

Miscellaneous Report 153—1979

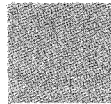
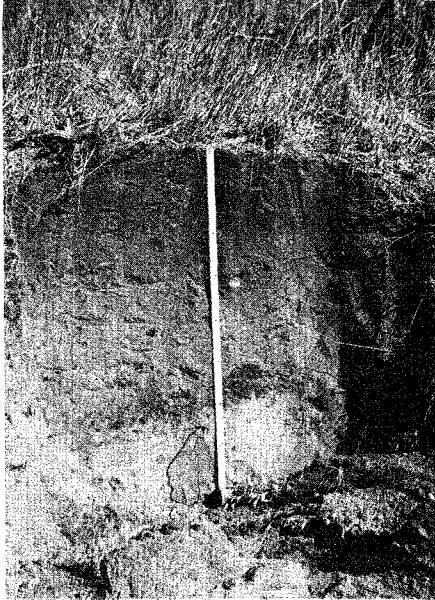
MINNESOTA
SOIL ATLAS

st. cloud
sheet

Agricultural Experiment Station
University of Minnesota

A typical landscape on the Fergus Falls Till Plain. ▶

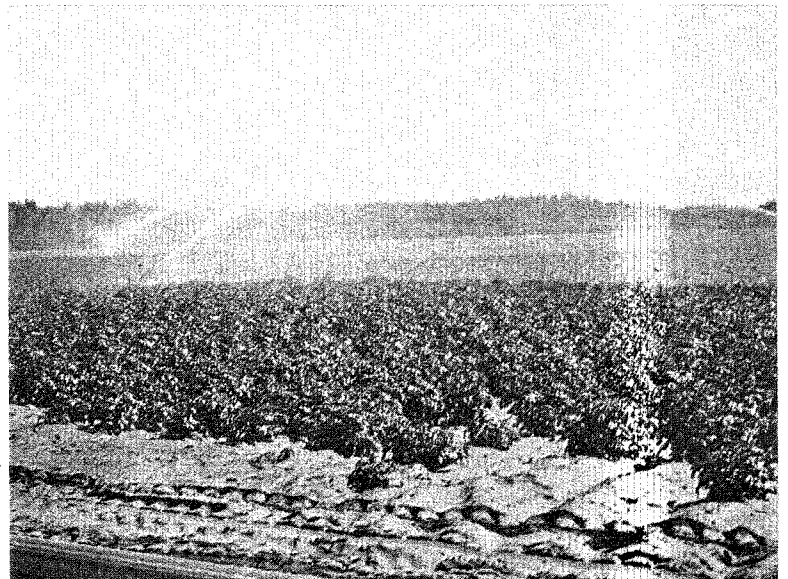
Sandy soils such as this Hubbard soil are extensive in the St. Paul Sheet area of central Minnesota. These are shown as yellow and gold on the map.

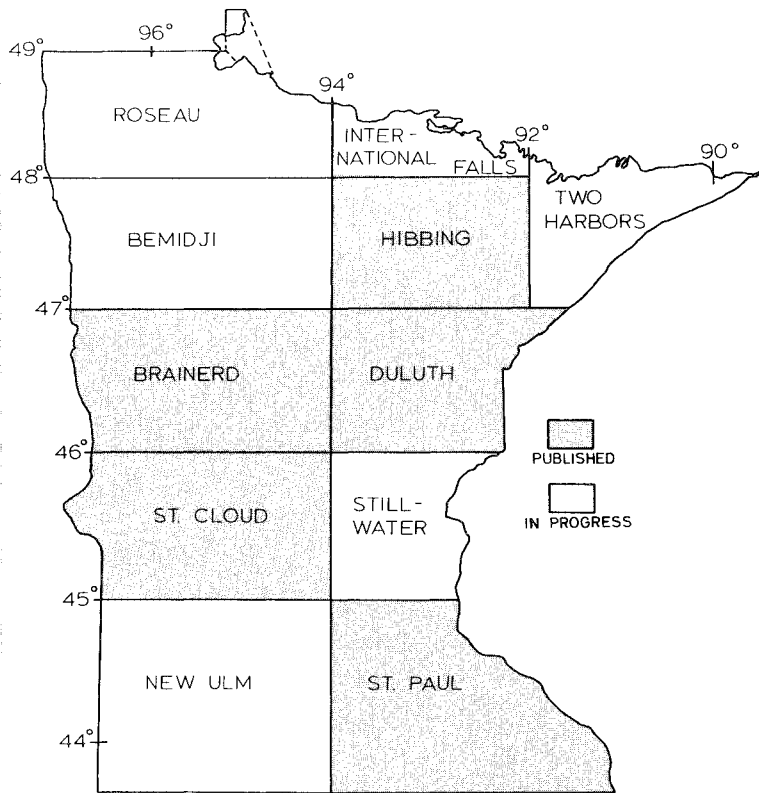


Dairy herds allow efficient use of the extensive hay and pasture land of this part of the state.

▲
Lakes of all sizes are numerous in this part of Minnesota. The three largest lakes in the St. Cloud Sheet are Minnewaska in Pope County, Osakis in Todd and Douglas counties, and Green Lake in Kandiyohi County. Green Lake is near St. John's University at Collegeville.

Potatoes are grown in two main areas in Minnesota: in the Red River Valley and on sandy Mississippi terrace soils. From 18 to 22 inches of water are required per year by potatoes so irrigation is essential on sandy soils. ▶





CONTENTS

PAGE

Introduction, How the Map Was Prepared	4
Agassiz Lacustrine Plain, Red River Valley (1)	5
Fergus Falls Till Plain (2)	7
Graceville Till Plain (2E)	9
Alexandria Moraine Complex (3)	10
Todd Drumlin Area (7B)	13
Park Rapids-Staples Outwash Plain (8)	15
St. Croix Moraine Complex (9)	17
Darling Drumlin Area (10B)	19
Brainerd-Pierz Drumlin Area (10C)	21
Crow Wing Outwash Plain (13)	23
Mississippi Valley Outwash (29)	25
Minnesota Valley Outwash (32)	27
Waconia-Waseca Moraine (34)	28
Benson Lacustrine Plain (50)	30
Big Stone Moraine (51)	32
Osakis Till Plain (55)	34
Belgrade-Glenwood Outwash Plain (63)	36
Olivia Till Plain (64)	38
Olivia Till Plain, Clayey (64A)	39
Appleton-Clontarf Outwash Plain (65)	41
Blue Earth Till Plain, Undulating (66)	43
Development of Landforms in the St. Cloud Sheet Area ..	45
Climate of the St. Cloud Sheet Area	46
Information for the Engineer	52
Appendix—Short Description of Soil Series Classified in the Subgroup Category	53
Selected References	57
Water Resources—Surface and Ground Water in the St. Cloud Sheet Area	59
Glossary	62

Acknowledgement

The Department of Soil Science, University of Minnesota in cooperation with the Soil Conservation Service, U.S. Department of Agriculture, and the Minnesota Geological Survey prepared this Minnesota Soil Atlas—St. Cloud Sheet, fifth in a series of eleven covering the entire state. Already published are the Brainerd Sheet, Miscellaneous Report 90 (1969); Hibbing Sheet, Miscellaneous Report 110 (1971); St. Paul Sheet, Miscellaneous Report 120 (1973); and Duluth Sheet, Miscellaneous Report 148 (1978). R.A. Erickson, R.H. Rust, J.C. Harries, and L.D. Hanson did the field work, map, and report. J.E. Cummins, Soil Conservation Service, prepared the geomorphic area delineations. H.E. Wright, Jr. and C.L. Matsch, Department of Geology, University of Minnesota, gave technical assistance.

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Introduction

Information is lacking on the soils and landscape characteristics of large areas of Minnesota. Many planning agencies simply have to go without information needed for their work. Detailed soil surveys published on a scale of 1:20,000 or 1:15,480 are being made by the United States Department of Agriculture (USDA) Soil Conservation Service (SCS) in cooperation with the Minnesota Agricultural Experiment Station to fill this need. Because they cannot be supplied rapidly enough for broad planning, the Soil Atlas is being developed. It is not intended to replace detailed soil survey reports, which are essential for planning the use of smaller pieces of land. Detailed soil survey work, where available, has been assembled and supplemented to compile the St. Cloud Sheet of the Minnesota Soil Atlas.

Until detailed soil surveys are available for all Minnesota counties, broad planning can be facilitated by the eleven sheets to be published in the Minnesota Soil Atlas series (see inside cover). As detailed soil surveys become available, the broad view of large planning will still be necessary. It is proposed that this series of maps be published with explanatory texts for each sheet in the state. For uniformity the Atlas Sheets are being published on the same scale as the U.S. Geological Survey topographic maps and other maps prepared by the Minnesota Geological Survey. The St. Cloud Sheet contains the St. Cloud quadrangle and part of the Milbank quadrangle.

The St. Cloud Sheet encompasses approximately 5,567,874 acres in west-central Minnesota from 45° to 46° N. latitude and from 90° W. longitude to the state border with the Dakotas.

How the Map Was Prepared

The base map was prepared from the St. Cloud quadrangle and part of the Milbank quadrangle, by the U.S. Geological Survey, Department of Interior. The scale of 1:250,000 or about 1/4 inch to 1 mile makes it possible to show areas as small as 1 square mile. Contour intervals of 50 feet indicate some of the topography.

Soil landscape delineations were developed from detailed soil surveys where available. Field work was necessary when no detailed soil survey existed.

Attempting to provide a generalized map for the user with a minimum soils knowledge, soils are grouped into soil landscape units based on the following factors:

1. Texture of the soil material below 5 feet into sandy (S); loamy or silty (L); clayey (C); mixed sandy and loamy (X); mixed silty or loamy and clayey (Y); and bedrock (R).
2. Texture of the material above 5 feet, or a significant part of it, into sandy (S); loamy or silty (L); and clayey (C).
3. Drainage with moderately well, well, and excessively drained designated (W); and somewhat poorly, poorly, and very poorly drained designated (P). Units with (W) designation will normally have water tables below the rooting zone and units with (P), water tables commonly within the rooting zone.
4. Color of the surface soil with dark color designated (D); and light color designated (L).

Thus, the Nebish* series would appear on the map as LLWL and would be interpreted from the map as a light-colored, well-drained loamy soil over loamy material (in this instance loamy glacial till). Flak, Mora, and Hayden would also occur in this landscape unit in the St. Cloud Sheet area.

Some areas on the map do not have a four-letter symbol of a soil landscape unit. These are areas of organic soils which are shown with two-letter symbols. The first letter relates to the nature of the material below the rooting zone—acid (A) or non-acid (N) if organic and (C), (L), or (S) as previously defined for mineral soils.

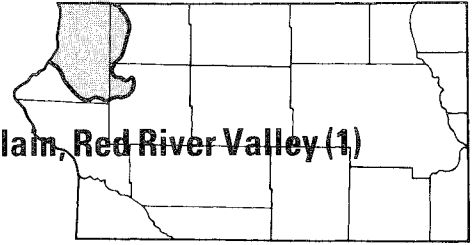
Twenty-one geomorphic areas are delineated to illustrate broad physiographic features and to provide some identification of parent materials on which the soils have developed (table 1). Several geomorphic areas will extend into adjoining Atlas Sheets. Soil landscape units are mostly delineated within the geomorphic areas. The soil series which occur within a soil landscape unit commonly differ among geomorphic areas. Principal soil series, when known, are included in tables.

* Brief descriptions of named soils in the region are in appendix.

Table 1. Acreage estimates of geomorphic areas within the St. Cloud Sheet

No.	Name	Acres	Percent of sheet
1	Agassiz Lacustrine Plain, Red River Valley	340,500	6.1
2	Fergus Falls (Young Gray Drift), Till Plain	376,120	6.7
2E	Graceville Till Plain, clayey	136,320	2.4
3	Alexandria Moraine Complex	998,120	18
7B	Todd Drumlin Area	37,620	0.7
8	Park Rapids—Staples Outwash Plain	40,340	0.7
9	St. Croix Moraine Complex, loamy, rolling to hilly	428,200	7.7
10B	Darling Drumlin Area	174,880	3.1
10C	Brainerd—Pierz Drumlin Area, loamy	144,680	2.6
13	Crow Wing Outwash Plain, sandy	138,970	2.5
29	Mississippi Valley Outwash	156,630	2.8
32	Minnesota Valley Outwash	48,070	0.9
34	Waconia—Waseca Moraine, loamy rolling	204,100	3.7
50	Benson Lacustrine Plain, silty	262,190	4.7
51	Big Stone Moraine, loamy	544,690	9.8
55	Osakis Till Plain, loamy	474,600	8.5
63	Belgrade—Glenwood Outwash Plain, undulating	319,610	5.7
64	Olivia Till Plain	210,380	3.5
64A	Olivia Till Plain, clayey	81,980	1.5
65	Appleton—Clontarf Outwash Plain, undulating	244,800	4.4
66	Blue Earth Till Plain, undulating, loamy	204,430	3.7

Agassiz Lacustrine Plain, Red River Valley (1)



This region contains approximately 340,500 acres or 6.1 percent of the St. Cloud Sheet.

It is in the southern segment of a large depressed plain, formerly occupied by Glacial Lake Agassiz. Although the plain is nearly level, a micro-relief exists with the variation in elevation generally being less than 1 foot. As the southern outlet eroded to lower levels the lake level lowered. At each lower stage beach lines were formed. In the St. Cloud Sheet the lake occupied four definite stages and formed beach lines at each level. The first and highest was the Herman stage at 1,060 feet above sea level, Norcross at 1,040 feet, Tintah at 1,020, and Campbell at elevation 980 feet. During the Campbell stage only a small part of the lake remained in the St. Cloud Sheet. Depth to seasonally high water table in most of the region is less than 3 feet. Three small lakes, each 160 acres or more in areas, and part of Lake Traverse are located in the region. The total water area is 2,613 acres.

Wave action in the large shallow body of water modified the upper 1 to 2 feet of till. Lacustrine sediments generally are over 3 feet thick in the units mapped CCPD and CLPD and in the LLWD areas located in Traverse County.

Approximately 30 percent of the region consists of alkaline soils. The alkalinity has a tendency to reduce availability of zinc and iron for crop use. Some crops are more susceptible to these deficiencies than others. Field corn is the crop most likely to be zinc deficient. Soybeans, flax, and some species of trees and shrubs are susceptible to iron deficiencies. Gypsum crystals are commonly present at depths of 2 to 4 feet.

The original vegetation was mostly tall prairie grass. Some northern hardwoods, mostly elm, cottonwood, basswood, and boxelder, border some streams. The main crops are wheat, barley, soybeans, corn, and sunflowers. Very little land remains in pasture or woods.

