
3	3	11	12	20.8	4.2		x
4	3	11	12	14.7	4.0		x
2	1	12	6	13.7	2.5	x	x
3	1	12	6	24.0	3.9	x	x
4	1	12	6	16.5	2.4		x
4	1	12	6	11.7	3.8		x
2	6	13	12	13.6	3.4		x
3	6	13	12	27.9	4.1	x	x
4	6	13	12	21.3	3.4		x
2	5	14	3	21.0	11.2	x	x
3	5	14	3	50.4	10.2	x	x
4	5	14	3	45.1	17.3		x
4	5	14	3	29.6	1.5		x
4	5	14	6	24.5	11.5		x
2	5	15	3	14.8	1.9		x
3	5	15	3	29.5	4.1	x	x
4	5	15	3	17.0	2.1		x
4	5	15	9	19.1	1.6		x
2	6	16	12	22.1	3.9	x	x
3	6	16	12	44.9	1.8		x
4	6	16	12	29.8	5.6		x
2	6	17	12	12.7	2.3		x
3	6	17	12	32.9	2.8		x
4	6	17	12	21.5	4.0		x
2	5	18	12	39.9	9.2	x	x
3	5	18	12	63.8	12.5	x	x
4	5	18	12	51.3	11.7		x
2	6	19	9	10.3	4.7		x
3	6	19	9	25.3	9.3	x	x
4	6	19	9	18.6	5.2		x
4	6	19	3	14.0	0.8		x
2	3	20	12	10.8	3.0	x	x
3	3	20	12	19.0	5.5	x	x
4	3	20	12	12.4	2.8		x

¶Land Cover Classes: 1=alfalfa, 3=corn, 5=pasture or hay, 6=small grain.

¶¶When the same dates are given sequentially, it indicates more than one field per site. All fields are not covered by aerial data.

variables (one at a time). The purpose was to find a means of placing the ground data in classes based on the remote data.

Footprint Basis

Brightness temperature data were used in the separate classification of each of the 7 ground variables. Only a few representative results are presented and discussed in this section. The remaining tables are in Appendix D.

Table 12 and Table 13 show the discriminant analysis for land cover classes using 17 and 20 July TB data. Overall the results are poor; the 17 July data did, however, show that corn could be discriminated with some repetition.

The 20 July L-band data indicate some relationship to water table contours. The results of discriminant analysis of these contours are shown in Table 14. The overall accuracy for these data is low, and any indication of bias is not apparent, that is, consistent misclassification.

Field Basis

When dealing on a field basis and including all of the flight data, only land cover and water table contours are available for discriminant analysis using TB and TIR. Representative results are discussed in this section. The remaining tables are in Appendix E.

Table 15 and Table 16 contrast discriminant analysis of land cover using 1) TIR and 2) TIR and TB. The results show improvement over discriminant analysis on a footprint basis. The TIR data allow good discrimination of corn, although pasture and small grains were often confused with corn. The combination of TIR and TB show a similar accuracy of corn discrimination, but an increase in precision (fewer Type 2 errors) is apparent.

The results of using TIR and TB to discriminate water table contours are shown in Table 17. Overall the results are mediocre. Accuracy levels rise as high as 66 percent, but precision is lacking. Bias with adjacent categories does indicate some consistency, e.g., category 2 is confused most often with categories 1 and 3. Again, lack of confidence in the actual water table contours presents problems in interpretation.

Table 12. Discriminant analysis results for land cover using 17 July TB data (footprint basis)

NUMBER OF OBSERVATIONS AND PERCENTS CLASSIFIED

Actual Land Cover	Land Cover 1	Land Cover 2	Land Cover 3	Land Cover 4	Land Cover 5	Land Cover 6	TOTAL
Land Cover 1	2	1	2	0	2	0	7
(Alfalfa)	28.57	14.29	28.57	0.00	28.57	0.00	100.00
Land Cover 2	0	5	1	0	1	0	7
(Soybeans)	0.00	71.43	14.29	0.00	14.29	0.00	100.00
Land Cover 3	0	5	33	0	0	0	38
(Corn)	0.00	13.16	86.84	0.00	0.00	0.00	100.00
Land Cover 4	2	1	3	0	0	0	6
(Farmland)	33.33	16.67	50.00	0.00	0.00	0.00	100.00
Land Cover 5	7	14	10	0	14	2	47
(Pasture or hay)	14.89	29.79	21.28	0.00	29.79	4.26	100.00
Land Cover 6	1	20	16	0	4	0	41
(Small Grains)	2.44	48.78	39.02	0.00	9.76	0.00	100.00
TOTAL	12	46	65	0	21	2	146
PERCENT	8.22	31.51	44.52	0.00	14.38	1.37	100.00
PRIOR PROBABILITY	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	

Table 13. Discriminant analysis results for land cover using 20 July TB data (footprint basis)

NUMBER OF OBSERVATIONS AND PERCENTS CLASSIFIED

Actual Land Cover	Land Cover 1	Land Cover 2	Land Cover 3	Land Cover 4	Land Cover 5	Land Cover 6	TOTAL
Land Cover 1	1	2	2	2	0	2	9
(Alfalfa)	11.11	22.22	22.22	22.22	0.00	22.22	100.00
Land Cover 2	0	2	0	1	0	0	3
(Soybeans)	0.00	66.67	0.00	33.33	0.00	0.00	100.00
Land Cover 3	5	13	1	26	0	2	47
(Corn)	10.64	27.66	2.13	55.32	0.00	4.26	100.00
Land Cover 4	0	0	0	3	0	1	4
(Farmsteads)	0.00	0.00	0.00	75.00	0.00	25.00	100.00
Land Cover 5	7	11	2	28	2	6	56
(Pasture or Hay)	12.50	19.64	3.57	50.00	3.57	10.71	100.00
Land Cover 6	7	18	1	18	2	10	56
(Small Grains)	12.50	32.14	1.79	32.14	3.57	17.86	100.00
TOTAL	20	46	6	78	4	21	175
PERCENT	11.43	26.29	3.43	44.57	2.29	12.00	100.00
PRIOR PROBABILITY	0.1667	0.1667	0.1667	0.1667	0.1667	0.1667	

Table 14. Discriminant analysis results for water table contours using 20 July TB data (footprint basis)

NUMBER OF OBSERVATIONS AND PERCENTS CLASSIFIED INTO WATER TABLE CONTOURS

Actual Water Table Contour Class	Water Table Contour Class 1	Water Table Contour Class 2	Water Table Contour Class 3	Water Table Contour Class 4	Water Table Contour Class 5	TOTAL
Water Table Contour 1	6	2	1	0	0	9
(2-5')	66.67	22.22	11.11	0.00	0.00	100.00
Water Table Contour 2	20	22	17	12	14	85
(5-8')	23.53	25.88	20.00	14.12	16.47	100.00
Water Table Contour 3	18	8	15	3	6	50
(8-11')	36.00	16.00	30.00	6.00	12.00	100.00
Water Table Contour 4	0	1	1	1	2	5
(11-14')	0.00	20.00	20.00	20.00	40.00	100.00
Water Table Contour 5	3	3	1	7	12	26
(14-17')	11.54	11.54	3.85	26.92	46.15	100.00
TOTAL	47	36	35	23	34	175
PERCENT	26.86	20.57	20.00	13.14	19.43	100.00
PRIOR PROBABILITY	0.2000	0.2000	0.2000	0.2000	0.2000	

Table 15. Discriminant analysis results for land cover using 17 July TIR data (field basis)

NUMBER OF OBSERVATIONS AND PERCENTS CLASSIFIED

Actual Land Cover	Land Cover 1	Land Cover 2	Land Cover 3	Land Cover 5	Land Cover 6	TOTAL
Land Cover 1	4	4	0	0	0	8
(Alfalfa)	50.00	50.00	0.00	0.00	0.00	100.00
Land Cover 2	1	3	2	0	0	6
(Soybeans)	16.67	50.00	33.33	0.00	0.00	100.00
Land Cover 3	1	7	30	0	0	38
(Corn)	2.63	18.42	78.95	0.00	0.00	100.00
Land Cover 5	10	17	13	3	3	46
(Pasture or Hay)	21.74	36.96	28.26	6.52	6.52	100.00
Land Cover 6	13	12	18	1	5	49
(Small Grains)	26.53	24.49	36.73	2.04	10.20	100.00
TOTAL	29	43	63	4	8	147
PERCENT	19.73	29.25	42.86	2.72	5.44	100.00
PRIOR PROBABILITY	0.2000	0.2000	0.2000	0.2000	0.2000	

Table 16. Discriminant analysis results for land cover using 17 July TB and TIR data (field basis)

NUMBER OF OBSERVATIONS AND PERCENTS CLASSIFIED

Actual Land Cover	Land Cover 1	Land Cover 2	Land Cover 3	Land Cover 5	Land Cover 6	TOTAL
Land Cover 1 (Alfalfa)	6 85.71	1 14.29	0 0.00	0 0.00	0 0.00	7 100.00
Land Cover 2 (Soybeans)	1 25.00	2 50.00	0 0.00	1 25.00	0 0.00	4 100.00
Land Cover 3 (Corn)	0 0.00	3 12.00	19 76.00	1 4.00	2 8.00	25 100.00
Land Cover 5 (Pasture or Hay)	2 6.90	13 44.83	3 10.34	6 20.69	5 17.24	29 100.00
Land Cover 6 (Small Grains)	5 20.83	5 20.83	6 25.00	1 8.33	6 25.00	49 100.00
TOTAL PERCENT	14 15.73	24 26.97	28 31.46	10 11.24	13 14.61	89 100.00
PRIOR PROBABILITY	0.2000	0.2000	0.2000	0.2000	0.2000	

Table 17. Discriminant analysis results for water table contours using 20 July TIR and TB data (field basis)