Nine soil landscape units are mapped in the region: LLPD, CCPD, LLWD, CLPD, A, CCWD, SLWD, SSWD, and YLPD. Table 2 lists selected features of the units. Additional information follows:

LLPD— Texture in 15 to 25 percent of the unit is clayey. These areas occur as inclusions (minor soil landscape units too small to map). Boundaries between units delineated as LLPD and CCPD in many places are very gradual and indistinct. This is especially true along the border area between the St. Cloud and Brainerd Sheets. Also

included are 5 to 10 percent somewhat poorly to moderately well-drained soils, 5 to 10 percent silt loams and 5 to 10 percent having a coarser horizon 10 to 20 inches thick in the upper 3 foot section. Fifteen to 25 percent of the unit consists of limy soils. (Typic Haplaquolls)

CCPD— Included in this unit are soils containing numerous areas 20 to 50 feet in diameter, having a grayish, silty, medium to slightly acid horizon, 6 to 15 inches thick below the surface. Fine clay lacustrine sediments occur below the gray layer. These small areas total about 10 percent of the unit. In the large CCPD area in Traverse County south of Wheaton, small patches 10 to 15 feet in diameter consist of poorly structured surface soils and fine clay subsoil and substrata. Water permeability is very slow. During wet periods water interferes considerably with tillage operations. Included are small areas of loamy and silty soils. Approximately 30 percent is limy soil. (Vertic Haplaquolls)

LLWD—Most of the soil in the unit is limy. In 5 to 10 percent of the unit clayey sediments occur within depths of 2 to 4 feet. Another 5 to 10 percent are poorly drained. (Aeric Calciaquolls)

CLPD— The unit includes 10 to 15 percent with loamy substrata. About 10 percent is better drained. (Typic Calciaquolls)

A— The unit includes some very poorly drained soils. (Not classified)

CCWD—Included are 10 to 15 percent poorly and very poorly drained and 10 to 15 percent loamy soils. (Udertic Haploborolls)

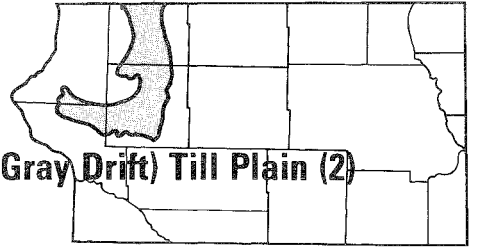
SLWD—Sand and gravel occur within 15 inches of the surface in 15 to 30 percent of the unit. Ten to 15 percent is poorly drained. (Pachic Udic Haploborolls and Udic Haploborolls)

SSWD—About 10 percent is sandy in the substrata. Another 10 percent is poorly drained. (Udorthentic Haploborolls)

YLPD— Soil texture below 24 to 36 inches is intermixed loamy and clayey. (Typic Haplaquolls and Vertic Haplaquolls)

Table 2. Selected features of soil landscape units within the Agassiz Lacustrine Plain, Red River Valley (1) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LLPD	61	nearly level lake plain	loam, clay loam, and silty clay loam (4)	loam, clay loam and silty clay loam (4-20+)	8-12	poorly drained	6.8-7.6	low	medium	Roliss
CCPD	18	nearly level lake plain	silty clay to clay (3-4)	silty clay to clay (4-20+)	8-12	poorly drained	6.6-7.8	low	high to very high	Fargo Hegne
LLWD	12	nearly level lake plain	silt loam (4)	silt loam to silty clay loam (4+)	8-12	moderately well to somewhat poorly drained	7.6-8.2	low	high	Bearden
CLPD	2	nearly level lake plain	fine sandy loam, loam and silt loam (2-4)	silty clay loam to silty clay (4+)	8-12	poorly drained	7.6-8.2	low	medium	Unnamed
A	2	nearly level stream bottoms	variable: sandy loam, loam, and silty clay loam (2-4)	variable: sandy loam, loam and silty clay loam (4+)	4-12	poorly drained	6.1-7.2	low	medium	Alluvial land Lamoure
CCWD	1	nearly level lake plain	silty clay to clay (4)	clay to silty clay (4+)	8-12	moderately well drained	6.4-7.4	low	high	Nutley
SLWD	1	nearly level to sloping outwash and beaches	sandy loam to loam (2-3)	sand and gravel (3-4+)	4-8	well drained	6.6-7.8	high	medium	Fordville Arvilla
SSWD	1	gently sloping beaches	sandy loam to gravelly sandy loam (1-2)	sand and gravel (2-4+)	4	well drained	6.6-7.8	high	low	Sioux Arvilla
YLPD	1	nearly level lake plain	loam, clay loam, and silty clay (2-4)	silty clay, silty clay loam, and clay loam (4+)	8-12	poorly drained	6.8-7.6	low	medium to high	Roliss Fargo
Water	1									



Fergus Falls (Young Gray Drift) Till Plain (2)

The region covers approximately 376,120 acres or 6.7 percent of the St. Cloud Sheet.

The plain is dominantly undulating to gently rolling. Bordering most lakes the topography is more rolling. A large nearly level area occurs in the southwestern part of the region. This area is poorly drained and mapped LLPD. Small marshes and pot holes are common. Seasonal high water tables are more than 5 feet deep on well-drained soils and less than 5 feet on poorly drained soils. Thirty-five lakes, each 160 acres or more in size and totaling 14,856 acres, occur in the region.

The till covering the region is loamy and calcareous. Several clayey areas are located here. Most occur along the Pomme de Terre River, in Stevens County, north of Morris.

This region was originally covered by tall prairie grass. Northern hardwoods border some lakes and streams. These were mainly elm, basswood, cottonwood, and ash. The principal crops are wheat, corn, oats, some soybeans, and hay (brome grass, alfalfa). Five to 10 percent is pasture and less than 5 percent is wooded. About 90 percent is cropland.

Seven soil landscape units are mapped: LLWD, LLPD, CCWD, CCPD, A, SLWD, and SLPD. Table 3 lists selected characteristics of the units. Additional information follows.

LLWD—An estimated 70 percent of the unit has well-drained soils, 20 percent has moderately well drained, and 10 percent has poorly to very poorly drained. Fifteen to 25 percent is limy to the surface. The unit includes less than 5 percent sandy, gravelly, and clayey soils. The till contains a relatively high percent silt in places, especially in parts of Grant County. A thin silt cap occurs in places. (Udic Haploborolls)

LLPD—The large area in the southwest part of the region and some areas bordering region (1) show some influence of water working. The unit includes 10 to 15 percent moderately well-drained soils, 15 to 20 percent limy, and about 5 percent shallow peat. Approximately 10 percent of the unit has very poorly drained soils. About 15 percent is clayey. (Typic Haplaquolls)

CCWD—An estimated 10 percent is loamy, 10 percent poorly drained, and 5 percent limy. (Udertic Haploborolls)

CCPD—Approximately 10 percent is moderately well drained and 10 percent very poorly drained. Another 5 to 15 percent is loamy. (Typic Haplaquolls)

A— These flood plains are subject to frequent overflows. (Not classified).

SLWD—The unit includes some upland loamy soils and gravelly soils. (Udic Haploborolls)

SLPD—Included is some loamy and some gravelly soil. (Typic Haplaquolls)

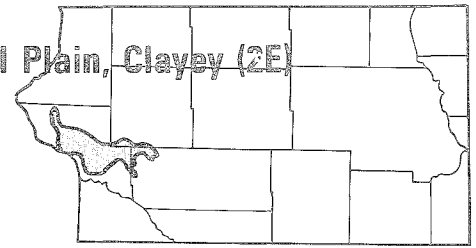


The soil landscape unit designation for this loamy soil developed under a mixed forest and prairie vegetation is LLWD.

Table 3. Selected features of soil landscape units within the Fergus Falls (Young Gray Drift) Till Plain (2) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LLWD	67	undulating upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	well to moderately well drained	6.6-7.5	low	high	Barnes Langhei Hamerly Svea
LLPD	25	gently sloping to depressional upland	loam, clay loam, and silty clay loam (4)	loam clay loam, and silty clay loam (4-20+)	8-12	poorly to very poorly drained	6.6-7.8	low	medium	Flom Vallers Quam
CCWD	2	gently sloping lake plain	silty clay to clay (4)	silty clay to clay (4+)	8-12	moderately well drained	6.4-7.2	low	high	Nutley Hattie
CCPD	1	gently sloping to depressional	silty clay to clay (4)	silty clay to clay (4+)	8-12	poorly to very poorly drained	6.4-7.2	low	medium	Fulda Dovray
A	1	nearly level stream bottoms	variable: loamy sand to loam (2-4)	variable: loamy sand to loam (4+)	4-12	poorly drained	6.1-7.2	low	medium	Alluvial land
SLWD	<1	level to depressional	sandy loam to loam (2-3)	sand and gravel (3-4+)	4-8	somewhat poorly to very poorly drained	6.6-7.8	high	medium	Renshaw
SLPD	<1	level to depressional	sandy loam to loam (2-3)	sand and gravel (3-4+)	4-8	somewhat poorly to poorly drained	6.6-7.8	high	medium	Forada Hangaard
Water	4									

Graceville Till Plain, Clayey (2E)



The plain includes approximately 136,320 acres or 2.4 percent of the St. Cloud Sheet.

The region consists of a nearly level to gently rolling till plain. It includes some rolling topography. Numerous small marshes and potholes occur in the western two-thirds of the region, but are less common in the eastern third. Ten lakes, each 160 acres or more and totaling approximately 8,069 acres, are located here. The water table is normally over 6 feet deep on the higher positions and above the surface to 6 feet deep in lower positions.

The clayey sediments may have been transported from Glacial Lake Agassiz by glacial action.

This region was originally prairie vegetation. Present estimated land use is about 90 percent under cultivation, 5 to 10 percent pasture, and less than 5 percent forest. The main crops are corn, soybeans, wheat, and oats.

Six soil landscape units are mapped: CCWD, LLWD, CCPD, LLPD, SLWD, and M. Table 4 gives selected features of the units. Additional information follows:

CCWD—Twenty-five to 35 percent of the unit consists of limy soils. It includes 10 to 20 percent poorly and

very poorly drained and 5 to 15 percent loamy soils. (Udertic Haploborolls)

LLWD—The unit includes 10 to 20 percent poorly drained soils with some marshy areas and about 5 percent limy soils. (Pachic Udic Haploborolls)

CCPD—Approximately 5 percent is marshy. The unit includes 15 to 25 percent moderately well-to well-drained soils. About 10 percent is loamy. (Typic Haplaquolls)

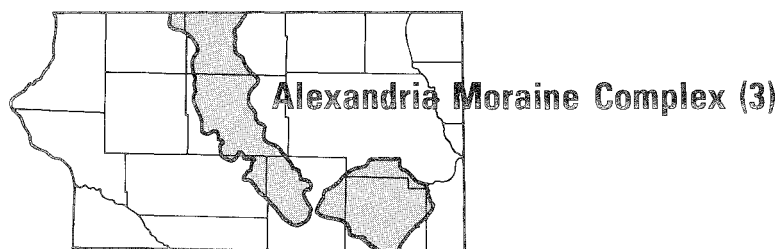
LLPD—The unit includes approximately 10 percent moderately well-drained, 10 percent clayey, and 5 percent very poorly drained soils. (Typic Haplaquolls)

SLWD—Included are small areas of gravelly and deep sandy soils. (Udic Haploborolls)

M—Some poorly drained soils are included.

Table 4. Selected features of soil landscape units within the Graceville Till Plain, clayey (2E) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
CCWD	43	undulating upland	silty clay to clay (4)	silty clay to clay (4+)	8-12	moderately well to well drained	6.4-7.4	low	high	Nutley Hattie
LLWD	27	nearly level to gently rolling upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	moderately well to well drained	6.2-7.4	low	high	Aastad Svea Forman
CCPD	19	gently sloping to depressional lake plain	silty clay to clay (4)	silty clay to clay (4+)	8-12	poorly to very poorly drained	6.4-7.4	low	medium	Fulda Dovray
LLPD	5	gently sloping to depressional upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	poorly to very poorly drained	6.6-7.4	low	medium	Flom
SLWD	<1	level to gently rolling outwash	sandy loam to loam (2-3)	sand and gravel (3-4+)	4-8	well drained	6.6-7.8	high	medium	Renshaw Fordville
M	<1	low lying depressions	peat or mineral soil	peat or mineral soil	1-4 feet of water on surface	marshy				
Water	6									



The region contains approximately 998,120 acres or 18 percent of the St. Cloud Sheet.

It is a prominent moraine which in many places has elevation 100 feet or higher than in bordering regions. The land form is a rolling to hilly knob and kettle type containing many small bogs and depressions. The water table is normally deeper than 10 feet on knobs and slopes. On marshes, peat bogs, and poorly drained positions, the water table occurs at the surface to 6 feet deep. The region contains 157 lakes, each 160 acres or more and totaling approximately 85,688 acres.

The region consists mainly of loamy till, but includes several sandy outwash areas. Most of them occur east of Green Lake. In the region's eastern part some areas consist of an intermixture of till, sand, and gravel. Several relatively small clayey areas occur throughout the region. Glacial stones are fairly common. Most of them have been removed on cultivated land.

Regarding native vegetation, the northern and eastern parts of the region consisted originally of oak and areas of scattered oak trees. In the rest of the region, tall prairie grass dominated. The present land use is mainly 50 to 55 percent cultivated land, 20 to 25 percent pasture, 15 to 25 percent woodland, and 5 to 10 percent marsh and peat. The marshes and peat areas are habitat for wildlife. Principal crops are corn, oats, and hay (brome grass, alfalfa).

Eighteen soil landscape units are mapped in the region: LLWD, LLLPD, SLWD, NP, XLWL, LLWL, SLPD, CCWD, A, SSWD, LP, M, XLWD, LCWD, LSWL, SP, SLWL, and SSWL. Table 5 lists selected characteristics of the units. Additional information follows:

- LLWD— The unit includes 5 to 10 percent poorly to very poorly drained soils and less than 5 percent each of clayey, peat, and sandy to gravelly soils. It also includes small amounts of light-colored soils. (Udic Haploborolls)
- LLPD— An estimated 5 to 15 percent of the unit has moderately well-drained soils. Another 5 to 15 percent has very poorly drained soils and 5 percent has organic soils. (Typic Haplaquolls)
- SLWD— Included are 10 to 20 percent sandy, gravelly, and shallow loamy soils over sand and gravel. Five to 10 percent is poorly drained. (Typic Hapludolls)
- NP— Approximately 15 percent of the unit consists of shallow peat, 10 percent consists of poorly and very poorly drained mineral soils, and 5 percent has moderately well-drained soils. (Euic Typic Borosaprists)
- XLWL— Approximately 40 percent of the unit has well-drained loamy soils and 35 percent has well-drained sandy and gravelly soils. Inclusions

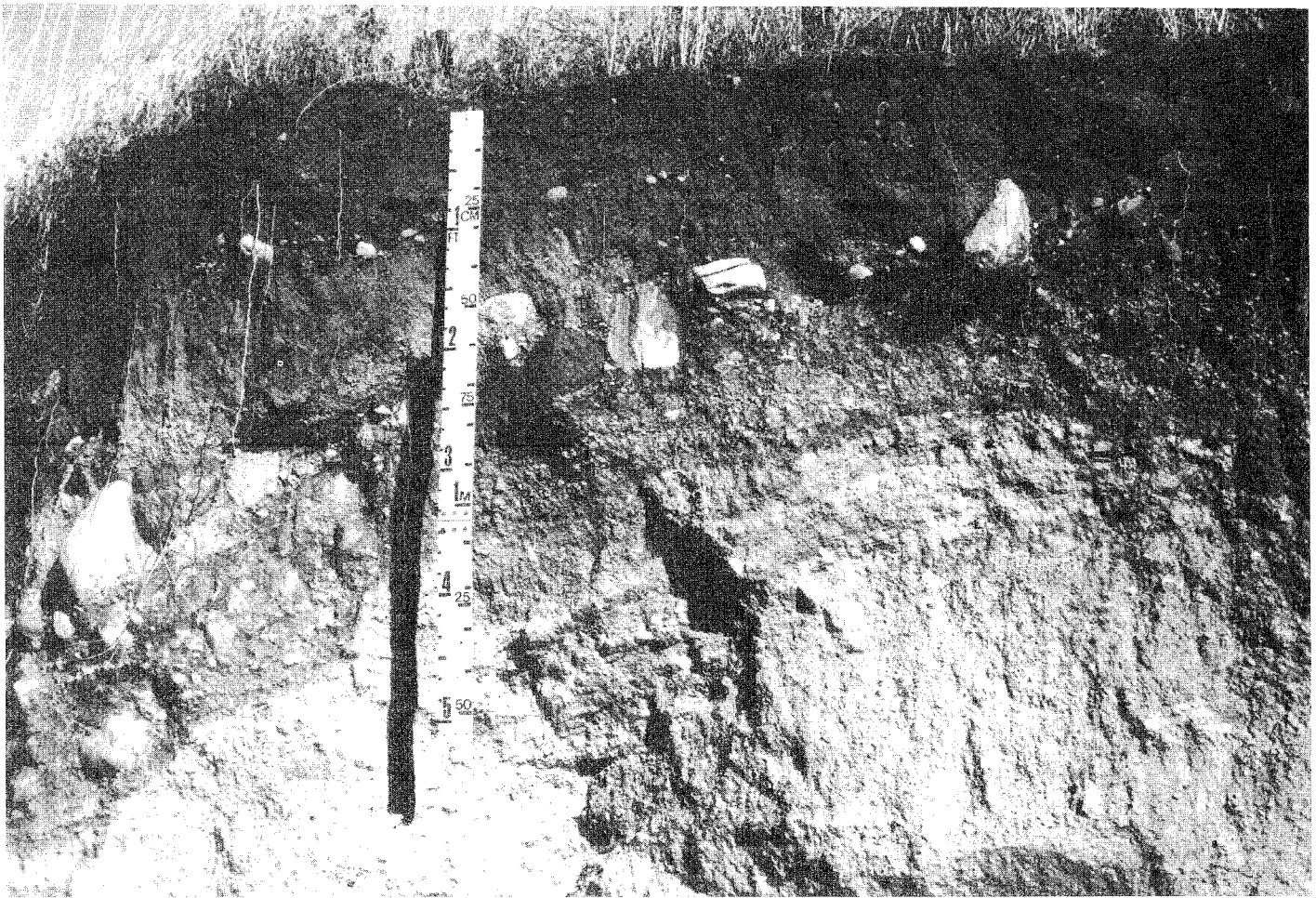
are about 10 percent sandy over loamy, 5 percent poorly drained, 5 percent shallow peat soils, and 5 percent marshy areas. (Typic Hapludalfs)

- LLWL— Moderately well-drained soils make up about 5 percent of the unit; 5 percent, each, is dark colored, sandy and gravelly; organic and marshy, and poorly drained. (Typic Hapludalfs)
- SLPD— The unit includes approximately 10 percent moderately well and well-drained soils, 10 percent shallow to sand and gravel and coarse textured, and 5 percent shallow organic soils. (Typic Haplaquolls)
- CCWD— Included with this unit is 5 to 10 percent loamy soil, 5 to 10 percent poorly and very poorly drained clayey, and 5 percent loamy poorly drained to marshy. (Pachic Udic Haploborolls)
- A— About 10 percent of this unit has organic soils. Well-drained upland soils areas make up another 5 percent. (Not classified)
- SSWD— Included with this unit is about 10 percent loamy over 20 inches thick over sand and gravel. Another 5 percent is poorly drained and 5 percent is shallow organic and marshy soils. (Entic Hapludolls)
- LP— Included is 5 to 10 percent poorly and very poorly drained mineral soils, 5 to 10 percent deep organic, and about 5 percent moderately well-drained soil. (Terric Borosaprists)
- M— This unit includes some organic and some mineral soils.
- XLWD— About 40 percent of this unit consists of well-drained loamy soils and 30 percent sandy and gravelly soils. It includes about 5 percent poorly drained and 5 percent shallow organic and marshy soils. (Typic Hapludolls)
- †LCWD— Approximately 10 percent of the unit has deep loamy soils and 5 percent has poorly drained soils. (Aquic Hapludolls) (Incorrectly mapped as CLWD)
- LSWL— About 10 percent of the unit has loamy soils and 10 percent has deep sandy soils. (Arenic Eutrochrepts or possibly Eutroboralfs)
- SP, SLWL, and SSWL are minor units.