NUMBER OF OBSERVATIONS AND PERCENTS CLASSIFIED INTO WATER TABLE CONTOUR

Actual Water Table Contour Class	Water Table Contour Class 1	Water Table Contour Class 2	Water Table Contour Class 3	Water Table Contour Class 4	Water Table Contour Class 5	TOTAL
Water Table Contours 1 (2-5')	4 66.67	1 16.67	1 16.67	0 0.00	0 0.00	6 100.00
Water Table Contours 2 (5-8')	9 18.75	13 27.08	11 22.92	5 10.42	10 20.83	48 100.00
Water Table Contours 3 (8-11')	9 29.03	4 12.90	10 32.26	5 16.13	3 9.68	31 100.00
Water Table Contours 4 (11-14')	0 0.00	1 50.00	0 0.00	1 50.00	0 0.00	2 100.00
Water Table Contours 5 (14-17')	1 9.09	0 0.00	2 18.18	3 27.27	5 45.45	11 100.00
TOTAL PERCENT	23 23.47	19 19.39	24 24.49	14 14.29	18 18.37	98 100.00
PRIOR PROBABILITY	0.2000	0.2000	0.2000	0.2000	0.2000	

CONCLUSIONS

I. Regression Analysis

According to earlier theoretical discussions, TB variations with soil water ($^{\circ}$0-5 cm layer) are tied to the divergent dielectric characteristics of a dry soil and a wet soil. This analysis was primarily directed at grouping TB into units indicative of the influence of soil properties on soil moisture quantities without ground sampling for soil moisture quantities. In this regard, vegetation (or land cover) was also included since it exerts an influence on soil moisture through transpiration, shading, etc., and on TB values through attenuation and/or emission at the microwave wavelengths. The third general variable was the computer-generated water table contours. These data are of an undefined accuracy, but may hold potential. A further assessment of the accuracy of the isoline map is needed, possibly using 'kriging' (Olea, 1975).

Footprint Data

Two dates of L-band TB's were examined. The 17 July data, collected under dry soil conditions, produced significant results--an R^2 of 0.48. On this date, the land cover of corn was the first variable to enter the regression model, but 7 other soil-based variables were also significant. The 20 July data, collected under wet soil conditions, produced R^2 results of 0.32. Compared to the 17 July data a new set of variables, less the variables of corn and western uplands, were significant contributors. The water table contours were the most numerous, significant contributors (variables in regression) in the 20 July data.

The spatial grouping of ground variables, namely by soil features and land cover, holds promise for qualitative assessment of soil moisture or for a means of reducing variance within the sampling space. Dry conditions, more so than wet, appear to be more conducive to producing meaningful statistical results.

Field Basis

Regression results using the field-averaged values of TB and TIR did not approach the higher R^2 values using within field variation. The valuation of corn as a variable under dry conditions is emphasized in the 17 July regression results (TB as dependent variable). The variance associated with the TIR data (as dependent variable) was not accounted for to the degree accomplished with TB as a dependent variable, in both a footprint and field basis, under the 17 July conditions. The 20 July TIR and TB data on a field basis produced similar R^2 results--corn accounting for more variance with the TIR variable than with the TB variable. The early season, bare soil conditions of 20 May produced the highest R^2 values for the TIR data.

Site Basis

Regression analysis using field-averaged gravimetric moisture data and the remote sensing data produced no significant results. The following factors were attributed to the poor results: 1) low degrees of freedom, 2) complexity within fields, 3) observations related to fields rather than footprints thereby eliminating use of soil factors and removing the possibility of transforming soil moisture as a percent of field capacity, and 4) sampling to 15 cm.

II. Discriminant Analyses

In general, the discriminant analysis indicated some capacity to distinguish categories with the results being somewhat better on a field basis than a footprint basis. Based on the good regression results, it may be that refinement of or use of other types of this analysis will lead to increased levels of accuracy and precision in discrimination of variables using TB and/or TIR.

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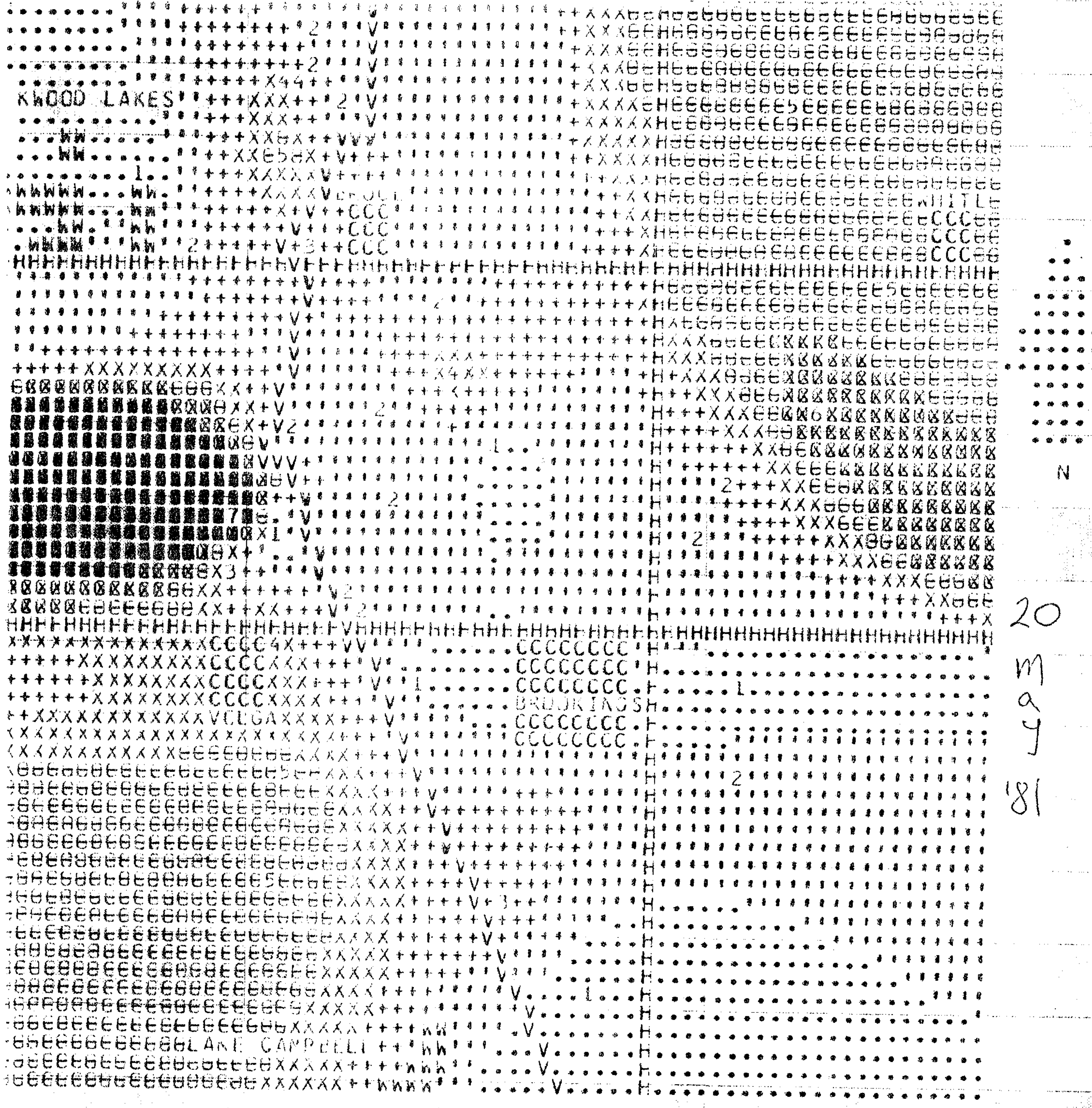
APPENDIX A

SYMAP-produced water table contour maps

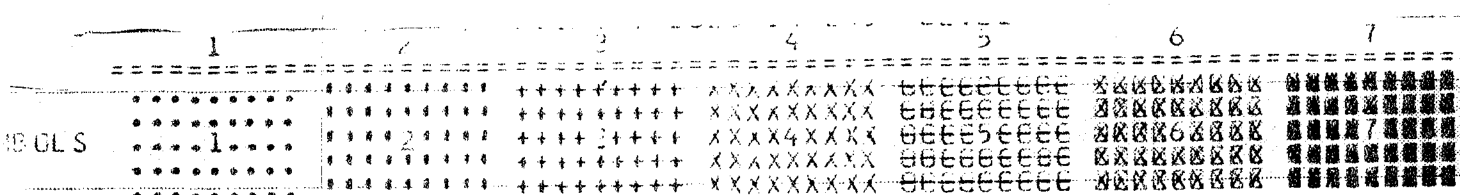


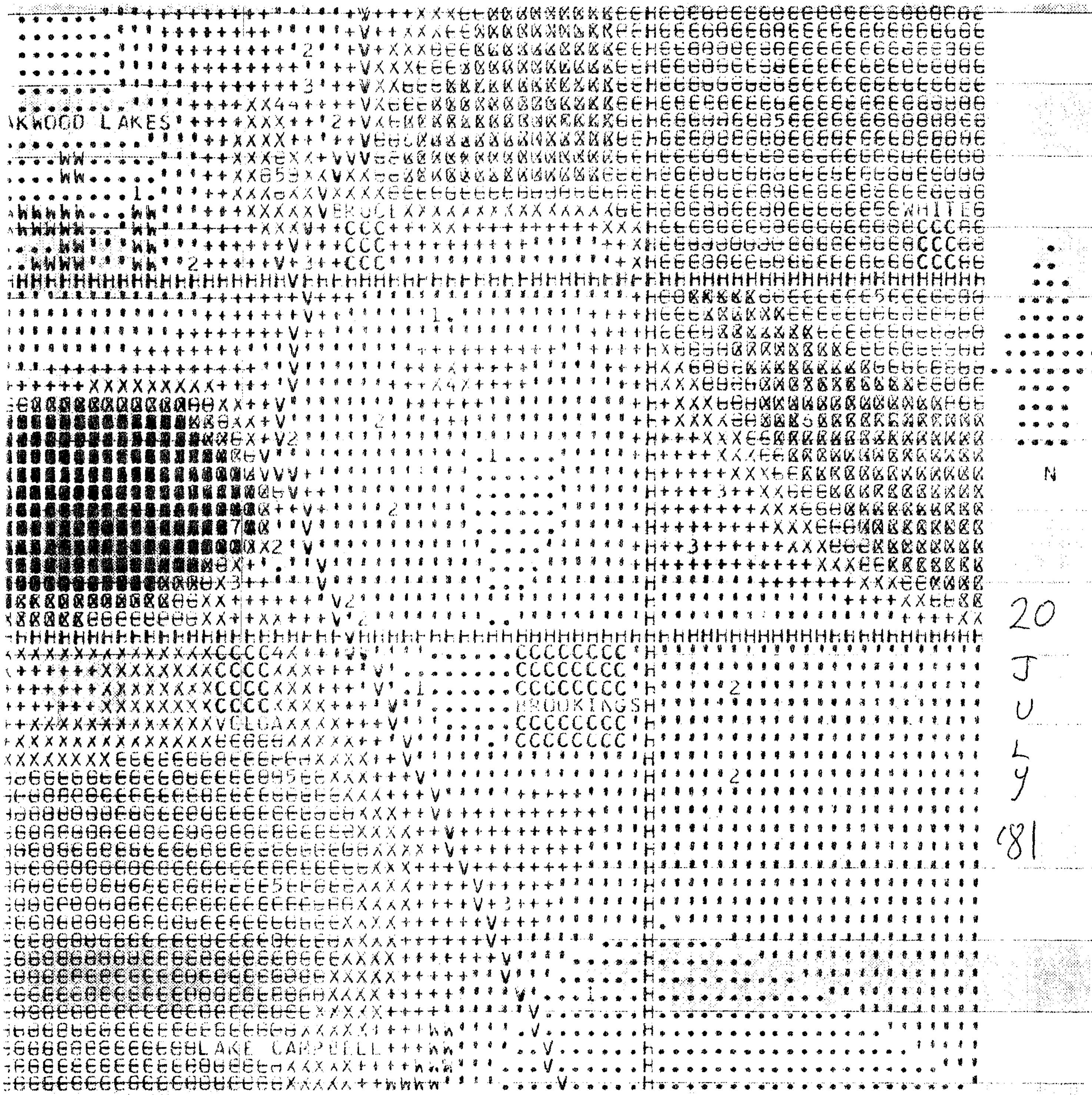
20 May '81

V BIG SIOUX RIVER

H MAJOR HIGHWAY

I--I--I--I--I--I
0 1 2 3 4 5
MILES





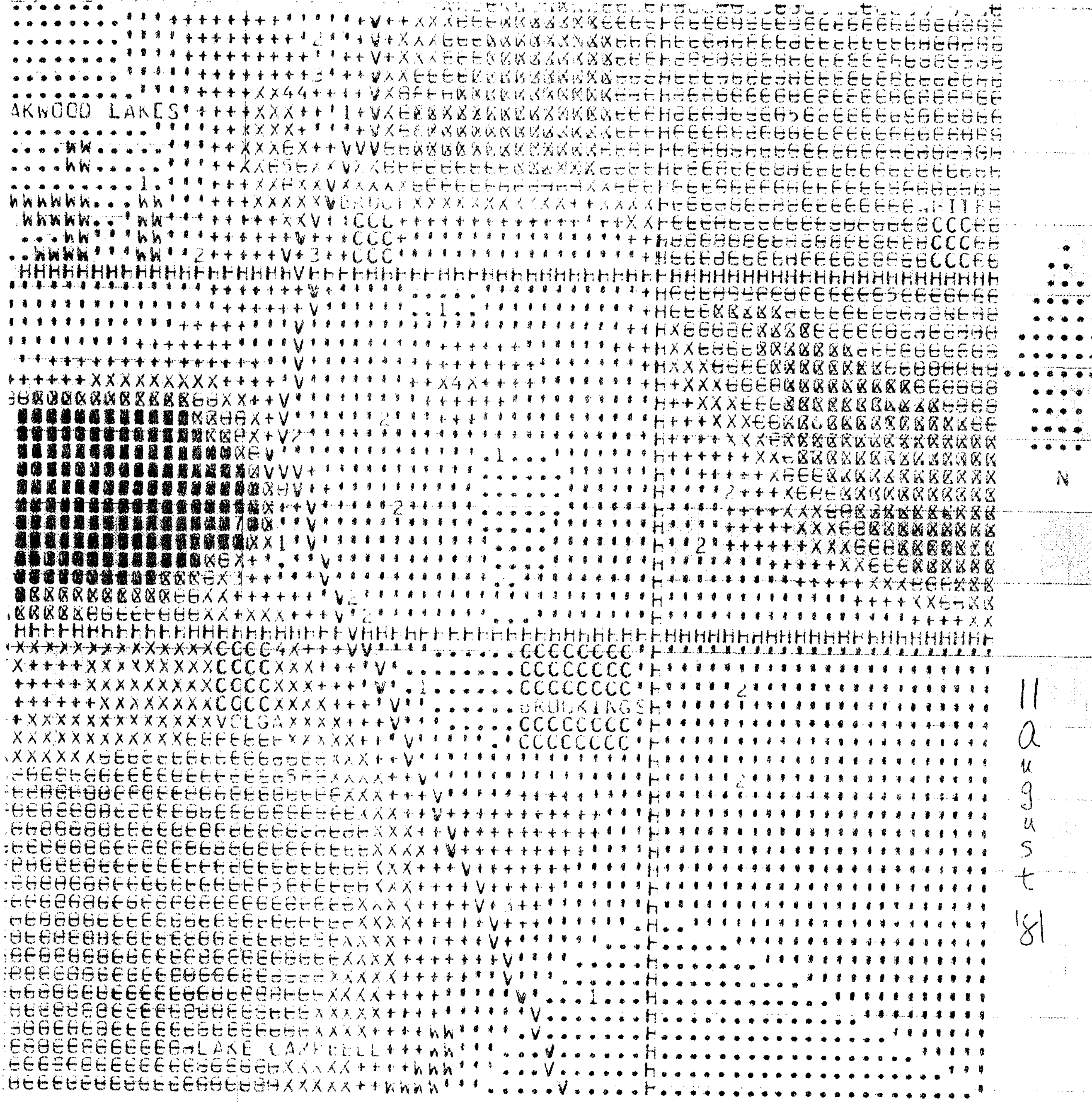
20 JULY '81

VVV BIG SIOUX RIVER

HH MAJOR HIGHWAY

I--I--I--I--I--I
0 1 2 3 4 5
MILES

	1	2	3	4	5	6	7
SYMBOLS	....1....	''''2''''	++++3++++	XXXX4XXXX	EEEE5EEEE	ØØØØ6ØØØØ	■■■■7■■■■



VV BIG SIOUX RIVER

HH MAJOR HIGHWAY

I--I--I--I--I--I
0 1 2 3 4 5
MILES

	1	2	3	4	5	6	7
BCLS	....1....	''''2''''	++++3++++	XXXX4XXXX	EEEE5EEEE	ØØØ6ØØØØ	■■■■7■■■■

APPENDIX B

Raw TB ground data files (less gravimetric moistures) on a footprint basis

A	B	C	D	E	F	G	H	I	J	K
2	1	284.24	5	1	4	8	1	4	143	3
2	2	282.66	4	4	2	3	2	3	999	3
2	3	285.66	3	2	2	6	1	3	140	3
2	4	287.33	5	2	2	6	1	3	137	3
2	5	283.41	5	3	2	3	2	3	136	3
2	6	290.33	5	1	4	8	1	5	136	3
2	7	291.33	4	3	2	3	2	3	999	3
2	8	292.67	5	3	2	3	2	3	131	3
2	9	267.14	5	1	4	8	1	5	131	3
2	10	263.64	5	3	2	3	2	3	131	3
2	11	283.32	5	3	2	3	2	3	129	3
2	12	260.63	5	1	4	8	1	5	127	3
2	13	271.98	5	1	4	8	1	5	127	3
2	14	264.30	5	1	4	8	1	5	127	3
2	15	271.31	5	1	4	8	1	5	127	3
2	16	279.66	5	1	4	8	1	5	125	3
2	17	295.34	3	3	2	3	2	3	124	3
2	18	292.33	3	3	2	3	2	3	124	3
2	19	274.23	5	1	4	8	1	5	123	3
2	20	277.65	6	1	4	8	1	5	121	2
2	21	271.64	6	1	4	8	1	5	121	2
2	22	270.98	6	1	4	8	1	5	121	2
2	23	279.99	5	1	4	8	1	5	120	2
2	24	270.90	5	1	4	8	1	5	120	2
2	25	274.98	5	1	4	8	1	4	119	2
2	26	267.56	5	1	4	8	1	5	119	2
2	27	267.56	5	1	4	8	1	5	117	2
2	28	266.64	5	1	4	8	1	5	115	1
2	29	270.06	5	1	4	8	1	5	115	1
2	30	266.98	5	1	4	8	1	5	115	1
2	31	258.63	5	1	4	8	1	4	113	1
2	32	266.30	5	1	4	8	1	5	112	1
2	33	287.99	5	1	4	8	1	5	112	1
2	34	270.47	6	1	4	8	1	5	108	1
2	35	286.99	6	1	4	8	1	2	107	2
2	36	290.33	6	2	2	7	2	2	107	2
2	37	287.99	6	2	2	7	2	2	105	2
2	38	285.66	6	3	2	2	1	2	106	2
2	39	293.41	3	3	2	2	1	2	102	2
2	40	293.67	6	3	2	2	1	2	101	2
2	41	285.66	6	3	2	2	2	2	100	2
2	42	282.57	6	3	2	2	1	2	99	2
2	43	291.00	3	3	2	2	1	2	98	2
2	44	293.41	3	2	2	2	1	2	96	2
2	45	282.32	6	2	2	6	1	2	95	2
2	48	265.89	5	1	4	8	1	4	93	2
2	49	264.63	5	3	2	8	1	3	93	2
2	50	287.58	1	3	2	2	1	3	92	2
2	51	285.99	3	3	2	2	1	3	90	2
2	52	288.41	3	3	2	2	1	3	88	2
2	53	288.33	3	3	2	2	1	3	86	2
2	54	287.58	3	3	2	2	1	3	84	3
2	55	265.64	1	3	2	2	1	3	83	3
2	56	285.91	3	2	2	6	1	3	82	4
2	57	285.32	3	3	2	2	1	4	80	3
2	58	282.99	3	3	2	2	1	3	80	3