†The soil landscape unit, CLWD, which occurs in this region has an incorrect symbol and color on the map. The correct symbol is LCWD and the color should correspond with the symbol.

Table 5. Selected features of soil landscape units within the Alexandria Moraine Complex (3) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LLWD	67	rolling to hilly upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	well drained	6.2-7.4	low	medium to high	Waukon, Barnes Langhei Clarion Lester
LLPD	6	gently sloping to depressional upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	poorly to very poorly drained	6.6-7.8	low	low to medium	Webster Flom
SLWD	5	level to rolling outwash	sandy loam to loam (2-3)	sand and gravel (3-4+)	4-8	well drained	5.6-7.3	high	low to medium	Estherville Renshaw
NP	3	low lying depressions	peat (3)	peat (3-4+)	12+	very poorly drained	5.4-7.3	low	low	Sellyville Rifle
XLWL	2	rolling to hilly upland	loam, clay loam and sandy loam (2-3)	loam, clay loam sand and gravel (3-20+)	4-12	well drained	5.1-6.5	medium	low to medium	Hayden Burnsville
LLWL	2	rolling to hilly upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	well drained	5.1-6.5	medium	medium	Hayden
SLPD	1	nearly level to depressional	sandy loam to loam (2-3)	sand and gravel (3-4+)	4-8	poorly drained	6.1-7.3	low	low	Biscay Unnamed Forada
CCWD	1	gently sloping upland	silty clay to clay (4)	silty clay to clay (4+)	8-12	moderately well drained	6.5-7.2	low	high	Sinal
A	1	nearly level stream bottoms	variable: loamy sand to loam (2-4)	variable: loamy sand to loam (4+)	4-12	poorly drained	6.1-7.2	low	medium	Alluvial land
SSWD	1	level to rolling outwash	gravelly sandy loam to sandy loam (1-2)	sand and gravel (2-4+)	4	well-drained	6.2-7.8	high	low	Salida Sioux Hubbard
LP	1	low lying depressions	peat (1-4)	loam to clay loam (4+)	8+	very poorly drained	5.5-7.3	low	low	Cathro
M	1	low lying depressions	peat or mineral soil	peat or mineral soil	1-4 feet of water on surface	marshy				
XLWD	<1	rolling to hilly upland	loam, clay loam, sandy loam (2-3)	loam, clay loam, sand and gravel (3-20+)	4-12	well drained	6.2-7.3	low to high	low to medium	Storden Clarion Estherville Salida



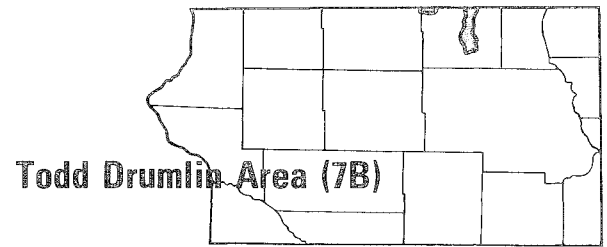
A cross section of soils in a moraine area often reveals a substratum of wide mixture of materials ranging from sands to glacial boulders. This soil is shown as an XLWD soil landscape unit on the St. Cloud Sheet.

Table 5 (continued). Selected features of soil landscape units within the Alexandria Moraine Complex (3) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LCWD*	<1	rolling upland	loam to clay loam (2-3)	silty clay loam to silty clay (3-4+)	8-12	well drained	5.6-6.5	medium	medium	Guckeen
LSWL	<1	rolling to hilly upland	loamy fine sand to fine sand (2-3)	loam (3-20+)	4-8	well drained	5.1-7.3	low to medium	low to medium	Braham
SP	<1	low lying depressions	peat (1-4)	sand or loamy sand (4+)	4+	very poorly drained	6.0-7.8	low	low	Markey Deerwood
SLWL	<1	rolling to hilly outwash	sandy loam to loam (2-3)	sand and gravel (3-4+)	4-8	well drained	5.6-6.5	medium	low to medium	Burnsville
SSWL	<1	rolling to hilly outwash	loamy fine sand to fine sand	fine sand (4+)	4	well drained	5.1-6.0	high	low	Zimmerman

Water 9

*Incorrectly shown on map as CLWD.



This region is approximately 37,620 acres or 0.7 percent of the St. Cloud Sheet.

Only the southern portion of the Todd Drumlin area extends into the St. Cloud Sheet. The drumlins here tend to be oval shaped hills rather than the characteristic elongated form. They are 15 to 40 feet high, north-south oriented, and separated by poorly to very poorly drained mineral and organic soils. Slopes of the drumlins are generally 4 to 10 percent. Normally the water table is over 6 feet deep on the drumlins and at the surface to 3 feet deep on low lying inter-drumlin areas. Two lakes, each over 160 acres in size and totaling approximately 407 acres are located here.

The till is yellowish-brown, calcareous sandy loam.

Originally the region was covered by northern hardwoods, mainly of elm, maple, and oak. Approximately 50 percent is now cultivated, 30 percent pasture, and 20 percent forested. Principal crops are corn, oats, and hay (alfalfa, brome grass, clover).

Eight soil landscape units are mapped in the region: LLWL, LLPL, XLWL, SSWD, P, LLWD, A, and SP.

Table 6 gives selected features of the units. Additional information follows:

LLWL—This unit includes 10 to 20 percent very poorly to poorly drained soils and 5 to 15 percent organic soils. About 5 percent is sandy. (Typic Eutroboralfs)

LLPL— The unit includes 10 to 20 percent shallow organic soils and 5 to 15 percent moderately well-drained soils. (Aeric Ochraqualfs or Fragiaqualfs)

XLWL—Included in this unit is 5 to 15 percent poorly and very poorly drained soil and 5 to 15 percent organic soil.

SSWD— The unit includes some loamy soils. (Udorthentic Haploborolls)

P, LLWD, A, and SP are minor units.

Table 6. Selected features of soil landscape units within the Todd Drumlin Area (7B) geomorphic region

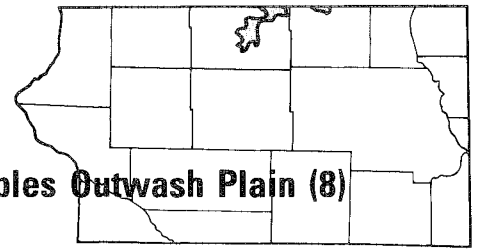
Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LLWL	71	gently sloping to sloping upland	sandy loam (2-3)	sandy loam to loam (3-20+)	4-8	well to moderately well drained	5.8-6.3	medium	low	Rockwood Blowers
LLPL	20	gently sloping to depressional	sandy loam (2-3)	sandy loam to loam (3-20+)	8-12	somewhat poorly to very poorly drained	5.8-6.3	low	medium	Paddock Runeberg
XLWL	4	rolling upland	sandy loam, gravelly sandy loam, and loam (2-3)	sandy loam, sand and gravel (3-20+)	8	well drained	5.8-6.8	medium to high	low	Rockwood Marquette
SSWD	2	level to gently sloping outwash	loamy sand to gravelly sandy loam (1-2)	sand and gravel (2-4+)	4	well drained	5.5-7.8	high	low	Sioux Hubbard
P	1	low lying depressions	peat (1-4)	sandy loam (4+)	8+	very poorly drained	5.5-7.8	low	low	Cathro
LLWD	1	gently rolling upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	well drained	5.1-7.2	low	medium	Waukon

Table 6 (continued). Selected features of soil landscape units within the Todd Drumlin Area (7B) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
A	<1	nearly level stream bottoms	variable: loamy sand to loam (2-4)	variable: loamy sand to loam (4+)	4-12	poorly drained	6.1-7.2	low	medium	Alluvial land
SP	<1	low lying depressions	peat (1-4)	sandy to loamy sand (4+)	4+	very poorly drained	6.0-7.8	low	low	Markey Deerwood
Water	1									

Runoff of waste from a feedlot in Big Stone County is diverted to this lagoon. The liquid manure is then applied to cropland which recycles the fertility elements to crops and helps protect Big Stone Lake from excessive amounts of pollution nutrients.





Park Rapids—Staples Outwash Plain (8)

This region encompasses an area of approximately 40,340 acres of 0.7 percent of the St. Cloud Sheet.

The outwash plain is nearly level to gently rolling with steeper slopes bordering some lakes. Some marshy areas and a few small peat bogs and depressions occur in the plain. Nine lakes each 160 acres or more are located in the region. The total water area is approximately 7,565 acres. The water table is normally over 6 feet deep on well-drained sites. On marshy and poorly drained positions it is surface to 6 feet deep.

Most of the soils are loamy sands to loam underlain at 12 to 24 inches by sand and gravel. Some soils have formed in loamy till. The water holding capacities range from low to moderate.

The original vegetation was mainly areas of scattered oak trees. Approximately 70 percent is cultivated, 20 percent pasture, 10 percent forested, and 5 percent marshy. Principal crops are corn, oats, and brome-alfalfa hay.

Eight soil landscape units are mapped in the region: SLWD, SSWD, LLWL, M, XLWL, SLPD, LLPL, LLPD. Table 7 gives selected features of the units. Additional information follows:

SLWD—The unit includes 10 to 20 percent coarse-textured soils, 5 to 15 percent poorly drained, or-

ganic, and marshy areas and less than 5 percent loamy subsurface materials. (Udic Haploborolls)

SSWD—Included is 5 to 10 percent loamy soil underlain by sand and in places some gravel. Poorly drained, organic and marshy areas represent another 5 percent of the unit. (Udorthentic Haploborolls)

LLWL—These areas include about 5 percent sandy over loamy materials, 5 to 10 percent sandy and gravelly soils, and 5 percent marshy areas, or poorly to very poorly drained soils and shallow organic soils. (Typic Eutroboralfs)

M— An estimated 45 percent is shallow organic, 35 percent deep organic, and 15 percent poorly to very poorly drained mineral soils. About 5 percent is moderately well-drained sandy soil.

XLWL—Includes small areas of dark-colored soils, marshes, and poorly drained soils. (Typic Eutroboralfs)

SLPD, LLPL, and LLPD are minor units.

Table 7. Selected features of soil landscape units within the Park Rapids—Staples Outwash Plain (8) geomorphic region

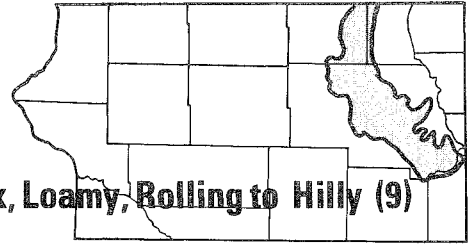
Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
SLWD	32	level to gently sloping outwash	sandy loam to loam (2-3)	sand and gravel (3-4+)	4-8	well drained	6.1-7.8	medium to high	low to medium	Arvilla Dorset Sverdrup
SSWD	30	level to sloping outwash	loamy sand to sandy loam (1-2)	sand and gravel (2-4+)	4	well drained	6.6-7.8	high	low	Sioux Arvilla
LLWL	14	gently rolling to rolling upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	well drained	6.1-6.8	low	high	Nebish
M	3	low lying depressions	peat or mineral soil	peat or mineral soil	1-4 feet of water on surface	marshy				

Table 7 (continued). Selected features of soil landscape units within the Park Rapids—Staples Outwash Plain (8) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
XLWL	2	rolling upland	loam, clay loam and sandy loam (1-4)	loam, clay loam, sand and gravel (4-20+)	12	well drained	6.1-7.8	low to high	low to high	Nebish Arvilla Sioux
SLPD	<1	level to depressional	sandy loam to loam (2-3)	sand and gravel (3-4+)	4-8	somewhat poorly to very poorly drained	6.1-7.3	low	low	Forada
LLPL	<1	gently sloping to depressional	sandy loam (2-3)	sandy loam to loam (3-20+)	8-12	somewhat poorly to very poorly drained	5.8-6.3	low	medium	Paddock Runeberg
LLPD	<1	gently sloping to depressional	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	poorly to very poorly drained	6.6-7.4	low	medium	Flom Parnell
Water	19									

This is a common type of landscape in the St. Croix Moraine. Although some erosion may occur on cropland, the land contains many closed depressions which hold sediment out of streams and lakes.





St. Croix Moraine Complex, Loamy, Rolling to Hilly (9)

This moraine covers approximately 428,200 acres or 7.7 percent of the St. Cloud Sheet.

The St. Croix is a prominent moraine, having a rolling to hilly complex land form. Small peat bogs and depressions are common. The water tables on the knolls are more than 20 feet deep. On lower positions the water tables are at the surface to 6 feet deep. There are 37 lakes, each 160 acres or more, making the total water area approximately 18,700 acres. The Sauk River cuts through the moraine near St. Cloud.

The till texture is mainly acid and sandy loam. Along the west and southwest a limy loam till occurs. In places the two tills are intermixed. In the southern and northern parts the till is intermixed with sandy loams and loamy sands underlain by sand and gravel. A relatively large outwash plain is located in the southern end of the moraine.

The original vegetation consisted largely of northern hardwoods with some areas of scattered oak trees. An estimated 50 to 60 percent is currently forested, 20 to 30 percent is pastured, and 10 to 20 percent is cropped. Main crops are oats, corn, alfalfa, and brome. About 5 percent consists of marshy and peat areas.