A= DATE, 17 JULY 1981

B= FOOTPRINT NUMBER

C= BRIGHTNESS TEMPERATURE, °K

D= LAND USE, (SEE TABLE 2, P. 9) FOR EXPLANATION OF THIS AND FOLLOWING CATEGORIES

E= GENERAL SOIL GROUP

F= HYDROLOGIC GROUP

G= MANAGEMENT GROUP

H= SLOPE

I= TEXTURE

J= FIELD NUMBER

K= WATER TABLE CONTOUR CLASS

2	59	282.15	3	3	2	7	1	1	79	2
2	60	283.32	3	3	2	7	1	1	79	2
2	61	255.29	4	2	2	6	1	3	999	2
2	62	278.40	5	3	2	3	2	3	78	2
2	63	264.63	5	3	2	3	2	3	78	2
2	64	281.32	3	3	4	3	2	4	77	2
2	65	256.63	5	1	4	8	1	4	74	2
2	66	268.31	5	1	4	8	1	4	74	2
2	3	275.33	6	2	2	6	1	3	70	2
2	4	261.98	6	2	2	6	1	3	70	2
2	5	265.31	6	2	2	6	1	3	70	2
2	6	270.32	6	2	2	6	1	3	70	2
2	7	283.11	3	2	2	6	1	3	69	2
2	8	271.43	5	2	2	6	1	3	68	3
2	9	275.33	5	2	4	8	1	5	68	3
2	10	269.35	6	2	2	6	1	3	65	3
2	11	264.20	6	1	3	8	1	4	65	3
2	12	263.09	6	1	4	8	1	4	65	3
2	19	275.33	3	1	3	8	1	4	61	3
2	20	273.66	5	1	3	8	1	4	60	3
2	21	266.43	2	1	4	8	1	5	59	3
2	22	259.20	1	2	1	6	1	1	57	3
2	23	265.18	1	7	2	4	3	2	56	3
2	24	257.67	1	3	2	2	1	2	56	3
2	25	280.61	3	3	2	7	1	1	53	3
2	26	278.66	3	3	2	7	1	1	53	3
2	27	266.98	6	3	2	7	1	1	51	3
2	28	274.21	6	3	2	7	1	1	51	3
2	29	283.67	3	3	2	7	1	1	50	2
2	30	280.89	6	3	2	7	1	1	49	2
2	31	288.12	3	3	2	7	1	1	48	2
2	32	286.86	3	3	2	2	1	2	48	2
2	33	281.86	6	3	2	2	1	2	47	2
2	34	291.04	6	3	2	7	1	1	47	2
2	35	277.55	6	3	2	2	1	2	47	2
2	36	284.78	1	3	2	1	1	4	44	2
2	37	273.10	6	1	3	8	1	4	43	2
2	38	263.09	5	1	3	8	1	4	42	2
2	39	260.87	5	1	3	8	1	4	42	2
2	40	283.11	3	2	2	6	1	3	41	2
2	41	286.03	3	3	2	2	2	2	41	2
2	42	275.19	3	3	2	2	1	3	41	2
2	43	274.77	5	3	2	2	1	3	39	2
2	44	274.21	6	3	2	2	1	3	40	2
2	45	280.33	6	3	2	1	1	4	40	2
2	46	280.33	5	3	2	2	1	3	37	2
2	47	258.64	5	4	2	1	1	4	37	2
2	48	286.45	5	1	4	8	1	2	36	2
2	49	291.87	3	2	2	6	1	4	35	2
2	50	276.85	6	2	2	1	1	4	33	2
2	51	287.78	6	3	2	2	1	2	32	2
2	52	285.78	2	3	2	1	1	4	31	2
2	53	284.78	6	3	2	2	1	2	30	2
2	54	271.77	4	3	2	2	1	3	999	2
2	55	285.45	4	3	2	2	1	3	999	2
2	56	284.11	3	3	2	1	1	4	28	2

2	57	288.12	3	3	2	1	1	4	28	2
2	58	273.52	2	3	2	2	1	4	25	2
2	59	270.18	2	3	2	2	1	2	25	2
2	60	273.10	2	3	2	1	1	4	25	2
2	61	256.75	5	4	2	1	1	4	27	2
2	62	278.77	5	2	1	6	1	3	24	3
2	63	270.43	5	2	2	6	1	3	24	3
2	64	264.76	5	2	2	6	1	3	24	3
2	65	269.76	5	2	2	6	1	3	21	4
2	66	285.11	5	2	2	6	1	3	21	4
2	71	275.44	6	2	2	6	1	3	16	5
2	72	277.44	6	2	2	6	1	3	16	5
2	73	277.77	6	2	2	6	1	3	16	5
2	74	273.77	6	2	2	6	1	3	14	5
2	75	276.44	6	2	2	6	1	3	14	5
2	76	276.10	6	2	2	6	1	3	14	5
2	77	288.12	3	2	2	6	1	3	12	5
2	78	283.78	3	2	2	6	1	3	12	5
2	79	278.11	3	2	2	6	1	3	12	5
2	80	277.10	1	2	2	6	1	3	13	5
2	81	278.44	2	2	2	6	1	3	11	5
2	82	278.44	2	2	2	6	1	3	11	5
2	83	282.11	6	2	2	6	1	3	7	5
2	84	281.11	6	2	1	6	2	1	7	5
2	85	272.77	6	1	4	8	1	4	7	5
2	86	277.77	6	1	4	8	1	4	6	5
2	87	272.43	3	4	2	1	1	4	5	5
2	88	254.75	5	4	2	1	1	4	4	5
2	89	258.09	4	7	2	4	3	2	999	5
2	90	287.45	3	3	2	3	1	2	2	5
2	91	288.78	3	3	2	2	1	2	2	5
2	92	286.45	3	3	2	2	1	2	2	5
2	93	285.11	3	3	2	2	1	2	1	5
2	94	284.45	3	3	2	2	1	2	1	5

A	B	C	D	E	F	G	H	I	J	K
3	2	230.54	5	1	4	8	1	4	142	3
3	3	281.01	5	4	2	3	2	3	141	3
3	4	257.56	3	2	2	6	1	3	140	3
3	5	261.24	5	2	1	6	2	1	139	3
3	6	242.21	5	2	2	6	1	3	137	3
3	7	258.90	5	1	4	8	1	4	136	3
3	8	244.88	5	3	2	3	2	3	136	3
3	9	251.39	6	3	2	8	2	3	133	3
3	10	229.70	6	3	2	3	2	3	133	3
3	11	229.54	3	3	2	3	2	3	132	3
3	12	232.20	5	3	2	3	2	3	131	3
3	13	266.82	5	1	4	8	1	5	130	3
3	14	251.56	5	3	2	3	2	3	130	3
3	15	237.21	5	3	2	3	2	3	129	3
3	16	253.06	5	3	2	3	2	3	129	3
3	17	239.21	5	1	2	8	1	5	127	3
3	18	256.90	5	1	4	8	1	5	127	3
3	19	261.40	5	1	4	8	1	5	127	3
3	20	252.89	5	1	4	8	1	5	127	3
3	21	274.58	5	1	4	8	1	5	125	3
3	22	250.56	5	1	4	8	1	5	125	3
3	23	252.89	3	3	2	8	1	3	124	3
3	24	255.56	3	3	2	3	2	3	124	3
3	25	252.64	3	3	2	3	2	3	124	3
3	26	245.88	3	1	4	8	1	5	124	3
3	27	245.22	5	1	4	8	1	5	123	3
3	28	236.38	6	1	4	8	1	5	121	2
3	29	250.89	6	1	4	8	1	5	121	2
3	30	255.56	6	1	4	8	1	5	121	2
3	31	262.23	6	1	4	8	1	5	121	2
3	32	252.89	6	1	4	8	1	5	121	2
3	33	246.88	5	1	4	8	1	5	120	2
3	34	252.89	5	1	4	8	1	5	120	2
3	35	244.88	5	1	4	8	1	5	119	2
3	36	254.56	5	1	4	8	1	5	119	2
3	37	263.90	5	1	4	8	1	5	119	2
3	38	248.89	5	1	4	8	1	5	118	2
3	39	262.90	5	1	4	8	1	5	118	2
3	40	265.15	6	1	4	8	1	5	116	1
3	41	258.23	5	1	4	8	1	5	115	1
3	42	254.56	5	1	4	8	1	5	115	1
3	43	278.08	5	1	4	8	1	5	113	1
3	44	261.24	5	1	4	8	1	5	112	1
3	45	267.58	5	1	4	8	1	5	112	1
3	46	270.15	5	1	4	8	1	5	112	1
3	47	244.55	3	1	4	8	1	5	111	1
3	48	245.88	5	1	4	8	1	5	109	1
3	49	253.47	6	3	2	3	2	3	107	2
3	50	241.88	6	2	2	7	2	2	107	2
3	51	245.88	6	2	2	7	2	2	107	2
3	52	245.13	6	2	4	8	1	2	107	2
3	53	244.29	5	2	2	7	2	2	103	2
3	54	242.88	5	3	2	2	1	2	103	2
3	55	245.55	3	3	2	2	1	2	102	2
3	56	271.82	6	3	2	2	1	2	101	2
3	57	242.54	6	3	2	2	1	2	100	2