Fourteen soil landscape units are mapped: XLWL, LLWL, SLWD, SLPD, LP, SSWD, LLPD, LLPL, P, SSWL, SP, LLWD, A, and SLWL. Table 8 lists selected characteristics of the units. Additional information follows:

XLWL—The underlying materials are intermixed sand, gravel, and sandy loam glacial till. The unit includes 5 to 10 percent poorly to very poorly drained mineral soils, organic, and marshy areas. (Typic Fragiocrepts)

LLWL—Soils underlain by sand and gravel occur in 10 to 15 percent of the unit. Another 5 to 15 percent is intermingled with acid, sandy loam, and limy loamy till. Shallow peat marshes and poorly drained soils make up about 5 percent. (Typic Fragiocrepts)

SLWD—Approximately 15 percent of the unit is underlain by sand with little or no gravel. Another 10 to 15 percent is coarse textured, 5 to 15 percent loamy till, and 5 to 10 percent poorly drained, organic, and marshy soil. (Typic Hapludolls)

SLPD— The unit includes 5 to 15 percent sandy surface soil, 5 to 15 percent moderately well to well drained, 10 to 15 percent shallow peat over sand, and 5 to 10 percent loamy soil. (Typic Haploborolls)

LP— Approximately 15 percent of the unit is deep peat and 10 percent is loamy soil. (Terric Borosapristis)

SSWD—This unit includes 10 to 15 percent loamy soil, and 5 to 10 percent poorly drained, organic, and marshy soil. (Udorthentic Haploborolls)

LLPD— Ten to 15 percent of the unit has moderately well-drained soil, 5 to 10 percent is underlain by sand and gravel, and 5 to 15 percent has organic soils and marshy areas. (Typic Haplaquolls)

LLPL— The unit includes some darker-colored, coarse-textured and moderately well-drained soil. Some organic soils and marshy areas are also included. (Aeric Fragiagualls)

P— Approximately 65 percent is shallow peat and 25 percent is deep. Poorly drained mineral soils make up another 10 percent. (Terric Borosapristis)

SSWL—Included are small areas of dark-colored soils, sandy loam, till, and poorly drained soils. (Eutric Glossoboralfs)

SP— Small areas of deep peat, shallow peat over loamy till, and some mineral soils are included. (Terric Borosapristis)

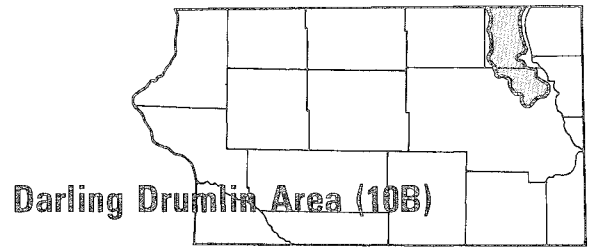
LLWD—Inclusions are minor areas of light, colored soils, poorly drained, organic, and coarse-textured soils. (Mollic Hapludalfs)

A— Some organic soils are included. (Not classified)

SLWL—This unit includes some coarse-textured soils, poorly drained, organic, and till areas. (Typic Hapludalfs)

Table 8. Selected features of soil landscape units within the St. Croix Moraine, loamy, rolling to hilly (9) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
XLWL	37	rolling to hilly upland	sandy loam, loamy sand, and gravelly loamy sand (1-4)	sandy loam and sand and gravel (4-20+)	8	well drained	5.0-6.0	high to very high	low to medium	Flak, Chetek, Emmert
LLWL	30	rolling to hilly upland	sandy loam (2-3)	sandy loam (3-20+)	4-8	well drained	5.2-6.5	medium to high	low	Flak, Hayden
SLWD	12	nearly level to rolling outwash	sandy loam, loam, and silt loam (2-3)	sand and gravel (3-4+)	4-8	well drained	5.6-7.3	medium to high	low to medium	Estherville, Fairhaven
SLPD	3	nearly level to depressional	sandy loam to loam (2-3)	sand and gravel (3-4+)	4-8	poorly to very poorly drained	6.1-7.3	low	low	Biscay, Talcot
LP	3	low lying depressions	peat (1-4)	sandy loam to loam (4+)	8+	very poorly drained	5.5-7.3	low	low	Cathro
SSWD	2	nearly level to rolling outwash	loamy sand to sandy loam (1-2)	sand and gravel (2-4+)	4	well drained	5.4-7.3	high	low	Hubbard, Salida
LLPD	2	nearly level to depressional	sandy loam (1-3)	sandy loam (3-20+)	8-12	very poorly to poorly drained	5.0-6.2	low to medium	low	Adolph, Barrows, Parent
LLPL	1	nearly level to depressional	sandy loam (1-3)	sandy loam (3-20+)	8-12	somewhat poorly drained	5.0-6.2	medium to high	low	Nokay, Freer
P	1	low lying depressions	peat (1-4)	sandy loam or peat (4+)	8+	very poorly drained	5.4-7.3	low	low	Cathro, Seelyville
SSWL	1	rolling outwash	sandy loam to loamy sand (1-2)	sand and gravel (2-20+)	<4	well drained	4.8-6.0	high	low	Chetek, Zimmerman
SP	1	low lying depressions	peat (1-4)	sand to loamy sand (4+)	4+	very poorly drained	6.0-7.8	low	low	Markey, Deerwood
LLWD	1	rolling upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	well to moderately well drained	6.1-7.3	low	medium	Lester, LeSueur
A	1	nearly level stream bottoms	variable: loamy sand to loam (2-4)	variable: loamy sand to loam (4+)	4-12	poorly drained	6.1-7.2	medium	low	Alluvial land
SLWL	1	rolling outwash	sandy loam to loam (2-3)	sand and gravel (3-4)	4-8	well drained	5.6-6.5	medium	low to medium	Burnsville
Water	4									



This region contains approximately 174,880 acres or 3.1 percent of the St. Cloud Sheet.

The drumlins are prominent in the northern part of the region, but resemble a till plain toward the south. Primarily it is gently sloping with a few rolling areas bordering the rivers. Four streams, Swan, North Two, Two Rivers, and Spunk Creek cut through the region. The poorly drained soils occur in broad flats as well as in interdrumlin areas. The water tables are normally over 6 feet deep on the drumlins and at the surface to 6 feet deep in the poorly drained areas. No lakes of 160 acres or larger occur in the region. The water area is about 1,086 acres.

The till is noncalcareous brown sandy loam and is somewhat compact with a slow permeability rate.

The native vegetation was primarily northern hardwoods. Present land use consists of about 15 to 20 percent forest of second growth hardwoods, 50 percent cropland, and 20 percent pasture. Major crops are corn, oats, and hay. Ten to 15 percent consists of peat. At times it is pastured but during wet periods the water table is surface.

Fourteen soil landscape units are mapped in the region: LLWL, LLPL, XLWL, LP, LLPD, SSWD, NP, A, SP, SLPD, SLWD, P, LSPL, and SSWL. Table 9 gives selected features of the units. Additional information follows:

LLWL—This unit includes 10 to 20 percent poorly and very poorly drained soils and 5 to 15 percent shallow peat. Less than 5 percent is sandy and gravelly. In places, small amounts of calcareous loam till is intermixed with the noncalcareous sandy loam till. (Aquic Fragiocrepts)

LLPL— Included in this unit is 5 to 15 percent moderately well-drained soil, 5 to 15 percent shallow peat, and small amounts of dark-colored soils. (Aeric Fragiocrepts)

XLWL—Two major areas occur in the unit, one along Swan River and the other in the southern part. The unit includes 5 to 15 percent poorly drained soils and 5 to 10 percent shallow peat. (Typic Fragiocrepts)

LP— About 10 percent deep peat and 5 percent poorly drained soils are included. (Terric Borosaprists)

LLPD— The boundary between LLPL and LLPD is indistinct. This unit includes about 5 percent moderately well and well-drained soil. (Mollic Haplocrepts)

SSWD—These outwash areas include 10 to 15 percent sandy loams (SLWD), and 5 to 10 percent poorly drained soils. (Typic Udipsamments)

NP— The unit includes about 20 percent shallow peat, 5 percent very poorly to poorly drained mineral soils, and less than 5 percent moderately well-drained soils. (Euic Typic Borosaprists)

A— This unit includes some shallow organic soils. (Not classified)

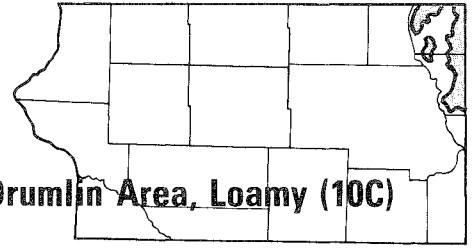
SP, SLPD, SLWD, P, LSPL, and SSWL are minor units.

Table 9. Selected features of soil landscape units within the Darling Drumlin Area (10B) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LLWL	53	gently sloping drumlins	sandy loam to loam (2-3)	sandy loam to (3-20+)	4-8	moderately well to well drained	5.0-5.8	very high	low	Brainerd Flak
LLPL	13	gently sloping to depression upland	loam (2-3)	sandy loam (3-20+)	8-12	somewhat poorly to very poorly drained	5.2-6.4	low to medium	low	Nokay
XLWL	11	gently sloping to sloping upland	sandy loam, loam, and loamy sand (1-3)	sandy loam, sand and gravel (3-20+)	<8	well drained	5.2-6.5	medium to high	low to medium	Flak Hoidingford Emmert

Table 9 (continued). Selected features of soil landscape units within the Darling Drumlin Area (10B) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LP	9	low lying depressions	peat (1-4)	sandy loam to loam (4+)	8+	very poorly drained	5.5-7.3	low	low	Cathro
LLPD	6	level to depressional	loam to sandy loam (2-3)	sandy to loam (3-20+)	8-12	very poorly to somewhat poorly drained	5.2-6.4	low to medium	low	Barrows Unnamed
SSWD	2	level to gently sloping outwash	loamy sand (2-3)	sand (3-20+)	4	well drained	5.5-6.5	high to very high	low	Nymore Hubbard
NP	2	low lying depressions	peat (3)	peat (3-4+)	12+	very poorly drained	6.0-7.3	low	low	Seelyeville Brophy
A	1	nearly level stream bottoms	variable: loamy sand to loam (2-4)	variable: loamy sand to loam (4+)	4-12	poorly drained	6.1-7.2	low	medium	Alluvial land
SP	1	low lying depressions	peat (1-4)	sandy or loamy sand (4+)	4+	very poorly drained	6.0-7.8	low	low	Markey Deerwood
SLPD	1	nearly level to depressional	sandy loam to loam (2-3)	sand and gravel (3-4+)	4-8	well drained	6.1-7.3	medium	low	Dassel Unnamed
SLWD	<1	nearly level to gently sloping outwash	sandy loam to loam (2-3)	sand (3-4+)	4-8	well drained	4.8-6.0	high	low	Burkhardt
P	<1	wet drainage ways	peat (1-3)	peat or sandy loam (3-4)	8+	very poorly drained	5.5-7.3	low	low	Cathro Seelyeville
LSPL	<1	nearly level capped till areas	sand loamy sand (2-3)	sandy loam (3-20+)	4-8	poorly to very poorly drained	5.0-6.0	low	low	Watab Nokasippi
SSWL	<1	esker-like formation	gravelly loamy sand (1-3)	stratified sand and gravel (3-20+)	<4	well drained	4.8-6.2	very high	low	Emmert Chetek
Water	1									



Brainerd—Pierz Drumlin Area, Loamy (10C)

The region contains an area of approximately 144,680 acres or 2.6 percent of the St. Cloud Sheet.

The fairly prominent drumlins are 15 to 30 feet high, 0.1 to 0.3 miles wide, and 1 to 2 miles long. They are oriented in a northeast-southwest direction. The drumlins are separated by low, wet mineral and peat soils. Many of these inter-drumlin areas are too narrow to delineate on the map. The water tables are normally over 6 feet deep on the drumlins and at the surface to 6 feet deep on inter-drumlin areas. Two lakes, each more than 160 acres in size, are located in the region. Total water area is about 581 acres.

The drumlins consist of non-calcareous, brown sandy loam, somewhat compact till which is slowly permeable. Cobbles and small boulders are quite common in the till.

The native vegetation on the drumlins in the northern part of the region was mostly white spruce and balsam fir. In the southern part, oak dominated. Tamarack, black spruce, and some wet meadows covered the wet inter-drumlin areas. Approximately 55 percent of the region is now under cultivation. The main crops are corn, oats, and hay (brome grass, alfalfa, clover).

About 20 percent is pasture and 20 percent forest. The major tree species are aspen, birch, and some elm and oak. Approximately 5 percent of the area consists of organic soils. At times it is pastured, but when wet it is idle.

Thirteen soil landscape units are mapped in the region: LLWL, LLPL, LSWL, LLPD, A, XLWL, NP, LP, SSWL, SP, SSWD, SSPD, and P. Table 10 gives selected features of the units. Additional information follows:

LLWL—The unit includes about 10 percent poorly drained, 10 percent very poorly drained, and 5 percent shallow peat. Another 5 percent has a sand cap 18 to 42 inches thick over the till. (Aquic Fragiocrepts)

LLPL— Approximately 10 percent of the soil in this unit is moderately well drained, 10 percent shallow peat, and another 5 percent moderately dark to dark colored. (Aeric Fragiaqualfs)

LSWL—An estimated 15 percent is poorly to very poorly drained, and 5 percent is shallow peat. The unit includes about 5 percent loamy surface soils and 5 percent deep sands. (Typic Fragiocrepts)

LLPD— This unit consists of approximately 10 percent peat, and 10 percent better-drained soils. Small areas of sandier soils are also included. (Mollic Haplaquepts)

A— The unit includes areas of organic soils and small areas of upland. (Not classified)

XLWL—The unit includes about 10 percent poorly and very poorly drained mineral soils and 5 percent organic. (Typic Fragiocrepts)

NP— Approximately 20 percent of the unit consists of shallow peat and about 5 percent mineral soils. (Euic Typic Borosaprists)

LP— Deep peat makes up to about 15 percent of the unit. Another 5 to 10 percent has mineral soil. (Terric Borosaprists)

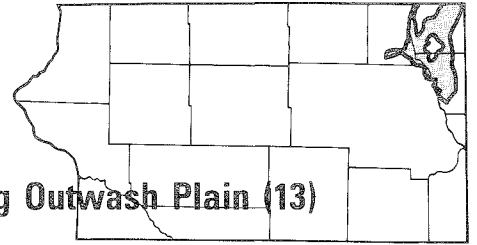
SSWL— Included are minor areas of deep loamy soils, shallow sand over loamy till and some poorly drained soils. (Typic Udipsamments)

SP— Small areas of deep peat and shallow peat over loamy till are included. (Terric Borosaprists)

SSWD, SSPD and P are minor units.

Table 10. Selected features of soil landscape units within the Brainerd-Pierz Drumlin Area, loamy (10C) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LLWL	43	gently sloping and sloping drumlins	sandy loam (2-3)	sandy loam (3-20+)	4-8	moderately well to well drained	5.0-5.8	very high	low	Brainerd Flak
LLPL	13	low broad drainage ways and depressions	sandy loam (2-3)	sandy loam (3-20+)	8-12	poorly to very poorly drained	5.4-6.4	low to medium	low	Nokay Barrows
LSWL	15	sloping to gently sloping drumlins	loamy sand to sand (2-3)	sandy loam (3-20+)	4-8	well to moderately well drained	4.6-5.6	medium to high	low	Pomroy
LLPD	10	low broad drainage ways and depressions	sandy loam to loam (2-3)	sandy loam (3-20+)	8-12	poorly to very poorly drained	5.4-6.4	low to medium	low	Unnamed Barrows
A	4	nearly level stream bottoms	variable: loamy sand to loam (2-4)	variable: loamy sand to loam (4+)	4-12	poorly drained	6.1-7.2	medium	low	Alluvial land
XLWL	3	sloping to gently sloping upland	sandy loam to gravelly loamy sand (1-3)	sandy loam, sand and gravel (3-20+)	<8	well drained	4.6-6.2	medium to high	low	Flak Emmert Pomroy
NP	2	drainageways and low lying depressions	peat (3)	peat (3-4+)	12+	very poorly drained	5.5-6.8	low	low	Seelyville Mooselake
LP	2	drainageways and low lying depressions	peat (1-4)	sand (4+)	8+	very poorly drained	5.4-7.3	low	low	Cathro
SSWL	1	sloping to gently sloping upland	loamy sand and sand (1-3)	sand (3-4+)	<4	well drained	5.4-6.4	very high	low	Menahga
SP	1	drainage ways and low lying depressions	peat (1-4)	sand to loamy sand (4+)	4+	very poorly drained	6.0-7.5	low	low	Markey
SSWD	1	nearly level to sloping upland	loamy sand to sand (2-3)	sand (3-20+)	<4	well drained	5.5-6.5	high to very high	low	Hubbard Nymore
SSPD	<1	drainage ways	sandy loam, loamy sand and sand (1-3)	sand (3-4+)	<4	poorly to very poorly drained	5.5-6.5	low	low	Isan
P	<1	low lying depressions	peat (1-3)	peat or sandy loam (3-4+)	8+	very poorly drained	5.5-7.3	low	low	Cathro Seelyville
Water	<1									



Crow Wing Outwash Plain (13)

This region has approximately 138,970 acres or 2.5 percent of the St. Cloud Sheet.

The Crow Wing Outwash Plain occurs along the Mississippi River and terminates near St. Cloud. The plain is level to undulating, but includes small areas of rolling topography. The water table on well-drained soils is normally over 6 feet deep and at the surface to 6 feet deep on lower positions. Four lakes each 160 acres or more in size and totaling about 7,600 acres occur in this region.

Most of the soils are loamy sands and shallow loams underlain by sand. The region includes small areas of till capped with sands. Most of the soils have a low water holding capacity.

The original vegetation was oak, and areas of scattered oak trees, with areas of red, jack, and white pine. At present 10 to 15 percent of the region is forested. The main species are oak, aspen, and jack pine. An estimated 55 to 65 percent is cropland and 15 to 25 percent is pasture. Corn, oats, soybeans, and brome, alfalfa, hay, are the main crops.

Another 5 to 10 percent consists of organic soils, generally idle, but at times pastured.

Eleven soil landscape units are mapped: SSWD, SSPD, SP, LSWL, A, SLWD, SSPL, SLPD, P, LLPL, and LLPD. Table 11 lists selected characteristics of the units. Additional information follows:

SSWD— The unit includes 5 to 15 percent loamy surfaces with sandy or gravelly subsoils and about 5 percent of poorly to very poorly drained soils. (Typic Udipsamments)

SSPD— Included are 10 to 20 percent moderately well-drained soils, and 5 to 15 percent shallow organic soils. (Typic Haplaquolls)

SP— Approximately 10 percent is deep peat soil and 15 percent poorly to moderately well-drained soil. (Terric Borosaprists)

LSWL— This unit consists of till “islands” capped by sand. It includes small areas of deep sandy soils. (Typic Fragiocrepts)

A— This unit includes some organic soils. (Not classified)

SLWD— Included in the unit are small areas of poorly drained soils, deep sandy soils, and shallow organic soils. (Typic Hapludolls)

SSPL— Minor areas of loamy surface soils and organic soils are included. (Aquic Udipsamments)

SLPD— The unit includes small areas of shallow peat and moderately well-drained soils. (Typic Haplaquolls)

P— Most of the unit is shallow peat over sand but includes some deep peat and poorly drained sandy soils. (Terric Borosaprists)

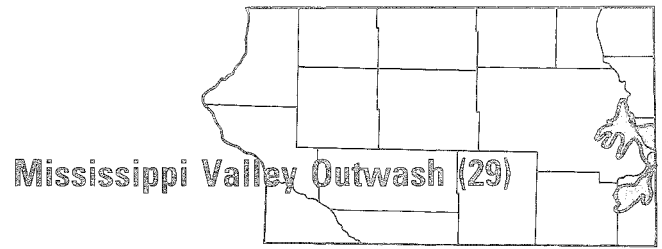
LLPL and LLPD are minor units.