A= DATE, 20 JULY 1981

B= FOOTPRINT NUMBER

C= BRIGHTNESS TEMPERATURE, °K

D= LAND USE, (SEE TABLE 2, P. 9) FOR EXPLANATION OF THIS AND FOLLOWING CATEGORIES

E= GENERAL SOIL GROUP

F= HYDROLOGIC GROUP

G= MANAGEMENT GROUP

H= SLOPE

I= TEXTURE

J= FIELD NUMBER

K= WATER TABLE CONTOUR CLASS

3	58	266.90	6	3	2	2	1	2	99	2
3	59	236.37	6	3	2	2	1	2	99	2
3	60	244.21	3	3	2	2	1	2	98	2
3	61	253.22	6	3	2	2	1	2	97	2
3	62	234.28	3	2	2	2	1	2	96	2
3	63	252.22	6	2	2	6	1	2	95	2
3	68	261.23	5	1	4	8	1	5	93	2
3	69	243.46	5	3	2	3	2	3	93	2
3	70	239.87	5	3	2	3	2	3	93	2
3	71	257.22	6	3	2	2	1	3	91	2
3	72	230.11	3	3	2	2	1	3	90	2
3	73	245.55	6	3	2	2	1	3	89	2
3	74	227.53	6	3	2	2	1	3	87	2
3	75	233.87	3	3	2	2	1	3	86	2
3	76	252.64	6	3	2	2	1	3	85	3
3	77	231.87	1	3	2	2	1	3	83	3
3	78	249.22	1	3	2	2	1	3	83	3
3	79	247.63	3	2	2	1	1	3	82	4
3	80	254.22	3	3	2	2	1	3	82	4
3	81	260.56	3	3	4	8	1	4	80	3
3	82	259.89	3	3	2	2	1	3	80	3
3	83	255.97	3	3	2	2	1	3	80	3
3	84	252.22	3	3	2	7	1	1	79	2
3	85	257.22	3	3	2	7	1	1	79	2
3	86	256.81	4	2	2	6	1	3	999	2
3	87	229.86	5	3	2	3	2	3	78	2
3	88	253.22	5	3	2	3	2	3	78	2
3	89	244.21	5	3	2	3	2	3	78	2
3	90	245.96	3	3	2	3	2	3	76	2
3	91	252.55	5	1	4	8	1	4	74	2
3	92	254.56	5	1	4	8	1	4	74	2
3	93	250.55	5	1	4	8	1	4	74	2
3	1	254.62	3	2	2	6	1	3	71	2
3	2	242.69	6	2	2	6	1	3	70	2
3	3	240.02	6	2	2	6	1	3	70	2
3	4	242.69	6	2	2	6	1	3	70	2
3	5	271.72	3	2	2	6	1	3	69	2
3	6	261.37	3	2	2	6	1	3	69	2
3	7	273.05	5	1	4	8	1	5	68	3
3	8	256.37	5	2	2	6	1	3	68	3
3	9	266.38	6	2	2	6	1	3	65	3
3	10	251.70	6	2	2	6	1	3	65	3
3	11	245.03	6	2	2	6	1	3	65	3
3	18	234.18	3	1	3	8	1	4	61	3
3	19	262.38	3	1	3	8	1	4	61	3
3	20	264.04	5	1	3	8	1	5	60	3
3	21	253.70	2	1	3	8	1	4	59	3
3	22	248.36	6	1	4	8	1	5	58	3
3	23	255.03	1	2	2	6	1	2	57	3
3	24	248.36	1	7	2	4	3	2	56	3
3	25	256.71	3	3	2	2	1	2	53	3
3	26	257.04	3	3	2	7	1	1	53	3
3	27	256.71	3	3	2	7	1	1	53	3
3	28	250.36	6	3	2	7	1	1	51	3
3	29	256.29	3	3	2	2	2	1	50	2
3	30	244.02	3	3	2	7	1	2	50	2

3	31	262.54	6	3	2	7	1	1	49	2
3	32	260.37	3	3	2	7	1	1	48	2
3	33	263.38	3	3	2	7	1	4	48	2
3	34	260.71	3	3	2	1	1	4	46	2
3	35	258.70	3	3	2	2	1	2	46	2
3	36	257.04	6	3	2	7	1	1	45	2
3	37	257.04	1	3	2	2	1	2	44	2
3	38	254.37	6	3	2	1	1	4	43	2
3	39	235.35	5	1	3	8	1	4	42	2
3	40	235.85	5	1	3	8	1	4	42	2
3	41	232.93	5	1	3	8	1	3	42	2
3	42	270.47	3	2	2	6	1	3	41	2
3	43	244.69	6	3	2	2	1	3	40	2
3	44	246.28	6	3	2	2	1	3	40	2
3	45	245.36	6	3	2	2	1	2	40	2
3	46	239.60	6	3	2	2	1	3	40	2
3	47	231.34	5	3	2	1	1	4	37	2
3	48	227.92	5	3	2	1	1	4	37	2
3	49	238.35	3	1	4	8	1	2	35	2
3	50	255.45	3	1	4	8	1	2	34	2
3	51	239.69	3	2	2	6	1	4	34	2
3	52	238.69	6	3	2	1	1	4	32	2
3	53	221.67	6	3	2	2	1	2	30	2
3	54	221.34	6	3	2	1	1	4	30	2
3	55	221.25	6	3	2	2	1	3	30	2
3	56	252.04	4	3	2	2	1	3	999	2
3	57	234.60	3	3	2	2	1	3	28	2
3	58	236.69	3	3	2	1	1	4	28	2
3	59	235.85	3	3	2	1	1	4	28	2
3	60	241.36	6	3	2	1	1	4	26	2
3	61	232.79	6	3	2	2	1	2	26	2
3	62	242.25	6	3	2	1	1	4	26	2
3	63	253.79	5	4	2	1	1	4	24	3
3	64	236.27	5	2	2	6	1	3	24	3
3	65	222.92	6	2	2	6	1	3	22	4
3	66	241.14	5	2	2	6	1	3	21	4
3	67	212.49	5	2	2	6	1	3	21	4
3	73	213.89	6	2	2	6	1	3	15	5
3	74	210.55	6	2	2	6	1	3	15	5
3	75	214.58	6	2	2	6	1	3	15	5
3	76	237.24	6	2	2	6	1	3	14	5
3	77	234.60	6	2	2	6	1	3	14	5
3	78	235.85	6	2	2	6	1	3	14	5
3	79	242.80	1	2	2	6	1	3	13	5
3	80	236.69	1	2	2	6	1	3	13	5
3	81	239.19	1	2	2	6	1	3	13	5
3	82	245.03	1	2	2	6	1	3	13	5
3	83	239.47	4	2	2	6	1	3	999	5
3	84	225.84	2	2	2	6	1	3	10	5
3	85	222.78	2	2	2	6	1	3	10	5
3	86	260.46	4	2	2	6	1	3	999	5
3	87	228.76	6	2	2	6	1	3	9	5
3	88	240.86	6	2	4	8	1	4	9	5
3	89	236.13	6	1	4	8	1	4	6	5
3	90	231.13	6	1	4	8	1	4	6	5
3	91	233.77	3	1	4	8	1	4	5	5

3	92	248.37	5	1	4	8	1	4		4	5
3	93	255.04	6	7	2	4	2	2		3	5
3	94	257.12	3	3	2	2	1	2		2	5
3	95	258.93	3	3	2	2	1	2		2	5
3	96	227.93	3	3	2	2	1	2		1	5
3	97	227.79	3	3	2	2	1	2		1	5
3	98	220.84	3	3	2	2	1	2		1	5

APPENDIX C

Raw TIR-TB ground data files (less gravimetric moistures) on a field basis

Date	Field	Land Use	TIR °C	Water Table Class	TB/Field °K
1	1	3	33.2	5	
2	1	3	26.7	5	284.78
3	1	3	21.4	5	225.52
4	1	3	19.6	5	
1	2	3	36.2	5	
2	2	3	26.7	5	287.56
3	2	3	19.5	5	258.02
4	2	3	21.3	5	
1	3	6	25.7	5	
2	3	6	34.3	5	
3	3	6	24.3	5	255.04
4	3	6	23.6	5	
1	4	5	25.5	5	
2	4	5	33.5	5	254.75
3	4	5	23.8	5	248.37
4	4	5	20.7	5	
1	5	3	36.9	5	
2	5	3	25.6	5	272.43
3	5	3	20.3	5	233.77
4	5	3	21.1	5	
1	6	6	26.4	5	
2	6	6	30.2	5	277.77
3	6	6	24.3	5	233.63
4	6	6	25.3	5	
1	7	6	26.6	5	
2	7	6	37.4	5	278.66
3	7	6	19.1	5	
4	7	6	22.9	5	
1	8	6	28.9	5	
2	8	6	24.4	5	
3	8	6	26.7	5	
4	8	6	25.3	5	
1	9	6	24.8	5	
2	9	6	27.8	5	
3	9	6	24.0	5	234.81
4	9	6	23.0	5	
1	10	2	30.7	5	
2	10	2	28.1	5	
3	10	2	23.0	5	224.31
4	10	2	24.8	5	
1	11	2	31.3	5	
2	11	2	30.4	5	278.44
3	11	2	22.5	5	
4	11	2	19.6	5	
1	12	3	31.1	5	
2	12	3	30.6	5	283.34
3	12	3	24.6	5	
4	12	3	21.5	5	
1	13	1	21.3	5	

2	13	1	34.5	5	277.10
3	13	1	23.0	5	240.93
4	13	1	20.0	5	
1	14	6	31.5	5	
2	14	6	24.6	5	275.44
3	14	6	22.7	5	235.90
4	14	6	22.9	5	
1	15	6	30.7	5	
2	15	6	30.2	5	
3	15	6	23.8	5	213.01
4	15	6	34.9	5	
1	16	6	26.8	5	
2	16	6	26.4	5	276.88
3	16	6	24.4	5	
4	16	6	25.3	5	
1	18	5		5	
2	18	5	19.4	5	
3	18	5	28.8	5	
4	18	5	21.1	5	
1	20	6		5	
2	20	6	30.4	5	
3	20	6	27.2	5	
4	20	6	21.8	5	
1	21	5	25.7	4	
2	21	5	35.1	4	277.43
3	21	5	27.5	4	226.81
4	21	5	20.9	3	
1	22	6	25.7	4	
2	22	6	36.8	4	
3	22	6		4	222.92
4	22	6	22.0	3	
1	23	5		4	
2	23	5	25.2	4	
3	23	5	23.3	4	
4	23	5	19.8	3	
1	24	5	23.8	3	
2	24	5	20.9	3	271.32
3	24	5	21.9	3	245.03
4	24	5	19.8	2	
1	25	2	25.6	3	
2	25	2	26.7	2	272.27
3	25	2	22.2	2	
4	25	2	20.9	2	
1	26	6	30.0	3	
2	26	6	21.9	2	
3	26	6	27.6	2	238.80
4	26	6	18.7	2	
1	27	5	19.1	3	
2	27	5	25.0	2	256.75
3	27	5	23.0	2	
4	27	5	22.7	2	
1	28	3	28.1	3	
2	28	3	24.8	2	286.11
3	28	3	18.8	2	235.71