Table 11. Selected features of soil landscape units within the Crow Wing Outwash Plain, sandy (13) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
SSWD	64	nearly level to undulating outwash	loamy sand to sand (1-3)	sand (3-20+)	<4	well drained	5.5-6.5	high to very high	low	Nymore Hubbard
SSPD	13	nearly level to depressional	sandy loam, loamy sand and sand (1-3)	sand (3-20+)	<4	poorly to very poorly drained	5.5-6.5	low	low	Isan
SP	7	low lying depressions	peat (1-4)	sand (4+)	4+	very poorly drained	6.0-7.5	low	low	Markey

Table 11 (continued). Selected features of soil landscape units within the Crow Wing Outwash Plain, sandy (13) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LSWL	3	gently sloping to sloping upland	loamy sand to sand (2-3)	sandy loam (3-20+)	4-8	well to moderately well drained	4.6-5.6	medium to high	low	Pomroy
A	3	nearly level stream bottoms	variable: loamy sand to loam (2-4)	variable: loamy sand to loam (4+)	4-12	poorly drained	6.1-7.2	medium	low	Alluvial land
SLWD	2	nearly level to undulating outwash	sandy loam (2)	sand and gravel (2-20+)	4-8	well drained	4.8-6.0	high	low	Burkhardt
SSPL	1	nearly level to depressional	loamy sand (1-3)	sand (3-4+)	<4	somewhat poorly to poorly drained	5.2-6.2	low	low	Lino
SLPD	1	nearly level to depressional	loam to sandy loam (2-3)	sand (3-4+)	4-8	somewhat poorly to very poorly drained	6.0-7.0	medium	low	Hanska Dassel
P	1	level to depressional	peat (1-3)	sand (3-4+)	4+	very poorly drained	6.0-7.8	low	low	Markey Deerwood
LLPL	<1	nearly level to depressional till	sandy loam (2-3)	sandy loam (3-20+)	8-12	poorly to very poorly drained	5.2-6.4	low to medium	low	Nokay Barrows
LLPD	<1	nearly level to depressional till	sandy loam to loam (2-3)	sandy loam (3-20+)	8-12	very poorly drained	5.2-6.2	low to medium	low	Barrows Unnamed
Water	5									



The region has approximately 156,630 acres or 2.8 percent of the St. Cloud Sheet.

The land form is level to undulating with small areas of gently rolling to rolling topography, especially bordering the lakes located in the southern portion. The water table is normally more than 6 feet deep. On the organic soils and poorly drained soils the water table is surface to 6 feet deep. Twelve lakes each 160 acres or larger and totaling about 12,800 acres are located in the region.

Most of the soils are loamy sands and sandy loams, but include some loams. The substrata ranges from sand to sand and gravel. The water holding capacity of the soils is low to moderate.

Originally, the vegetation consisted of oak, areas of scattered oak trees, and northern hardwoods. Present land use consists of about 10 percent forest. Oak and aspen are the principal species. Cropland makes up 65 to 75 percent and pasture 10 to 20 percent of the region. Principal crops are corn, oats, soybeans, and hay. About 5 percent of the region is peat and idle land.

Ten soil landscape units are mapped in the region: SSWD, SLWD, SLWL, SLPD, SP, NP, A, LLWL, SSWL, and LSWL. Table 12 lists selected features of the units. Additional information follows:

SSWD—Approximately 15 percent of the unit consists of sandy soils underlain by sand and gravel, 5 percent sandy loams to loams having sand and gravel substrata, and 5 percent poorly drained soils. (Udorthentic Haploborolls)

SLWD—The unit includes 20 percent shallow loamy sands with some containing very little gravel.

Approximately 5 percent of the unit has poorly drained soils. (Typic Hapludolls)

SLWL—Inclusions consist of about 10 percent dark-colored soils; 10 percent loamy sand surfaces, and 10 percent poorly drained soils. (Typic Hapludalfs)

SLPD—Approximately 10 percent of the unit has well-drained soils, another 10 percent has deep sandy soils, and 5 percent has shallow organic soils. (Typic Haplaquolls)

SP—This unit includes 5 to 15 percent poorly drained mineral soils, about 5 percent well-drained soils and 5 percent deep peat. (Terric Borosaprists)

NP—Approximately 15 percent is shallow peat and 10 percent poorly drained mineral soils. (Euc Typic Borosaprists)

A—The unit includes some shallow organic soils. (Not classified)

LLWL—The unit includes small areas of sandy surface soils underlain by loamy till. (Typic Fragiochrepts)

SSWL—Small areas of sand underlain at 2 to 4 feet by loamy till are included in this unit. (Typic Udipsamment)

LSWL—This unit includes some deep sands (SSWL). (Typic Fragiochrepts)

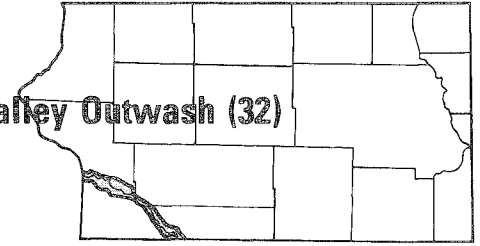
Table 12. Selected features of soil landscape units within the Mississippi Valley Outwash (29) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships			Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K		
SSWD	46	nearly level to undulating outwash	loamy sand (1-3)	sand (3-20+)	4	well drained	5.5-6.5	very high	low	Hubbard	
SLWD	19	nearly level to undulating outwash	sandy loam to loam (2-3)	sand and gravel (3-20+)	4-8	well drained	6.1-7.3	high	low to medium	Estherville	

Table 12 (continued). Selected features of soil landscape units within the Mississippi Valley Outwash (29) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
SLWL	12	nearly level to gently rolling outwash	sandy loam to loam (2-3)	sand and gravel (3-20+)	4-8	well drained	5.6-6.5	medium	low to medium	Burnsville
SLPD	7	nearly level to depressional	loam to sandy loam (2-3)	sand and gravel (3-4+)	4-8	poorly to very poorly drained	6.0-7.3	low to medium	low	Dassel Biscay
SP	2	low lying depressions	peat (1-4)	sand (4+)	4+	very poorly drained	5.0-7.5	low	low	Markey
NP	2	low lying depressions	peat (3)	peat (3-4)	12+	very poorly drained	6.0-7.3	low	low	Seelyeville
A	1	nearly level streams bottoms	loamy sand to loam (2-4)	loamy sand to loam (4+)	4-12	poorly drained	6.1-7.2	low	medium	Alluvial land
LLWL	1	gently rolling to rolling upland	sandy loam	sandy loam	4-8	well to moderately well drained	4.8-5.8	very high	low	Milaca Mora
SSWL	1	nearly level to undulating outwash	sandy to loamy sand (2-3)	sand (3-20+)	<4	well drained	5.4-6.4	very high	low	Sartell
LSWL	1	gently sloping to sloping upland	loamy sand to sand (2-3)	sandy loam (3-20+)	4-8	well to moderately well drained	4.6-5.6	medium to high	low	Pomroy
Water	8									

Minnesota Valley Outwash (32)



The geomorphic region has an area of approximately 48,070 acres or 0.9 percent of the St. Cloud Sheet.

The sharp wide valley was cut by the Glacial River Warren that drained Glacial Lake Agassiz. The valley floor is over 100 feet below the surrounding upland. The present day Minnesota River is a relatively small stream compared to the glacial River Warren. The valley is nearly level to sloping but is dissected to some extent by old stream channels. Some colluvial footslopes occur at the base of the valley wall. Seasonally high water tables are less than 5 feet deep in most of the region. The water area is about 9,550 acres.

In the St. Cloud Sheet most of the region consists of alluvial land quite variable in texture.

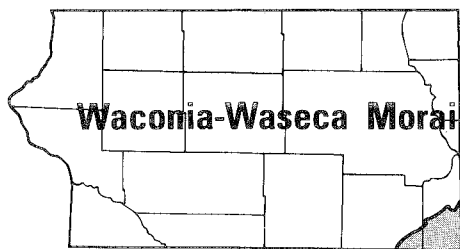
The original vegetation was mainly prairie and bottom-land hardwoods. Approximately 70 percent is forested and 30 percent is cropland and pasture. Corn, oats, and hay are the main crops. The marshes are good waterfowl habitat areas.

Five soil landscape units are mapped in the region: A, LLPD, LLWD, SLWD, and M. Table 13 gives selected features of the units. Additional information follows:

- A— Approximately 20 percent is moderately well drained and 20 percent is very poorly drained. (Not classified)
- LLPD— An estimated 15 percent of the unit has sandy over loamy soils and another 10 percent has well-drained soils. (Cumulic Haplaquolls)
- LLWD—About 15 percent of the unit has poorly drained soils. The unit also includes some sandy and some clayey soils. (Cumulic Udic Haploborolls)
- SLWD—About 10 percent of the unit has deep loamy soils and 10 percent has deep sandy soils. (Pachic Udic Haploborolls)
- M— This unit is marshy most of the time.

Table 13. Selected features of soil landscape units within the Minnesota Valley Outwash (32) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
A	51	nearly level stream bottoms	variable: sandy loam to silty clay loam (2-4)	variable: sandy loam to silty clay loam (4+)	4-12	poorly drained	5.6-8.4	low	medium	Alluvial land Lamoure Rauville
LLPD	13	nearly level stream bottoms	silty clay loam (2-4)	silty clay loam (4+)	8-12	poorly drained	6.6-7.3	low	medium	Lamoure
LLWD	7	nearly level stream bottoms	loam (4)	loam (4+)	8-12	moderately well drained	7.8+	low	medium	LaPrairie
SLWD	7	nearly level to gently sloping stream terraces	sandy loam to loam (2-3)	sand and gravel (3-20+)	4-8	well drained	6.6-7.3	medium	low to medium	Fordville Shible
M	2	low lying depressions	either peat or mineral soil	either peat or mineral soil	1-4 feet of water on surface	marshy				
Water	20									



Waconia-Waseca Moraine, Loamy, Rolling (34)

This geomorphic region encompasses an area of approximately 204,100 acres or 3.7 percent of the St. Cloud Sheet.

Only the northern portion of this moraine is located in the St. Cloud Sheet area. It consists of loamy mantled moraines and ice disintegrated features. The topography ranges from rolling to steep. Differences in elevation between lakes to hilltops range from about 60 to 160 feet. The water table range is from over 10 feet deep to less than 5 feet deep. Twenty-eight lakes each 160 acres or more are located in the region. Total water area is about 17,000 acres. Only small areas of sand occur.

This region is within the area known as the Big Woods. Most of the area, however, was originally tall prairie grass before being encroached by the forest. The woods consisted mainly of oak, elm, basswood, ash, maple, and wild cherry. Five to 10 percent of the region is pasture, 5 to 10 percent peat bogs and marshy areas, 10 percent forests, and 75 percent cropland. The principal crops are corn, oats, alfalfa brome hay, and soybeans.

Ten soil landscape units are mapped in the region: LLWD, LLWL, NP, A, M, LCPD, LP, LLPD, SLWD, and XLWD. Table 14 lists selected features of the units. Additional information follows:

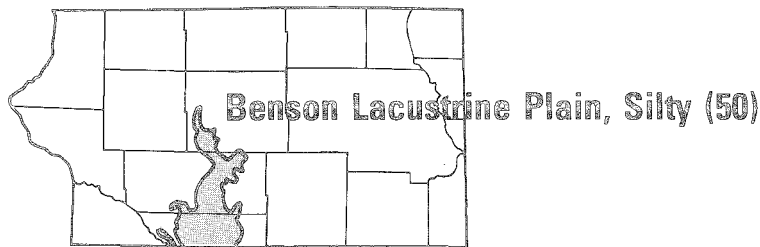
LLWD—Approximately 10 percent of the unit has poorly drained soils, 5 percent wet mineral and peat soils, another 5 percent sandy soils, and less than 5 percent light-colored soils. (Mollic Hapludalfs)

LLWL—This soil landscape unit includes 5 to 10 percent poorly drained areas, 5 percent dark-colored soils, and less than 5 percent peat areas. (Typic Hapludalfs)

- NP**— About 15 percent of the unit consists of shallow peat and about 10 percent mineral soils. (Euic Typic Borosaprists)
- A**— This unit occurs mainly along the North Branch Crow Wing River. Textures are variable and the alluvial land floods quite frequently. (Not classified)
- M**— These areas are marshy most of the time.
- LCPD**— Approximately 10 percent of the unit consists of better-drained soils. Another 5 percent has shallow peat soils and small areas of loamy soils. (Typic Argiaquolls)
- LP**— This unit includes about 10 percent deep peat and 10 percent mineral soils. (Terric Borosaprists)
- LLPD**— Approximately 15 percent of the unit has well-drained soils. (Typic Haplaquolls)
- SLWD**—About 10 percent of the unit consists of deep loamy soils. (Typic Hapludolls)
- XLWD**—About 55 percent is loamy and 45 percent sandy and gravelly. (Mollic Hapludalfs and Typic Hapludolls)

Table 14. Selected features of soil landscape units within the Waconia-Waseca Moraine, loamy, rolling (34) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LLWD	63	undulating to rolling upland	loam to clay loam (4)	loam to clay loam (4+)	8-12	well drained	6.1-7.3	low	medium	Lester Le Sueur
LLWL	14	rolling uplands	loam to clay loam (4)	loam to clay loam (4+)	8-12	well drained	5.1-6.5	medium	medium	Hayden
NP	4	low lying depressions	peat (1-3)	peat (3-4+)	12+	very poorly drained	6.0-7.3	low	low	Seelyeville
A	3	nearly level stream bottoms	variable; loamy sand to silt loam (2-4)	variable; loamy sand to silt loam (4+)	4-12	well to poorly drained	5.6-7.8	low	medium	Alluvial land Huntsville Colo
M	2	low lying depressions	peat or mineral soil	peat or mineral soil	1-4 feet of water on surface	marshy				
LCPD	2	depressional upland	silty clay loam (4)	loam to clay loam (4+)	8-12	poorly drained	6.1-6.5	low to medium	medium	Cordova
LP	1	low lying depressions	peat (1-4)	peat or silty clay loam (4+)	8-12+	very poorly drained	5.5-7.3	low	low	Cathro Millerville
LLPD	1	gently sloping to depressional upland	loam to clay loam (4)	loam to clay loam (4+)	8-12	poorly to very poorly drained	6.1-7.3	low to medium	low to medium	Webster Glencoe Cordova
SLWD	1	nearly level outwash plain	sandy loam to loam (2-3)	sand and gravel (3-20+)	4-8	well drained	5.1-7.3	medium to high	low to medium	Estherville Wadena
XLWD	1	rolling upland	sandy loam, loam and clay loam (2-3)	sand, gravel and loam (3-4+)	4-12	well drained	5.1-7.3	low to medium	low to medium	Lester Estherville Dickenson
Water	8									



This geomorphic region has approximately 262,190 acres or 4.7 percent of the St. Cloud Sheet.

The region consists of a broad low relief lake plain. Higher positions are gently sloping to undulating. Lower positions are nearly level to slightly depressional. The seasonably high water table in better-drained positions ranges from 3 to 4 feet deep. In the sandy and gravelly areas the water table is more than 5 feet deep. In poorly drained areas it is 2 to 3 feet deep. Eleven lakes, each 160 acres or more, occur in the region bringing the total water area to approximately 10,800 acres.

Alkaline soils are quite common. The high lime content may cause iron and zinc deficiencies in some crops. Soybeans, flax, and many ornamental shrubs and trees are affected by iron deficiencies. Corn can also be affected, but less seriously. Crops most seriously affected by zinc deficiencies are soybeans and flax. Potatoes, sugar beets, alfalfa, sorghum, tomatoes, and onions are mildly affected.

The original vegetation was tall prairie grass. Northern hardwoods, such as elm, oak, basswood, and maple bordered many lakes. The main crops are corn, soybeans, wheat, oats, and some sugar beets. Presently the land use distribution is about 90 percent cropland, 5 percent pasture, and 5 percent wooded.

Ten soil landscape units are mapped in the region: LLPD, LLWD, SLWD, CCPD, SLPD, SSWD, A, M, LP, and CCWD. Table 15 lists selected features of the units. Additional information follows:

LLPD— This unit includes an estimated 15 percent moderately well-drained soils, about 5 percent with clayey surfaces, and 5 percent underlain at less than 36 inches by sandy sediments. (Typic Calciaquolls)

LLWD—Poorly drained soil comprises 10 to 20 percent of the unit. About 5 percent is sandy, 5 percent has a clayey surface, and another 5 percent has a sandy substratum below 2 to 3 feet. (Aeric Calciaquolls)

SLWD—Deep silty or loamy soils occur in about 10 percent of the unit. Ten percent is poorly drained and another 10 percent is deep sandy soils. (Aeric Calciaquolls)

CCPD— This unit includes 10 to 15 percent moderately well-drained soils and 10 to 15 percent silty or loamy soils. (Typic Haplaquolls)

SLPD— About 10 percent of the unit has better-drained soils and 10 percent has deep loamy soils. Another 5 percent has deep sandy soils. (Typic Calciaquolls)

SSWD— The surface is loamy in about 15 percent of the unit. About 5 percent has poorly drained soils. (Udorthentic Haploborolls)

A— Small areas of shallow peat are included in this unit. (Not classified)

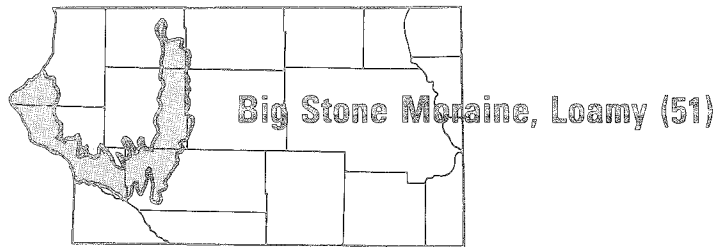
M— These areas are marshy most of the time.

LP— The unit includes about 10 percent deep peat and 10 percent mineral soils. (Terric Borosaprists)

CCWD—About 10 percent of the unit comprises poorly drained soils and 10 percent is loamy or silty. (Udertic Haploborolls)

Table 15. Selected features of soil landscape units within the Benson Lacustrine Plain, silty (50) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LLPD	45	level to depression lake plain	silt loam to silty clay loam (2-3)	loam to silty clay loam (3-4+)	8-12	poorly to very poorly drained	7.6-8.2	low	high	Colvin Winger Sletten
LLWD	32	level to gently sloping lake plain	silt loam to loam (4)	silt loam to loam (4+)	8-12	moderately well to somewhat poorly drained	7.6-8.2	low	high	Bearden McIntosh
SLWD	10	nearly level lake plain	silt loam to very fine sandy loam (2-3)	loamy very fine sand (3-4+)	4-8	moderately well to somewhat poorly drained	7.6-8.2	low	medium	Glyndon
CCPD	4	level to depression lake plain	silty clay loam to silty clay (2-4)	silty clay loam to silty clay (4)	8-12	poorly to very poorly drained	6.4-7.4	low	high	Fulda Dovray
SLPD	1	level to depression lake plain	very fine sandy loam to sandy clay loam (2-3)	loamy very fine sand (3-4+)	4-8	poorly drained	7.6-8.2	low	low to medium	Borup
SSWD	1	gently sloping beaches and lake plain	loamy fine sand, sandy loam and gravelly loam (1-2)	sand and gravel (2-4+)	<4	well drained	6.6-7.8	high	low	Sioux Maddock
A	1	nearly level stream bottoms	sand to loam (2-4)	sand to loam (4+)	4-12	poorly drained	6.1-7.2	variable	variable	Alluvial land
M	1	low lying depressions	peat or mineral soil	peat or mineral soil	1-4 feet of water on surface	marshy				
LP	1	low lying depressions	peat (1-4)	loam (4+)	8+	very poorly drained	5.5-7.3	low	low	Cathro Millerville
CCWD	1	gently sloping lake plain	clay to silty clay (4)	clay to silty clay (4+)	8-12	moderately well to well drained	6.5-7.3	low	high	Nutley Sinai
Water	4									



This region encompasses approximately 544,690 acres or 9.8 percent of the St. Cloud Sheet.

The moraine consists mainly of a rolling complex land form characterized by numerous low poorly drained areas, very small lakes, marshes, and pot holes. Many deep short ravines border Lake Traverse and Big Stone Lake. Numerous areas of nearly level to undulating topography occur. Approximately 13 percent of the land is poorly drained: the two most extensive areas located in the northwestern part and in Swift County, east of the Pomme de Terre River. The water table is over 10 feet deep over most of the upland. In lower positions the water table is surface to 6 feet deep. There are about 30 small lakes each 160 acres or more. In addition, Lake Traverse and Big Stone Lake border this unit and South Dakota. The total water area is approximately 30,500 acres.

Gray, loamy calcareous till occurs over the region. East of the Pomme de Terre River, the till generally contains a higher percent of silts. In that area a silt cap, 18 to 40 inches thick, over the till is common. Clayey soils total about 1 percent of the region. Along the Pomme de Terre and Chippewa valleys most of the soils are loams 12 to 24 inches thick over stratified sand and gravel outwash. The valleys also include some shallow gravelly loam to sandy loam soils.

The original vegetation in the Big Stone Moraine was tall grass prairie. Most of the land is in farms. Cropland totals about 70 percent of the land, pasture 25 to 30 percent, and woodland less than 5 percent. Corn, wheat, oats, hay (brome grass, alfalfa) and barley are the most extensive crops.

Ten soil landscape units are mapped: LLWD, LLPD, SLWD, A, CCPD, SSWD, CCWD, M, LP, and SLPD. Table 16 gives selected features of the units. Additional information follows:

LLWD—Poorly drained soils make up 5 to 10 percent of the unit. Less than 5 percent is sandy and gravelly. Ten to 15 percent of the unit has calcareous soils. (Udic Haploborolls)

LLPD— This unit includes 10 to 15 percent moderately well-drained soils. Twenty to 25 percent of the soil is calcareous. (Typic Haplaquolls)

SLWD—About 10 percent of the unit includes loamy soil and another 10 percent is shallow to sand and gravel. (Udic Haploborolls)

A— The unit is frequently flooded and is highly dissected by old stream channels. (Not classified)

CCPD— This unit includes about 10 percent loamy soils and 10 percent moderately well-drained soils. (Typic Haplaquolls)

SSWD— Approximately 15 percent is loamy in the upper 16 to 24 inches and about 10 percent underlain by sand. (Udorthentic Haploborolls)

CCWD—Poorly drained soils make up about 10 percent of the unit and about 5 percent is loamy. Only one area is mapped. (Udertic Haploborolls)

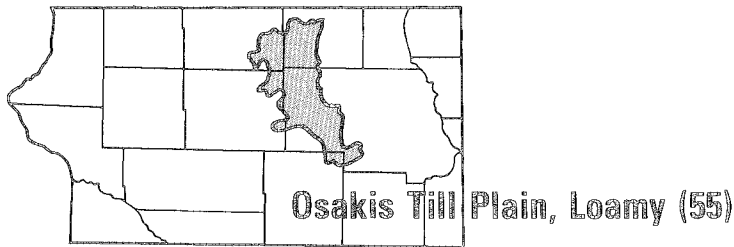
M, LP and SLPD are minor units.

Table 16. Selected features of soil landscape units within the Big Stone Moraine, loamy (51) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships			Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K		
LLWD	73	rolling upland	loam, silt loam and clay loam (4)	loam to clay loam (4-20+)	8-12	well drained	6.6-7.5	low	high	Barnes Doland Langhei, Tara Forman	
LLPD	12	nearly level to depressional upland	loam, silty loam and clay loam (4)	loam to clay loam (4-20+)	8-12	poorly to very poorly drained	6.6-7.8	low	medium	Flom Parnell Winger Vallers	

Table 16 (continued). Selected features of soil landscape units within the Big Stone Moraine, loamy (51) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
SLWD	5	nearly level to rolling outwash	loam to sandy loam (2)	sand and gravel (2-4+)	4-8	well drained	6.6-7.8	high	medium	Renshaw Arvilla
A	2	nearly level stream bottoms	loamy sand to loam (1-4)	loamy sand to loam (4+)	4-12	poorly drained	6.1-7.2	low	medium	Alluvial land
CCPD	1	nearly level to depressional	silty clay loam to silty clay (2-4)	silty clay to silty clay loam (4+)	8-12	poorly to very poorly drained	6.4-7.4	low	medium	Fulda Dovray
SSWD	1	nearly level to rolling outwash	gravelly sandy loam to sandy loam (1-2)	sand and gravel (2-4+)	<4	well drained	6.6-7.8	high	low	Sioux
CCWD	<1	gently rolling to rolling upland	clay to silty clay (4)	clay to silty clay (4+)	8-12	well to moderately well drained	6.4-7.4	low	high	Nutley Hattie
M	<1	low lying depressions	peat or mineral soil	peat or mineral soil	1-4 feet of water on surface	marshy				
LP	<1	low lying depressions	peat (1-4)	loam (4+)	8+	very poorly drained	5.5-7.3	low	low	Cathro Millerville
SLPD	<1	nearly level to depressional	sandy loam to loam (2-3)	sand, gravel and loam (3-20+)	4-12	poorly to very poorly drained	6.6-7.8	low	medium	Mayer Parnell
Water	6									



This region is approximately 474, 600 acres or 8.5 percent of the St. Cloud Sheet.

The till plain is dominantly gently rolling but includes some rolling areas bordering some lakes. Depressions and small pot holes are fairly common. The water table is over 10 feet deep on the higher positions and at the surface to 6 feet deep on lower poorly drained soils. Twenty-seven lakes each 160 acres or more and totaling 19,740 acres are located here.

The till is gray calcareous loam to clay loam. An area north of Sauk Centre is intermixed loamy and sandy till over sand and gravel.

The region was originally covered by tall prairie grass except in the northern part which was northern hardwoods. About 85 percent is cultivated with corn, wheat, and oats as the main crops. Five to 10 percent is pasture, and 5 to 10 percent is forested.

Thirteen soil landscape units are mapped: LLWD, LLPD, LLWL, SLWD, XLWL, SSWD, LLPL, SP, A, LP, NP, SLPD, and M. Table 17 gives selected characteristics. Additional information follows:

LLWD—This unit includes about 15 percent poorly drained soils, 5 to 10 percent moderately dark-colored soils, and about 5 percent shallow peat. (Typic Hapludoll)

LLPD— This unit includes 10 to 15 percent moderately well-drained soils and about 5 percent shallow peat over loamy till. (Typic Haplaquoll)

LLWL—Included in this unit is about 5 percent poorly drained soil, and about 5 percent dark colored. (Typic Hapludalf)

SLWD—The unit includes about 10 percent well-drained deep loamy soils; 10 percent shallow gravelly soils, and 5 percent poorly drained soils. (Typic Hapludoll)

XLWL—This unit includes 5 to 10 percent poorly drained soils and about 5 percent organic soils. (Typic Hapludalf)

SSWD— Approximately 15 percent of the unit has loamy surface soils, 10 percent poorly drained soils, and about 10 percent deep loamy soils. (Entic Hapludoll)

LLPL— Approximately 5 percent of the unit has well-drained soils, 5 percent darker-colored surface soils, and 5 percent shallow peat over loamy till. (Typic Albaqualf)

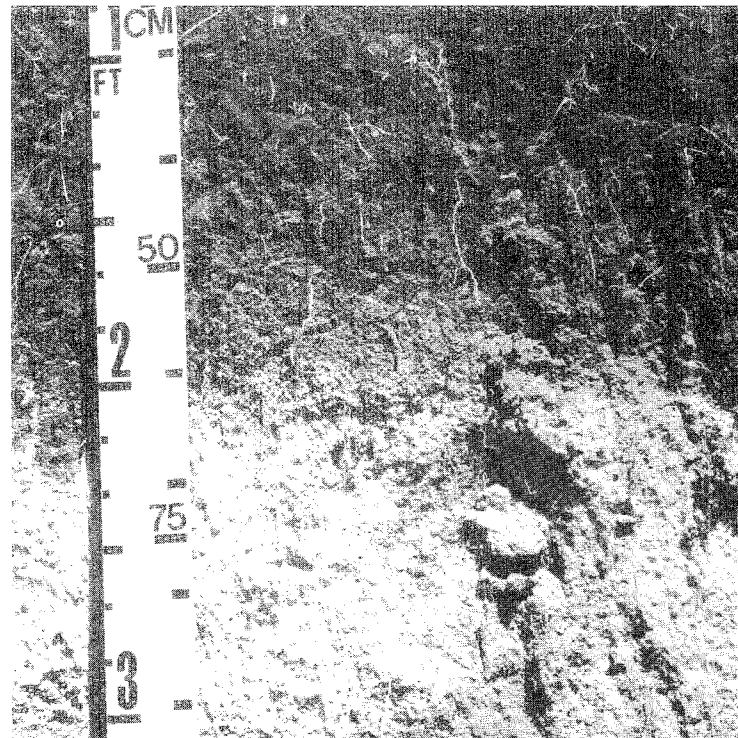
SP— This unit includes about 10 percent deep peat, 10 percent shallow peat over loamy till, and about 10 percent loamy over sand and gravel. (Terric Borosaprist)

A— About 10 percent of the unit consists of organic soils. (Not classified)

LP— Included is about 10 percent poorly drained mineral soil and about 5 percent deep peat. (Terric Borosaprist)

NP— Approximately 10 percent has poorly drained mineral soils and 15 percent shallow peat. (Typic Borosaprist)

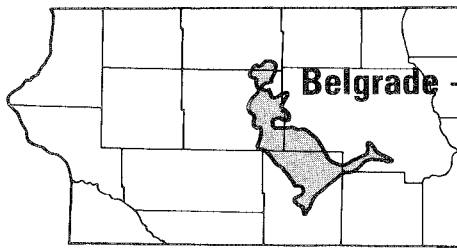
SLPD— This unit includes some alluvial soils and some well-drained loamy soils over gravel. (Typic Haplaquoll)



Soils developed under prairie vegetation in western Minnesota often have a light colored substratum layer which is an accumulation of calcium and magnesium carbonates.

Table 17. Selected features of soil landscape units within the Osakis Till Plain, Loamy (55) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LLWD	49	gently rolling to rolling upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	well to moderately well drained	6.1-7.3	low	medium	Clarion Nicollet
LLPD	18	gently sloping to depressional	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	poorly to very poorly drained	6.6-7.3	low	low to medium	Webster Glencoe
LLWL	11	gently rolling to gently rolling upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	well to moderately well drained	5.1-6.5	medium	medium	Hayden Nessel
SLWD	4	level to gently rolling outwash	sandy loam to loam (2-3)	sand and gravel (3-4+)	4-8	well drained	6.1-7.3	high	low to medium	Estherville
XLWL	3	rolling upland to depressional	loam, clay loam, loam (4)	loam, clay loam, loam (4-20+)	4-12	well drained	5.1-6.5	medium	low to medium	Hayden Burnsville
SSWD	3	nearly level to gently rolling outwash	loamy sand to sandy loam (1-2)	sand and gravel (2-4+)	<4	well drained	5.4-7.3	high	low	Salida
LLPL	2	gently sloping to depressional	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	poorly to very poorly drained	5.6-7.3	low	medium	Ames Bluffton
SP	2	low lying depressions	peat (1-4)	sand (4+)	4+	very poorly drained	6.0-7.5	low	low	Markey
A	1	narrow stream bottoms	loamy sand to loam (2-4)	loamy sand to loam (4+)	4-12	poorly drained	6.1-7.2	low	medium	Alluvial land
LP	1	low lying depressions	peat (1-4)	loam to clay loam (4+)	8+	very poorly drained	5.5-7.3	low	low	Cathro
NP	1	low lying depressions	peat (3)	peat (3-4+)	12+	very poorly drained	5.5-7.3	low	low	Seelyville
SLPD	1	level to depressional outwash	loam to silty clay loam (2-3)	sand and gravel (3-4+)	4-8	poorly to very poorly drained	6.1-7.3	low	low	Biscay Talcot
M	<1	low lying depressions	peat or mineral soils	peat or mineral soils	1-4 feet or water on surface					
Water	4									



Belgrade — Glenwood Outwash Plain, Undulating (63)

The region has approximately 319,610 acres or 5.7 percent of the St. Cloud Sheet.

The plain ranges from level to undulating and contains numerous level to depressional mineral and organic areas. The water table normally is over 10 feet deep on well-drained soils and at the surface to 6 feet deep on lower positions. Twenty-six lakes, each 160 acres or more, are located here. Total water area is about 17,400 acres.

The soils are mostly loamy to depths of 16 to 24 inches over stratified sand and gravel.

The original vegetation was primarily prairie. In Kandiyohi and Stearns counties some areas consisted of oak and scattered oak. Present land use is 70 to 75 percent under cultivation, about 10 percent pasture, and less than 5 percent woodland. Principal crops are corn, soybeans, and alfalfa brome hay. Peat and marshy areas make up 10 to 15 percent of the region. These areas are mostly idle land but some are pastured especially during dry periods and some serve as good wildlife habitats.