4	28	3	19.4	2	
1	29	3		2	
2	29	3	27.5	2	
3	29	3	22.4	2	
4	29	3	22.6	2	
1	30	6	31.3	2	
2	30	6	30.4	2	284.78
3	30	6	22.8	2	221.42
4	30	6	23.8	2	
1	31	2	31.7	2	
2	31	2	32.6	2	285.78
3	31	2	22.5	2	
4	31	2	20.0	2	
1	32	6	29.6	2	
2	32	6	25.0	2	287.78
3	32	6	22.8	2	238.69
4	32	6	23.9	2	
1	33	6	33.9	2	
2	33	6	25.8	2	276.85
3	33	6	28.0	2	
4	33	6	17.6	2	
1	34	3	31.7	2	
2	34	3	28.7	2	
3	34	3	21.7	2	247.57
4	34	3	18.9	2	
1	35	3	26.8	2	
2	35	3	25.6	2	291.87
3	35	3	22.0	2	238.35
4	35	3	19.4	2	
1	36	5	27.9	2	
2	36	5	19.6	2	286.45
3	36	5	23.2	2	
4	36	5	19.6	2	
1	37	5	30.2	2	
2	37	5	28.1	2	269.48
3	37	5	24.0	2	229.63
4	37	5	24.6	2	
1	38	2	31.3	2	
2	38	2	27.7	2	
3	38	2	19.8	2	
4	38	2	26.3	2	
1	39	5	28.7	2	
2	39	5	24.6	2	274.77
3	39	5	23.0	2	
4	39	5	24.2	2	
1	40	6	25.7	2	
2	40	6	33.1	2	277.27
3	40	6	24.3	2	243.98
4	40	6	27.4	2	
1	41	3	30.2	2	
2	41	3	24.8	2	281.44
3	41	3	19.1	2	270.47
4	41	3	22.0	2	
1	42	5	25.2	2	

2	42	5	33.1	2	261.98
3	42	5	27.6	2	234.71
4	42	5	20.1	2	
1	43	6	23.0	2	
2	43	6	21.3	2	273.10
3	43	6	18.8	2	254.37
4	43	6	19.1	2	
1	44	1	25.3	2	
2	44	1	32.6	2	284.78
3	44	1	24.6	2	257.04
4	44	1	25.3	2	
1	45	6	27.5	2	
2	45	6	32.0	2	
3	45	6	25.7	2	257.04
4	45	6	33.8	2	
1	46	3	31.1	2	
2	46	3	25.0	2	
3	46	3	19.0	2	259.70
4	46	3	19.6	2	
1	47	6	28.7	2	
2	47	6	33.7	2	283.48
3	47	6	23.3	2	
4	47	6	24.4	2	
1	48	3	34.9	2	
2	48	3	24.6	2	287.49
3	48	3	22.2	2	261.87
4	48	3	19.1	2	
1	49	6	29.6	2	
2	49	6	25.4	2	280.89
3	49	6	23.0	2	262.54
4	49	6	25.3	2	
1	50	3	30.7	2	
2	50	3	29.8	2	283.67
3	50	3	23.0	2	250.15
4	50	3	20.0	2	
1	51	6		3	
2	51	6	24.8	3	270.59
3	51	6	24.0	3	250.36
4	51	6	20.5	3	
1	52	5	27.9	3	
2	52	5	30.1	3	
3	52	5	27.2	3	
4	52	5	20.9	3	
1	53	3	24.2	3	
2	53	3	29.5	3	279.63
3	53	3	24.4	3	256.82
4	53	3	22.2	3	
1	54	6	29.4	3	
2	54	6	30.4	3	
3	54	6	23.5	3	
4	54	6	25.5	3	
1	55	3	26.4	3	
2	55	3	24.6	3	

3	55	3	20.4	3	
4	55	3	21.2	3	
1	56	1	21.3	3	
2	56	1	29.5	3	261.42
3	56	1	25.3	3	248.36
4	56	1	19.4	3	
1	57	1	22.4	3	
2	57	1	30.6	3	259.20
3	57	1	23.6	3	255.03
4	57	1	19.0	3	
1	58	6	30.9	3	
2	58	6	33.1	3	
3	58	6	29.3	3	248.36
4	58	6	22.0	3	
1	59	2	27.9	3	
2	59	2	29.5	3	266.43
3	59	2	22.8	3	253.70
4	59	2	19.1	3	
1	60	5	26.8	3	
2	60	5	29.2	3	273.66
3	60	5	26.8	3	264.04
4	60	5	19.9	3	
1	61	3	33.5	3	
2	61	3	27.1	3	275.33
3	61	3	24.4	3	248.28
4	61	3	20.0	3	
1	64	5	29.6	3	
2	64	5	28.7	3	
3	64	5	18.8	3	
4	64	5	23.9	3	
1	65	6	30.2	3	
2	65	6	25.8	3	265.55
3	65	6	22.8	3	254.37
4	65	6	23.5	3	
1	66	3	36.2	3	
2	66	3	24.6	3	
3	66	3	24.0	3	
4	66	3	21.3	3	
1	67	6	31.3	3	
2	67	6	25.0	3	
3	67	6	24.4	3	
4	67	6	24.9	3	
1	68	5	31.9	3	
2	68	5	25.8	3	273.38
3	68	5	23.6	3	264.71
4	68	5	19.6	3	
1	69	3	31.9	2	
2	69	3	27.5	2	283.11
3	69	3	22.0	2	266.54
4	69	3	19.6	2	
1	70	6	22.5	2	
2	70	6	25.6	2	268.23
3	70	6	23.3	2	241.80
4	70	6	25.7	2	

1	71	3		2	
2	71	3	23.4	2	
3	71	3	21.2	2	254.62
4	71	3	21.1	2	
1	72	5	33.0	2	
2	72	5	31.4	2	
3	72	5	25.1	2	
4	72	5	24.4	2	
1	73	6	14.8	2	
2	73	6	19.6	2	
3	73	6	18.7	2	
4	73	6	14.6	2	
1	74	5	25.1	2	
2	74	5	28.3	2	262.47
3	74	5	22.6	2	252.55
4	74	5	18.9	1	
1	75	3		2	
2	75	3	28.6	2	
3	75	3	20.7	2	
4	75	3	24.2	1	
1	76	3	30.1	2	
2	76	3	24.4	2	
3	76	3	19.0	2	245.96
4	76	3	19.4	1	
1	77	3		2	
2	77	3	23.6	2	281.32
3	77	3	19.0	2	
4	77	3	22.2	1	
1	78	5	21.4	2	
2	78	5	29.9	2	271.51
3	78	5	23.7	2	242.43
4	78	5	22.6	1	
1	79	3		3	
2	79	3	24.0	2	282.73
3	79	3	19.9	2	254.72
4	79	3	17.6	2	
1	80	3		3	
2	80	3	24.2	3	284.15
3	80	3	20.2	3	258.81
4	80	3	18.0	3	
1	81	6		4	
2	81	6	25.6	3	
3	81	6	24.4	3	
4	81	6	25.9	3	
1	82	3	32.3	4	
2	82	3	25.0	4	285.91
3	82	3	19.2	4	250.92
4	82	3	17.6	4	
1	83	1	21.1	3	
2	83	1	29.7	3	265.64
3	83	1	24.1	3	240.54
4	83	1	15.4	3	
1	84	3	30.1	3	
2	84	3	25.4	3	287.58

3	84	3	19.0	3	
4	84	3	17.8	3	
1	85	6	22.6	3	
2	85	6	26.3	3	
3	85	6	22.7	3	252.64
4	85	6	18.0	3	
1	86	3	26.1	2	
2	86	3	27.5	2	288.33
3	86	3	20.4	2	233.87
4	86	3	18.3	2	
1	87	6	26.7	2	
2	87	6	29.5	2	
3	87	6	22.6	2	227.53
4	87	6	20.9	2	
1	88	3	31.1	2	
2	88	3	27.3	2	288.41
3	88	3	21.2	2	
4	88	3	18.0	2	
1	89	6	25.7	2	
2	89	6	29.5	2	
3	89	6	22.7	2	245.55
4	89	6	28.8	2	
1	90	3	30.3	2	
2	90	3	28.7	2	285.99
3	90	3	22.1	2	230.11
4	90	3	18.3	2	
1	91	6	21.6	2	
2	91	6	35.4	2	
3	91	6	26.6	2	257.22
4	91	6	23.3	2	
1	92	1	25.3	2	
2	92	1	33.5	2	287.58
3	92	1	22.7	2	
4	92	1	20.0	2	
1	93	5	22.0	2	
2	93	5	28.4	2	265.26
3	93	5	22.9	2	248.19
4	93	5	22.5	2	
1	95	6	29.0	2	
2	95	6	34.4	2	282.32
3	95	6	23.2	2	252.22
4	95	6	23.1	2	
1	96	3	20.9	2	
2	96	3	27.7	2	293.41
3	96	3	19.4	2	234.28
4	96	3	18.3	2	
1	97	6	30.9	2	
2	97	6	35.0	2	
3	97	6	23.4	2	253.22
4	97	6		2	
1	98	3	33.0	2	
2	98	3	27.5	2	291.00
3	98	3	22.7	2	244.21
4	98	3	17.4	2	