Thirteen soil landscape units are mapped: SLWD, SLPD, SSWD, NP, SP, LLWD, XLWL, LLWL, M, XLWD, LLPD, A, and LP. Table 18 gives selected characteristics. Additional information follows:

SLWD—An estimated 10 percent of the unit consists of sandy surfaces shallow to sand and gravel, 5 percent has poorly drained, and 5 percent organic soils. (Typic Hapludoll)

SLPD— The unit includes about 5 percent well-drained soils, 5 percent deep loamy soils, and about 5 percent organic soils. (Typic Haplaquoll)

SSWD— Approximately 10 percent of the soil is loamy and deeper to sand and gravel, 5 percent poorly drained, and 5 percent organic. (Entic Hapludoll)

NP— This unit includes about 15 percent shallow peat and 5 percent mineral soils. (Typic Borosaprist)

SP— About 10 percent of the unit consists of poorly drained mineral soils and 5 percent deep peat. (Terric Borosaprist)

LLWD—This unit includes approximately 10 percent loamy surfaces over sand and gravel and 5 percent poorly drained soils. (Typic Hapludoll)

XLWL—The unit includes some darker-colored soils, some poorly drained and some shallow organic soils. (Typic Hapludalf)

LLWL—Small areas of darker-colored soils and poorly drained soils are included. (Typic Hapludalf)

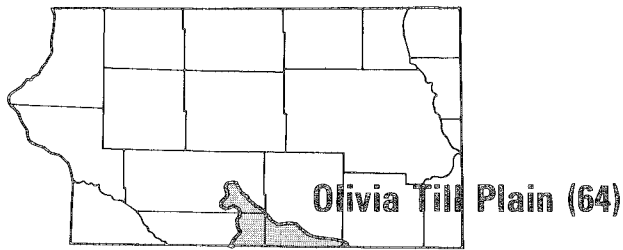
M— This area is mostly in Stearns County west of Belgrade.

XLWD—Small areas of poorly drained soils and shallow peat are included. (Typic Hapludoll)

LLPD, A, and LP are minor units.

Table 18. Selected features of soil landscape units within the Belgrade-Glenwood Outwash Plain, Undulating (63) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
SLWD	55	level to undulating outwash	sandy loam to loam (2-3)	sand and gravel (3-20+)	4-8	well drained	5.5-7.3	low	low	Estherville
SLPD	11	nearly level to depressional outwash	loam to sandy loam (2-3)	sand and gravel (3-20+)	4-8	poorly to very poorly drained	6.1-7.3	low	low	Biscaya Forada Mayer
SSWD	11	undulating outwash	loamy sand to sandy loam (1-2)	sand and gravel (2-20+)	<4	poorly drained	5.4-7.3	high	low	Salida
NP	7	level to depressional	peat (2-3)	peat (3-4+)	12+	very poorly drained	5.5-7.3	low	low	Seelyeville
SP	5	level to depressional	peat (1-4)	sand (4+)	4+	very poorly drained	6.0-7.8	low	low	Deerwood Markey
LLWD	2	gently rolling to rolling upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	well to moderately well drained	6.1-7.3	low	medium	Clarion Nicollet
XLWL	1	rolling upland	loam, clay loam, sandy loam (2-3)	loam, clay loam, sand and gravel (3-20+)	4-12	well drained	5.1-6.5	medium	low to medium	Hayden Burnsville
LLWL	1	gently rolling to rolling upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	well to moderately well drained	5.1-6.5	medium	medium	Hayden Nessel
M	1	low lying depressions	peat or mineral soils	peat or mineral soils	1-4 feet of water on surface					
XLWD	1	rolling upland	loam, sandy loam and loamy sand (1-4)	loam, sand and gravel (4-20+)	4-12	well drained	6.2-7.3	low to high	low to medium	Clarion Estherville Salida
LLPD	<1	nearly level to depressional	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	poorly to very poorly drained	6.6-7.3	low	low to medium	Webster Glencoe
A	<1	narrow stream bottoms	loamy sand to loam (2-4)	loamy sand to loam (4+)	4-12	poorly drained	6.1-7.2	low	medium	Alluvial land
LP	<1	level to depressional	peat (1-4)	loam (4+)	8+	very poorly drained	5.5-7.3	low	low	Cathro
Water	5									



This region has approximately 210,380 acres or 3.5 percent of the St. Cloud Sheet.

The Olivia Till Plain consists of gently undulating relief along with many nearly level to low depressional areas. Depths to seasonally high water tables are less than 5 feet in most of the region. Thirteen lakes, 160 acres or larger, totaling 8,640 acres, are located here.

The soils developed in limy, grayish, loam till. Small pockets of sandy and gravelly areas occur. These are too small to show on the map as separate soil landscape units. The till contains a silt cap, generally less than 4 feet thick in some areas.

The regional vegetation was tall prairie grass except for narrow bands of woods bordering some streams and lakes. Corn, soybeans, oats, and wheat are the main crops. Very little land is in woodland and pasture.

Four soil landscape units are mapped: LLPD, LLWD, NP, and LP. Table 19 gives selected features of the units. Additional information follows:

LLPD— Approximately 15 percent of the unit has moderately well-drained and 10 to 15 percent has alkaline soils. (Typic Haplaquolls)

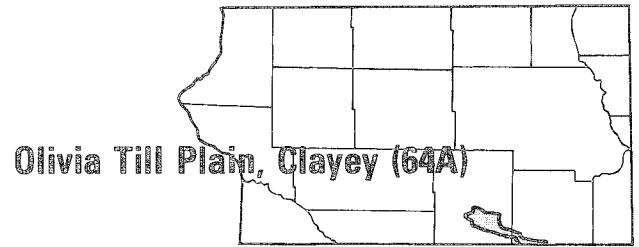
LLWD— Approximately 15 percent is poorly drained and 10 percent is alkaline. (Typic Hapludolls)

NP— This unit includes about 20 percent shallow peat soils and 10 percent poorly drained mineral soils. (Euic Typic Borosaprists)

LP— Approximately 15 percent is deep peat soil and 15 percent mineral. (Terric Borosaprists)

Table 19. Selected features of soil landscape units within the Olivia Till Plain (64) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LLPD	61	gently sloping to depressional upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	poorly to very poorly drained	6.6-7.3	low	low to medium	Webster Glencoe Flom, Quam
LLWD	34	gently rolling to rolling upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	moderately well to well drained	6.1-7.5	low	medium	Clarion Nicollet Barnes, Svea
NP	1	low lying depressions	peat (1-3)	peat (3-4+)	12+	very poorly drained	5.5-7.3	low	low	Seelyeville
LP	<1	low lying depressions	peat (1-4)	loam to clay loam (4+)	8-12+	very poorly drained	5.5-7.3	low	low	Cathro Millerville
Water	4									



This geomorphic region is approximately 81,980 acres, or 1.5 percent of the St. Cloud Sheet.

The Olivia Till Plain consists of an undulating to gently rolling ground moraine. Approximately 32 percent of the region is clayey, indicating that ice-blocked lakes probably existed for periods long enough for clays to be deposited on the loamy till. Seasonally high water tables are generally more than 5 feet deep on higher ground and less than 5 feet deep on lower positions. Six lakes of 160 acres or more occur in the region. The total water area is 5,350 acres.

Most of the soils are loamy. Some areas contain a shallow silt cap. A few small areas of sandy and gravelly soils also occur.

The original vegetation was tall prairie grass. Later open hardwood forest advanced over the region and has had some influence on the soil characteristics. Corn, soybeans, wheat, and oats are the main crops. Cropland makes up over 90 percent of the land; pastures, another 5 percent. Marshy and peat areas make up less than 5 percent.

Six soil landscape units are mapped in the region: LLWD, LCWD, LLPD, LCPD, LP, and M. Table 20 gives selected features of the units. Additional information follows:

LLWD— Approximately 15 percent of the unit has poorly drained soils, 10 percent has clayey surfaces,

and less than 5 percent has sandy surfaces. (Mollic Hapludalfs)

‡LCWD—The unit includes 10 to 15 percent deep loamy soils and 5 to 15 percent poorly drained soils. (Aquic Hapludolls)

LLPD— An estimated 10 to 20 percent of the unit has moderately well-drained soils, 5 to 15 percent has clayey surfaces, another 5 to 15 percent has alkaline, and less than 5 percent has shallow peat soils. (Typic Haplaquolls)

LCPD— Approximately 10 percent of the unit has better drained, 10 percent has deep loamy, 5 percent has alkaline soils and less than 5 percent has shallow peat over loamy till. (Typic Haplaquolls)

LP— This unit includes about 10 percent deep peat and 10 percent mineral soils. (Terric Borosaprists)

M— The water level fluctuates with the lake levels.

‡The soil landscape unit, CLWD, which occurs in this region has an incorrect symbol and color on the map. The correct symbol is LCWD and the color should correspond with the symbol.

Table 20. Selected features of soil landscape units within the Olivia Till Plain, clayey (64A) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships Inches of available water to 5 feet	Drainage class	Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum			pH	P	K	
LLWD	49	gently rolling to rolling upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12+	moderately well to well drained	6.1-7.3	low	medium	Lester LeSueur
LCWD	23	level to gently undulating upland	clay loam to silty clay loam (1-2)	silty clay loam to silty clay (2-4+)	8-12	moderately well drained	5.6-6.5	medium	medium	Guckeen
LLPD	9	gently sloping to depressional upland	loam, clay loam, and silty clay loam (4)	loam, clay loam, and silty clay loam (4-20+)	8-12	poorly to very poorly drained	6.1-7.3	low to medium	low to medium	Webster Cordova Glencoe

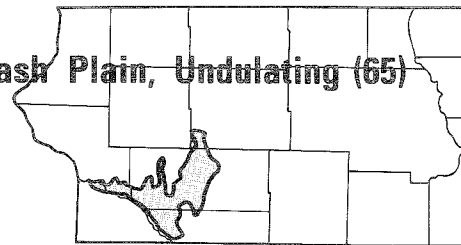
Table 20 (continued). Selected features of soil landscape units within the Olivia Till Plain, clayey (54A) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LCPD	9	nearly level to depressional upland	silty clay loam (2-3)	clay loam (3-4+)	8-12	poorly to very poorly drained	6.1-6.5	low to medium	medium	Marna Lura
LP	2	low lying depressions	peat (1-4)	loam to clay loam (4+)	8-12+	very poorly drained	5.5-7.3	low	low	Cathro Millerville
M	1	low lying depressions	peat or mineral soil	peat or mineral soil	1-4 feet of water on surface	marshy				
Water	7									



Drainage ditches provide outlets for underground tile systems which are essential to farming the extensive LLPD soils in the Olivia Till Plain.

Appleton-Clontarf Outwash Plain, Undulating (65)



The region has approximately 244,800 acres or 4.4 percent of the St. Cloud Sheet.

The outwash plain has a level to gently sloping land form, drained by the Chippewa and Pomme de Terre rivers. Two lakes, each 160 acres or more occur. The total water area is about 2,685 acres. The water table in well-drained soils is normally more than 6 feet deep and in poorly drained soils surface to 6 feet deep. The region is nearly equally divided between well-drained and poorly drained soils.

Over most of the region the upper 16 to 36 inches range from loamy to silty surfaces. The substrata has fine sand to stratified sand and gravel. Some lacustrine areas are included.

The original vegetation in the outwash plain was tall prairie grass. Some bottomland hardwoods occurred along the alluvial plains of the main streams. An estimated 90 to 95 percent of the region is cultivated, and 5 to 10 percent is pastured. Main crops are corn, soybeans, and wheat.

Thirteen soil landscape units are mapped in the regions: SLWD, SLPD, LLWD, LLPD, A, SSWD, LSWD, SSPD, M, CCPD, CLPD, CCWD, and LP. Table 21 gives selected features of the units. Additional information follows:

SLWD—This unit includes 10 to 20 percent poorly drained soils. About 10 percent of the unit has soils shallow to gravel and about 5 percent has loamy soils. (Udic Haploborolls)

SLPD— About 10 percent of the unit has well-drained soils, 5 to 10 percent has loamy and silty soils. (Typic Calciaquolls)

LLWD—The unit includes 10 to 20 percent poorly drained soils. These soils occur on both till and lacustrine areas. Five to 10 percent are loamy over sand and gravel. (Pachic Udic Haploborolls)

LLPD— About 10 percent has well-drained soils and 5 to 10 percent is underlain by sand below 10 to 20 inches. (Typic Calciaquolls)

A— This unit floods frequently and is highly dissected by old stream channels. (Not classified)

SSWD— Approximately 15 percent of the unit has loamy surfaces over sand and gravel. Another 5 percent is sandy over loamy. (Udorthentic Haploborolls)

LSWD—About 10 percent of the unit has poorly drained soils having sandy substrata. (Aquic Haploborolls)

SSPD— Minor areas of loamy soils 20 to 30 inches deep over sand are included. Small areas of well-drained soils are also included. (Typic Haplaquolls)

M— Most of this unit consists of shallow peat over sand.

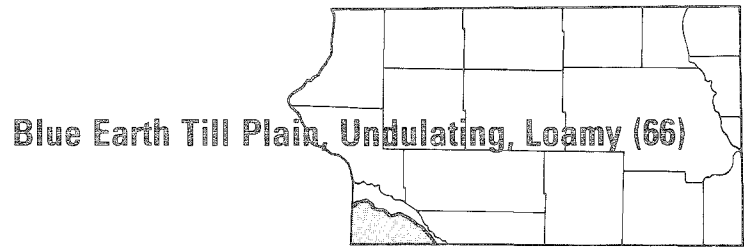
CCPD— This unit includes 10 to 20 percent deep sandy soils. About 10 percent of the clayey soils are moderately well drained. (Typic Haplaquolls)

CLPD— About 20 percent of the soils in this unit are loamy or silty in the substrata. (Typic Calciaquolls)

CCWD and **LP** are minor units.

Table 21. Selected features of soil landscape units within the Appleton-Clontarf Outwash Plain, undulating (65) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
SLWD	34	level to gently sloping outwash	sandy loam, loam, and silt loam (2-3)	sand or sand and gravel (3-20+)	4-8	well drained	6.6-7.8	high	medium	Renshaw Fordville Estelline
SLPD	30	nearly level to depressional	sandy loam to loam (2-3)	sand (3-20+)	4-8	poorly to very poorly drained	7.4-8.4	low	low	Marysland Arveson
LLWD	11	gently rolling upland	silt loam to loam (4)	loam (4-20+)	8-12	well to moderately well drained	6.6-7.5	low	high	Tara Barnes Hamerly
LLPD	9	nearly level lacustrine	silty clay loam to silt loam (4)	silt loam to silty clay loam (4+)	8-12	poorly drained	7.6-8.2	low	high	Colvin Perella
A	5	narrow stream bottoms	loamy sand to silty clay loam (2-4)	loamy sand to silty clay loam (4+)	4-12	poorly drained	6.1-7.2	low	medium	Alluvial land Rauville
SSWD	3	level to gently sloping outwash	gravelly sandy loam to sandy loam (1-2)	sand and gravel (2-4+)	<4	well drained	6.6-7.8	high	low	Sioux
LSWD	3	gently sloping to level lacustrine	loamy fine sand (2-4)	fine sandy loam (4+)	4-8	moderately well drained	6.6-7.8	high	low	Hecla
SSPD	1	level to depressional lacustrine	fine sandy loam to fine sand (1-2)	fine sand (2-4+)	<4	poorly to very poorly drained	7.0-7.8	medium	low	Fossum Venlo
M	1	low lying depressions	peat, muck or mineral soil	peat, muck or mineral soil	1-4 feet of water on surface	marshy				
CCPD	1	level to gently sloping	silty clay to clay (4)	silty clay to clay (4+)	8-12	poorly drained	6.4-7.4	low	medium	Fulda
CLPD	1	nearly level lake plain	fine sandy loam, loam, and silt loam (2-4)	silty clay loam to silty clay (4+)	8-12	poorly drained	7.6-8.2	low	high	Unnamed
CCWD	<1	nearly level to gently sloping lacustrine	silty clay to clay (4)	clay to silty clay (4+)	8-12	moderately well drained	6.4-7.4	low	high	Nutley
LP	<1	low lying depressions	peat (1-4)	loam (4+)	8+	very poorly drained	5.5-7.3	low	low	Cathro
Water	1									



The region has approximately 204,430 acres or 3.7 percent of the St. Cloud Sheet.

It is characterized as a weak lateral moraine formed during shrinkage of the ice lobe. The relief is generally undulating but includes a few more rolling areas. Nearly level to depressional poorly drained areas are common throughout the region. Depth to seasonally high water table is more than 5 feet on well-drained soils and less than 5 feet in lower positions. Six lakes of 160 acres or more are located in the region. The total water area is approximately 8,600 acres.

The till covering this region is grayish, limy, and loamy. In places it contains a silt cap up to 4 feet thick. Sandy soils make up only about 2 percent of the region.