1	99	6	27.0	2	
2	99	6	30.5	2	282.57
3	99	6	22.9	2	251.63
4	99	6	22.9	2	
1	100	6	27.0	2	
2	100	6	24.2	2	285.66
3	100	6	19.0	2	242.54
4	100	6	23.1	2	
1	101	6	32.3	2	
2	101	6	31.1	2	293.67
3	101	6	22.6	2	271.82
4	101	6	17.4	2	
1	102	3		2	
2	102	3	25.0	2	293.41
3	102	3	23.1	2	245.55
4	102	3	18.0	2	
1	103	5		2	
2	103	5	36.4	2	
3	103	5	28.6	2	243.58
4	103	5	20.7	2	
1	104	3		2	
2	104	3		2	
3	104	3		2	
4	104	3	20.7	2	
1	105	6		2	
2	105	6	32.8	2	287.99
3	105	6	28.8	2	
4	105	6	23.1	2	
1	106	6	31.5	2	
2	106	6	29.1	2	285.66
3	106	6	23.1	2	
4	106	6		2	
1	107	6	29.2	2	
2	107	6	28.3	2	288.66
3	107	6	22.7	2	246.59
4	107	6	22.9	2	
1	108	6		1	
2	108	6	30.5	1	270.47
3	108	6	24.4	1	
4	108	6	25.3	1	
1	109	5	26.5	1	
2	109	5	37.0	1	
3	109	5	23.9	1	245.88
4	109	5	21.3	1	
1	110	5		1	
2	110	5	28.5	1	
3	110	5	24.1	1	
4	110	5	21.4	1	
1	111	3		1	
2	111	3	25.4	1	
3	111	3	21.6	1	244.55
4	111	3	24.8	1	
1	112	5	19.1	1	
2	112	5	24.4	1	277.14

3	112	5	22.6	1	266.32
4	112	5	18.9	1	
1	113	5	18.0	1	
2	113	5	26.8	1	258.63
3	113	5	20.9	1	278.08
4	113	5	17.6	1	
1	114	6	21.1	1	
2	114	6	33.4	1	
3	114	6	24.2	1	
4	114	6	21.8	1	
1	115	5		1	
2	115	5	27.3	1	267.89
3	115	5	22.7	1	256.39
4	115	5		1	
1	116	6		1	
2	116	6	26.7	1	
3	116	6	24.2	1	265.15
4	116	6	21.1	1	
1	117	5		2	
2	117	5	29.3	2	267.56
3	117	5	23.4	2	
4	117	5	21.7	2	
1	118	5	25.9	2	
2	118	5	27.2	2	
3	118	5	22.7	2	255.89
4	118	5	22.7	2	
1	119	5	25.7	2	
2	119	5	27.1	2	271.27
3	119	5	23.2	2	254.45
4	119	5	22.2	2	
1	120	5	22.4	2	
2	120	5	29.4	2	275.44
3	120	5	22.4	2	249.88
4	120	5	23.9	2	
1	121	6		2	
2	121	6	30.7	2	273.42
3	121	6	25.0	2	251.59
4	121	6	23.3	2	
1	122	5		2	
2	122	5	29.7	2	
3	122	5	24.1	2	
4	122	5		2	
1	123	5	19.7	3	
2	123	5	32.6	3	274.23
3	123	5	26.1	3	245.22
4	123	5	24.6	3	
1	124	3	30.7	3	
2	124	3	32.4	3	293.83
3	124	3	22.4	3	251.74
4	124	3	17.8	3	
1	125	5		3	
2	125	5	24.9	3	279.66
3	125	5	20.2	3	262.57
4	125	5	21.7	3	

1	126	5		3	
2	126	5	39.7	3	
3	126	5	24.2	3	
4	126	5	22.9	3	
1	127	5	19.7	3	
2	127	5	25.3	3	267.05
3	127	5	19.5	3	252.60
4	127	5	18.7	3	
1	128	6		3	
2	128	6	27.3	3	
3	128	6	24.1	3	
4	128	6	25.9	3	
1	129	5	30.5	3	
2	129	5	23.4	3	283.32
3	129	5	20.6	3	245.13
4	129	5	23.9	3	
1	130	5		3	
2	130	5	32.4	3	
3	130	5	22.6	3	259.19
4	130	5	23.3	3	
1	131	5		3	
2	131	5	28.3	3	274.48
3	131	5	22.9	3	232.20
4	131	5	18.5	3	
1	132	3	20.3	3	
2	132	3	29.3	3	
3	132	3	20.2	3	229.54
4	132	3	18.9	3	
1	133	6		3	
2	133	6	27.5	3	
3	133	6	23.9	3	240.54
4	133	6	28.1	3	
1	134	3		3	
2	134	3	26.3	3	
3	134	3	20.2	3	
4	134	3	20.2	3	
1	135	1	31.5	3	
2	135	1	36.4	3	
3	135	1	22.7	3	
4	135	1	26.6	3	
1	136	5		3	
2	136	5	30.7	3	286.87
3	136	5	23.7	3	251.89
4	136	5	22.7	3	
1	137	5	22.4	3	
2	137	5	37.7	3	287.33
3	137	5	23.2	3	242.21
4	137	5	28.3	3	
1	138	5		3	
2	138	5	38.7	3	
3	138	5		3	
4	138	5		3	
1	139	5		3	
2	139	5	30.3	3	

3	139	5	24.4	3	261.24
4	139	5	28.3	3	
1	140	3		3	
2	140	3	27.3	3	285.66
3	140	3	20.0	3	257.56
4	140	3	19.6	3	
1	141	5		3	
2	141	5	32.7	3	
3	141	5	23.7	3	281.01
4	141	5	27.9	3	
1	142	5		3	
2	142	5	30.3	3	
3	142	5	22.7	3	230.54
4	142	5	24.2	3	
1	143	5		3	
2	143	5	23.4	3	284.24
3	143	5	19.4	3	
4	143	5	18.0	3	
1	144	6	15.3	3	
2	144	6	18.1	3	
3	144	6	18.0	3	
4	144	6	12.1	3	

APPENDIX D

Linear discriminant analysis results on a footprint basis

Footprint Basis
Water Table Contour = TB
17 July 1981

Actual Water Table Contour Class	NUMBER OF OBSERVATIONS AND PERCENTS CLASSIFIED INTO WATER TABLE CONTOURS					
	Water Table Contour Class 1	Water Table Contour Class 2	Water Table Contour Class 3	Water Table Contour Class 4	Water Table Contour Class 5	TOTAL
1	6 67.67	0 0.00	0 0.00	1 14.29	0 0.00	7 100.00
2	20 28.17	1 1.41	8 11.27	39 54.93	3 4.23	71 100.00
3	18 43.90	2 4.88	5 12.20	16 39.02	0 0.00	41 100.00
4	1 33.33	0 0.00	0 0.00	2 66.67	0 0.00	3 100.00
5	3 12.50	2 8.33	5 20.83	9 37.50	5 20.83	24 100.00
TOTAL PERCENT	48 32.88	5 3.42	18 12.33	67 45.89	8 5.48	146 100.00
PRIOR PROBABILITY	0.2000	0.2000	0.2000	0.2000	0.2000	

Footprint Basis
Hydrologic Group = TB
17 July 1981

NUMBER OF OBSERVATIONS AND PERCENTS

Hydro-logic Group	1	2	3	4	TOTAL
1	0 0.00	2 66.67	1 33.33	0 0.00	3 100.00
2	10 9.80	69 67.65	19 18.63	4 3.92	102 100.00
3	3 50.00	0 0.00	3 50.00	0 0.00	6 100.00
4	4 11.43	10 28.57	15 42.86	6 17.14	35 100.00
TOTAL PERCENT	17 11.64	81 55.48	38 26.03	10 6.85	146 100.00
PRIOR PROBABILITY	0.2500	0.2500	0.2500	0.2500	

Footprint Basis
Slope = TB
17 July 1981

NUMBER OF OBSERVATIONS AND PERCENTS

SLOPE	1	2	3	TOTAL
1	47 36.72	52 40.63	29 22.66	128 100.00
2	1 6.25	13 81.25	2 12.50	16 100.00
3	0 0.00	0 0.00	2 100.00	2 100.00
TOTAL PERCENT	48 32.88	65 44.52	33 22.60	146 100.00
PRIOR PROBABILITY	0.3333	0.3333	0.3333	

Footprint Basis
General Soil = TB
17 July 1981

NUMBER OF OBSERVATIONS AND PERCENTS

General Soil	1	2	3	4	7	TOTAL
1	12 30.77	5 12.82	6 15.38	10 25.64	6 15.38	39 100.00
2	6 15.38	13 33.33	15 38.46	2 5.13	3 7.69	39 100.00
3	6 9.89	5 8.20	44 72.13	5 8.20	1 1.64	61 100.00
4	1 20.00	0 0.00	1 20.00	0 0.00	3 60.00	5 100.00
7	0 0.00	0 0.00	0 0.00	1 50.00	1 50.00	2 100.00
TOTAL PERCENT	25 17.12	23 15.75	66 45.21	18 12.33	14 9.59	146 100.00
PRIOR PROBABILITY	0.2000	0.2000	0.2000	0.2000	0.2000	

Footprint Basis
Management Group = TB
17 July 1981

NUMBER OF OBSERVATIONS AND PERCENTS

MANAGE-MENT	1	2	3	4	6	7	8	TOTAL
1	1 9.09	0 0.00	4 36.36	3 27.27	1 9.09	1 9.09	1 9.09	11 100.00
2	4 11.76	1 2.94	22 64.71	2 5.88	1 2.94	2 5.88	2 5.88	34 100.00
3	0 0.00	1 8.33	7 58.33	2 16.67	1 8.33	1 8.33	0 0.00	12 100.00
4	0 0.00	0 0.00	0 0.00	2 100.00	0 0.00	0 0.00	0 0.00	2 100.00
6	1 2.94	0 0.00	9 26.47	5 14.71	11 32.35	3 8.82	5 14.71	34 100.00
7	1 8.33	0 0.00	6 50.00	0 0.00	1 8.33	3 25.00	1 8.33	12 100.00
8	5 12.20	0 0.00	5 12.20	12 29.27	4 9.76	2 4.88	13 31.71	41 100.00
TOTAL PERCENT	12 8.22	2 1.37	53 36.30	26 17.81	19 13.01	12 8.22	22 15.07	146 100.00
PRIOR PROBA-BILITY	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	

Footprint Basis
Texture = TB
17 July 1981

NUMBER OF OBSERVATIONS AND PERCENTS

Texture	1	2	3	4	5	TOTAL
1	3 25.00	5 41.67	1 8.33	1 8.33	2 16.67	12 100.00
2	0 0.00	22 81.48	1 3.70	0 0.00	4 14.81	27 100.00
3	2 3.70	23 42.59	9 16.67	6 11.11	14 25.93	54 100.00
4	1 3.33	8 26.67	2 6.67	8 26.67	11 36.67	30 100.00
5	2 8.70	2 8.70	1 4.35	2 8.70	16 69.57	23 100.00
TOTAL PERCENT	8 5.48	60 41.10	14 9.59	17 11.64	47 32.19	146 100.00
PRIOR PROBABILITY	0.2000	0.2000	0.2000	0.2000	0.2000	

Footprint Basis
Texture = T8
20 July 1981

NUMBER OF OBSERVATIONS AND PERCENTS

ACTUAL TEXTURE	1	2	3	4	5	TOTAL
1	9 90.00	0 0.00	0 0.00	0 0.00	1 10.00	10 100.00
2	10 32.26	1 3.23	4 12.90	14 45.16	2 6.45	31 100.00
3	20 28.17	2 2.82	15 21.13	29 40.85	5 7.04	71 100.00
4	9 31.03	1 3.45	5 17.24	12 41.38	2 6.90	29 100.00
5	13 38.24	2 5.88	0 0.00	8 23.53	11 32.35	34 100.00
TOTAL PERCENT	61 34.86	6 3.43	24 13.71	63 36.00	21 12.00	175 100.00
PRIOR PROBABILITY	0.2000	0.2000	0.2000	0.2000	0.2000	

Footprint Basis
Management Group = TB
20 July 1981

NUMBER OF OBSERVATIONS AND PERCENTS

MANAGE-MENT	1	2	3	4	6	7	8	TOTAL
1	7 58.33	0 0.00	0 0.00	3 25.00	1 8.33	1 8.33	0 0.00	12 100.00
2	15 39.47	0 0.00	0 0.00	11 28.95	3 7.89	7 18.42	2 5.26	38 100.00
3	9 52.94	0 0.00	0 0.00	7 41.18	0 0.00	0 0.00	1 5.88	17 100.00
4	0 0.00	0 0.00	0 0.00	2 100.00	0 0.00	0 0.00	0 0.00	2 100.00
6	18 48.65	0 0.00	0 0.00	5 13.51	6 16.22	5 13.51	3 8.11	37 100.00
7	3 23.08	0 0.00	0 0.00	3 23.08	0 0.00	6 46.15	1 7.69	13 100.00
8	15 26.79	0 0.00	0 0.00	22 39.29	0 0.00	10 17.86	9 16.07	56 100.00
TOTAL PERCENT	67 38.29	0 0.00	0 0.00	53 30.29	10 5.71	29 16.57	16 9.14	175 100.00
PRIOR PROBABILITY		0.1429	0.1429	0.1429	0.1429	0.1429	0.1429	0.1429

Footprint Basis
General Group Soil = TB
20 July 1981

NUMBER OF OBSERVATIONS AND PERCENTS

ACTUAL GENERAL GROUP SOIL	1	2	3	4	7	TOTAL
1	13 25.49	11 21.57	8 15.69	15 29.41	4 7.84	51 100.00
2	6 13.64	25 56.82	6 13.64	6 13.64	1 2.27	44 100.00
3	24 31.58	31 40.79	9 11.84	8 10.53	4 5.26	76 100.00
4	1 50.00	0 0.00	0 0.00	1 50.00	0 0.00	2 100.00
7	1 50.00	0 0.00	1 50.00	0 0.00	0 0.00	2 100.00
TOTAL PERCENT	45 25.71	67 38.29	24 13.71	30 17.14	9 5.14	175 100.00
PRIOR PROBABILITY	0.2000	0.2000	0.2000	0.2000	0.2000	

Footprint Basis
Slope = TB
20 July 1981

NUMBER OF OBSERVATIONS AND PERCENTS

ACTUAL SLOPE	1	2	TOTAL
1	74 49.33	76 50.67	150 100.00
2	13 54.17	11 45.83	24 100.00
3	0 0.00	1 100.00	1 100.00
TOTAL PERCENT	87 49.71	88 50.29	175 100.00
PRIOR PROBABILITY	0.5000	0.5000	

Footprint Basis
Hydrologic Group = TB
20 July 1981

NUMBER OF OBSERVATIONS AND PERCENTS

ACTUAL HYDRO-LOGIC GROUP	2	3	4	TOTAL
1	0 0.00	0 0.00	1 100.00	1 100.00
2	63 52.07	9 7.44	49 40.50	121 100.00
3	4 57.14	0 0.00	3 42.86	7 100.00
4	9 19.57	8 17.39	29 63.04	46 100.00
TOTAL PERCENT	76 43.43	17 9.71	82 46.86	175 100.00
PRIOR PROBABILITY	0.3333	0.3333	0.3333	

APPENDIX E

Linear discriminant analysis results on a field basis

Field Basis
Water Table Contour = TB, TIR
17 July 1981

NUMBER OF OBSERVATIONS AND PERCENTS
CLASSIFIED INTO WATER TABLE CONTOURS

Actual Water Table Contour Class	Water Table Contour Class 1	Water Table Contour Class 2	Water Table Contour Class 3	Water Table Contour Class 4	Water Table Contour Class 5	TOTAL
1	2 50.00	0 0.00	1 25.00	0 0.00	1 25.00	4 100.00
2	13 27.08	14 29.17	2 4.17	15 31.25	4 8.33	48 100.00
3	9 37.50	6 25.00	3 12.50	4 16.67	2 8.33	24 100.00
4	0 0.00	1 50.00	0 0.00	1 50.00	0 0.00	2 100.00
5	2 18.18	2 18.18	2 18.18	3 27.27	2 18.18	11 100.00
TOTAL PERCENT	26 29.21	23 25.84	8 8.99	23 25.84	9 10.11	89 100.00
PRIOR PROBABILITY	0.2000	0.2000	0.2000	0.2000	0.2000	

Field Basis
Land Use = TIR
20 May 1981

NUMBER OF OBSERVATIONS AND PERCENTS

LAND USE	1	2	3	5	6	TOTAL
1	4 57.14	0 0.00	1 14.29	2 28.57	0 0.00	7 100.00
2	0 0.00	0 0.00	4 66.67	1 16.67	1 16.67	6 100.00
3	3 11.54	0 0.00	19 73.08	1 3.85	3 11.54	26 100.00
5	10 38.46	2 7.69	4 15.38	6 23.08	4 15.38	26 100.00
6	7 18.92	8 21.62	10 27.03	5 13.51	7 18.92	37 100.00
TOTAL	24 23.53	10 9.80	38 37.25	15 14.71	15 14.71	102 100.00
PRIOR PROBABILITY	0.2000	0.2000	0.2000	0.2000	0.2000	

Field Basis
Land Use = TIR
20 July 1981

NUMBER OF OBSERVATIONS AND PERCENTS

LAND USE	1	2	3	5	6	TOTAL
1	5 62.50	2 25.00	0 0.00	1 12.50	0 0.00	8 100.00
2	1 16.67	4 66.67	1 16.67	0 0.00	0 0.00	6 100.00
3	8 21.05	12 31.58	18 47.37	0 0.00	0 0.00	38 100.00
5	23 51.11	8 17.78	6 13.33	0 0.00	8 17.78	45 100.00
6	24 51.06	9 19.15	6 12.77	1 2.13	7 14.89	47 100.00
TOTAL PERCENT	61 42.36	35 24.31	31 21.53	2 1.39	15 10.42	144 100.00
PRIOR PROBABILITY	0.2000	0.2000	0.2000	0.2000	0.2000	

Field Basis
Land Use = TB, TIR
20 July 1981

NUMBER OF OBSERVATIONS AND PERCENTS

LAND USE	1	2	3	5	6	TOTAL
1	3 50.00	1 16.67	0 0.00	2 33.33	0 0.00	6 100.00
2	0 0.00	1 50.00	0 0.00	1 50.00	0 0.00	2 100.00
3	1 3.70	4 14.81	16 59.26	5 18.52	1 3.70	27 100.00
5	7 21.88	4 12.50	5 15.63	11 34.38	5 15.63	32 100.00
6	6 19.35	8 25.81	3 9.68	10 32.26	4 12.90	31 100.00
TOTAL PERCENT	17 17.35	18 18.37	24 24.49	29 29.59	10 10.20	98 100.00
PRIOR PROBABILITY	0.2000	0.2000	0.2000	0.2000	0.2000	

Field Basis
Land Use = TIR
11 August 1981

NUMBER OF OBSERVATIONS AND PERCENTS

LAND USE	1	2	3	5	6	TOTAL
1	2 25.00	0 0.00	4 50.00	0 0.00	2 25.00	8 100.00
2	0 0.00	0 0.00	4 66.67	0 0.00	2 33.33	6 100.00
3	0 0.00	0 0.00	33 84.62	5 12.82	1 2.56	39 100.00
5	0 0.00	0 0.00	20 46.51	18 41.86	5 11.63	43 100.00
6	2 4.26	0 0.00	9 19.15	20 42.55	16 34.04	47 100.00
TOTAL PERCENT	4 2.80	0 0.00	70 48.95	43 30.07	26 18.18	143 100.00
PRIOR PROBABILITY	0.2000	0.2000	0.2000	0.2000	0.2000	