The original vegetation was tall prairie grass. Northern hardwoods of elm, oak, and basswood bordered some streams and lakes. Present crops are mainly corn, soybeans, wheat, oats, and hay (brome grass, alfalfa). Very little woodland and pasture exist in the region.

Seven soil landscape units are mapped: LLWD, LLPD, CCPD, SLWD, SLPD, A, and M. Table 22 gives selected features of the units. Additional information follows:

LLWD—An estimated 10 to 15 percent of the unit has poorly drained soils. Another 5 to 15 percent has alkaline soils and less than 5 percent has deep sandy or gravelly soils. (Udic Haploborolls)

LLPD— Approximately 25 percent of the soil in the unit is alkaline. Another 15 percent is moderately well drained. The unit also included a small amount of clayey soils. (Typic Haplaquolls)

CCPD— Moderately well-drained soils make up to 10 to 15 percent of the unit. Ten to 15 percent is loamy. (Typic Haplaquolls)

SLWD and SLPD—These two units include about 10 percent deep loamy soils. (Udic Haploborolls)

A— The soils are subject to frequent overflow. (Not classified)

M— Only one small area is mapped.

Table 22. Selected features of soil landscape units within the Blue Earth Till Plain, undulating, loamy (66) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
LLWD	64	undulating to gently rolling upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	well drained	6.6-7.8	low	high	Barnes Langhei
LLPD	24	nearly level to depressional upland	loam to clay loam (4)	loam to clay loam (4-20+)	8-12	poorly to very poorly drained	6.6+	low	medium	Flom Vallers Quam
CCPD	5	nearly level to depressional lake plain	silty clay loam to silty clay (2-4)	silty clay to silty clay loam (4+)	8-12	poorly to very poorly drained	6.5-7.3	low	high	Fulda Dovray
SLWD	1	level to sloping outwash plain	loam to sandy loam (2-3)	sand and gravel (3-4+)	4-8	well drained	6.6-7.3	medium	low to medium	Fordville Arvilla Sverdrup
SLPD	1	level to depressional outwash plain	loam to sandy loam (2-3)	sand and gravel (3-4+)	4-8	poorly to very poorly drained	6.6-7.3	medium	medium	Forada

Table 22 (continued). Selected features of soil landscape units within the Blue Earth Till Plain, undulating, loamy (66) geomorphic region

Soil landscape unit	Percent geomorphic region	Landscape position	Most common texture and thickness (feet)		Moisture relationships		Approximate fertility in rooting zone			Representative soil series
			Rooting zone	Substratum	Inches of available water to 5 feet	Drainage class	pH	P	K	
A	1	nearly level stream bottoms	variable: loamy sand to silt loam (1-4)	variable: loamy sand to silt loam (4+)	4-12	poorly drained	5.6+	variable	variable	Alluvial land
M	<1	low lying depressions	peat or mineral soil	peat or mineral	1-4 feet of water on surface	marshy				
Water	4									

Soil Conservation Service engineers designed this infiltration terrace to treat feedlot runoff. The loamy texture of the till plain geomorphic regions provide effective soil absorption of phosphorus and treatment of pathogens.



DEVELOPMENT OF LANDFORMS IN THE ST. CLOUD AREA

The shaping of landforms in the St. Cloud Sheet area may be divided into five phases: 1) Hewitt, 2) St. Croix, 3) Alborn, 4) Mankato, and 5) Agassiz. A short writeup of each as related to the landforms follows.

1. Hewitt Phase (more than 40,000 years ago)

The Wadena lobe probably advanced from the northwest down the shallow Red Lakes lowland of northwestern Minnesota, moving in a southeast direction. At this time the contemporaneous Rainy lobe advancing in a southwest direction probably diverted the Wadena lobe to the southwest. It later fanned to the west and south. In the St. Cloud Sheet the lobe was moving south to form the Todd Drumlin Area (7B).

It is reasonable to believe that the Des Moines lobe occupied the Red River lowland. It is lower in elevation than the Red Lakes lowland in which the Wadena lobe advanced.

The till does not contain Cretaceous shale indicating the source was southeastern Manitoba northeast of the area of Cretaceous bedrock.

2. St. Croix Phase (35,000 to 16,000 years ago)

As the Wadena lobe retreated northward, the Rainy lobe was advancing. On its left flank it was converging with the Superior lobe which was thicker and moving more rapidly in the deep lowlands. The right flank of the Superior lobe became mixed with the Rainy. This portion, called the Pierz sublobe, formed the Brainerd-Pierz Drumlin Area (10C) and the Darling Drumlin Area (10B). In the St. Cloud Sheet area the Pierz sublobe terminated at the St. Croix Moraine Complex (9). The till is brown to reddish brown, loamy, neutral to acid, and stony.

The Brainerd sublobe which consisted of the western part of the Rainy lobe advanced separately from the Superior Lobe terminating at the northernmost segment of the St. Croix Moraine (located in the Brainerd Sheet area). Here it met at an angle the Wadena lobe at the Itasca Moraine. Meltwaters from these two moraines carried sediments which formed the Park Rapids - Staples Outwash Plain (8) and some of the Mississippi Valley Outwash (29).

3. Alborn Phase (more than 11,600 years old)

Drainage from Glacial Lakes Aitkin I and Upham I during the Automba Phase probably deposited some sediments in the early formative stage of the Crow Wing Outwash Plain (13) and Mississippi Valley Outwash (29). Later, during the Alborn Phase, meltwaters from the St. Louis sublobe finally developed these two landforms.

4. Mankato Phase (18,000 to 14,000 years ago)

The main Des Moines lobe formed the surface drift of the Alexandria Moraine Complex (3) and buried the western and southern edge of the Todd Drumlin Area (7B). The Grantsburg sublobe, an off-shoot of the Mankato lobe moved northeastward, overrode the St. Croix Moraine, and terminated in Wisconsin. The St. Croix Moraine was

still occupied by decaying stagnant ice. The reddish-brown stony loamy and limy gray shale-rich drift are mixed in a number of locations indicating the areas where the Grantsburg sublobe overrode the St. Croix Moraine from the southwest.

In the meantime the Des Moines lobe had moved southward through Mankato and into Iowa. On its retreat the Blue Earth (66), Olivia (64), Olivia, Clayey (64A), and Osakis (55) Till Plains were formed. The Waconia-Waseca Moraine (34) was also formed by this lobe. By this time the Grantsburg sublobe had retreated to become part of the Des Moines lobe. It may have contributed some to forming the northern part of the Waconia-Waseca Moraine. Meltwaters, when the ice sheet was at the Alexandria Moraine complex (3), developed the Belgrade-Glenwood Outwash Plain (63). The ice then retreated northwest to the divide between the Minnesota and Red River valleys. Here it formed the Big Stone Moraine (51) and discharged great floods of outwash across the till plain to the southeast, thereby originating the Minnesota Valley Outwash (32). Further retreat opened the basin of Glacial Lake Agassiz north of the Big Stone moraine, and formed the Graceville Till Plain (2E).

The Des Moines lobe topography indicates ice stagnation and disintegration features. The Waconia-Waseca Moraine (34) contains landforms most clearly related to ice decay. Moraines (3) and (51) show some indication of ice stagnation. Several ground moraines (2E, 64A, 66) are somewhat similar but have low relief. The tops may have been occupied by ice-surrounded lakes, in which lacustrine clays and silts were deposited. This may account for the clayey areas occurring in these land forms. Geomorphic regions (2E) and (64A) contain extensive clayey areas (62 percent in 2E and 32 percent in 64A). In the Graceville Till Plain (2E) the clayey soils occur in one continuous area. It may have existed as a relatively large ice bound glacial lake.

Meltwaters carried down the Pomme de Terre and Chippewa river valleys were blocked along the south and east to form the Benson Lacustrine Plain (50). Sediments from the same source formed the Appleton-Clontarf Outwash Plain (65). As the lobe retreated farther north the Fergus Falls Till Plain (2) was formed. The Des Moines lobe deposited grayish, limy loamy till, high in Cretaceous shale.

A later theory suggests that the Des Moines lobe advanced down the Minnesota lowlands, then northeast along the Minneapolis lowland—the path of the Grantsburg sublobe. After the glacier had filled the lowlands it advanced south into Iowa.

5. Agassiz Phase (about 12,000 to 9,200 years ago)

Glacial Lake Agassiz was first formed in the Red River Lowland during the retreat of the Des Moines lobe at the end of the Mankato Phase. The highest major beach (Herman) formed at 1,060 feet above sea level. The maximum water depth south of Fargo, North Dakota at that time

was less than 200 feet. As the outlet was eroded the lake level lowered and stabilized at several levels and formed several beaches. Three additional beaches (Norcross at 1,040 feet, Tintah at 1,020 feet, Campbell at 980 feet above sea level) occur in the St. Cloud Sheet. However, only a small part of the Campbell beach extends into the sheet area.

Glacial River Warren, the main southern drainage outlet of the lake, cut the present deep, wide valley to form the Minnesota Valley Outwash (32). The several terrace levels along the valley are either local outwash deposits, or are related to downcutting of the river as the elevation and positions of the lake's outlet changed. In places the floor of the valley has been scoured out almost to bedrock leaving only a thin layer of bouldery till of an original valley fill.

The Campbell water level was the lowest phase of Lake Agassiz to drain south through River Warren. This phase was apparently longer than any other because of the massive beach formed during this stage. The sand and gravel of the Campbell beach are well rounded and well sorted as compared to other beaches formed by the lake, an indication of duration. This stage dates back about 10,500 years. Finally about 9,200 years ago the ice retreated far enough north to uncover a lower outlet, in Canada, to the east into Lake Superior.

Most of the plain consists of shallow lacustrine loamy to clayey sediments over loamy till. The beaches generally range from 2 to 15 feet high and 150 to 500 feet wide made up of stratified sand and gravel. Because they are better drained than the plain proper, many villages and farmsteads are located on the ridges which are a good source of gravel.

CLIMATE OF THE ST. CLOUD SHEET AREA

The climate of any land area is an extremely important component of the resources. Climate affects, to some degree, most people's activities.

Some of the general climate characteristics of this area appear in a series of figures. The area has a typical continental climate with wide temperature extremes from summer to winter. Total annual precipitation ranges from less than 22 inches in the western edge to 28 inches in the southeast corner (figure 1).

The average number of days with more than 6 inches of snow on the ground ranges from 60 in the northeast part of the sheet to 30 days in southwest (figure 2).

The length of the frost free growing season is quite uniform in the St. Cloud Sheet as shown in figures 3 and 4. The spring average date of last occurrence of 32° F ranges from May 7 to May 12, and the average fall date of 32° F ranges from September 26 to October 1.

One of the important aspects of the climate is the temperature and moisture range which occurs within the soil and within the air several feet above ground. The nature of the soil, local topography, direction of slope and vegetation all interact to modify long-term air temperature averages. For example areas close to a large lake will have a slightly modified climate with cooler summer temperatures and later fall frost dates. The outwash plain soils are sandy and have a relatively low water holding capacity,

while most lacustrine soils are silty or clayey with a high water holding capacity.

Surprising differences in temperatures and wind velocities can result from differences in location of lake residences. Usually lake homes or cabins on the south and east shore of a lake will have a cooler, more windy site than one located on the west or north because prevailing winds are from the northwest. Shelter from trees or hills is another important factor.

Additional information about the climate of the area is available from references at the end of this report.

AGRICULTURE

Farming and associated agribusiness is the most important economic activity and largest land use in the St. Cloud sheet area. Approximately 84 percent of the land was farmland in 1974 based on an estimate from five representative counties and 54 percent of total land area was used for harvested cropland. The value of the agricultural production from this land was about \$588 million in 1974 based on Census of Agriculture statistics for representative counties.

The type of farming varies throughout the St. Cloud Sheet and the various types of farm operations are closely related to soils and climate. The three principal types of farming are 1) dairy, diversified crop, and livestock, 2) irrigation, and 3) cash grain.

The dairy-diversified farms are located primarily in the eastern part of the sheet in the St. Croix moraine, the Waconia-Waseca moraine, and the Alexandria moraine complex geomorphic areas. Irrigation is concentrated in the Belgrade-Glenwood Outwash Plain, but new irrigation is being developed along the Mississippi River north of St. Cloud and on the Appleton-Clontarf Outwash Plains in the southwest part of the St. Cloud Sheet.

The beef cow herd operation is another type of farming that is scattered throughout the St. Cloud Sheet. These types of farms are often operated by people who get income from off-farm employment. Part-time farming is quite common in areas of Minnesota where off-farm employment is available. In the St. Cloud Sheet these types of operations are more common in the eastern counties.

According to the 1974 agricultural census about 17 percent of the farmers in Stearns and Meeker counties derived over 50 percent of their income off the farm while it is 4 to 8 percent in Traverse, Swift, and Big Stone counties.

Following are agricultural statistics from the 1974 Census of Agriculture for representative counties.

Table 23. Selected agricultural data, 1974

County	Total land area, acres	Harvested cropland, acres	Value of ag products per crop acre	Average size of farm, acres
Big Stone	313,792	199,668	\$128	438
Pope	428,288	219,886	155	311
Stearns	858,880	414,221	238	205
Swift	473,216	314,753	198	385
Traverse	363,776	267,160	129	535

Figure 1. Average daily maximum temperature during July

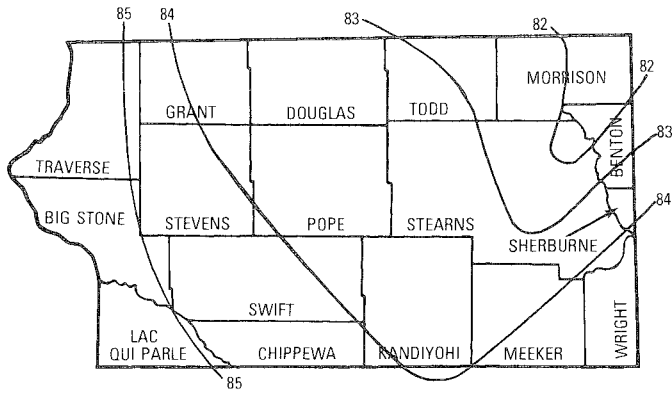


Figure 2. Average daily minimum temperature during July

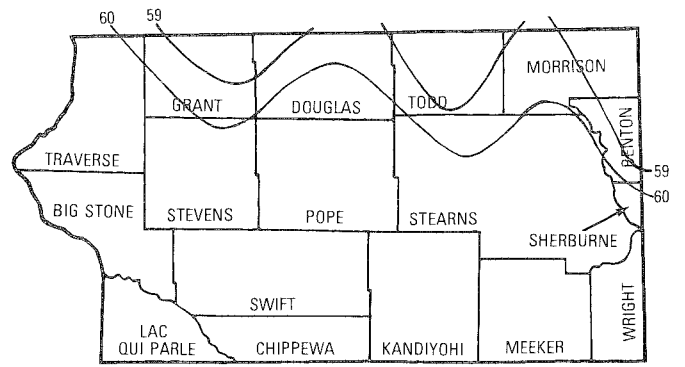


Figure 3. Average data of last occurrence of 32°F or lower in the spring

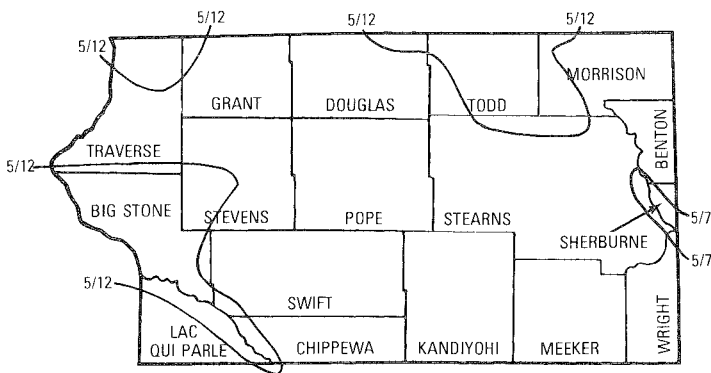


Figure 4. Average data of first occurrence of 32°F or lower in the fall

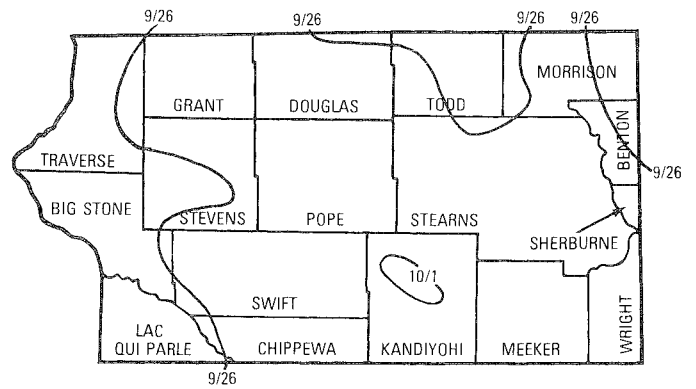


Figure 5. Mean annual precipitation, inches (1951-70)

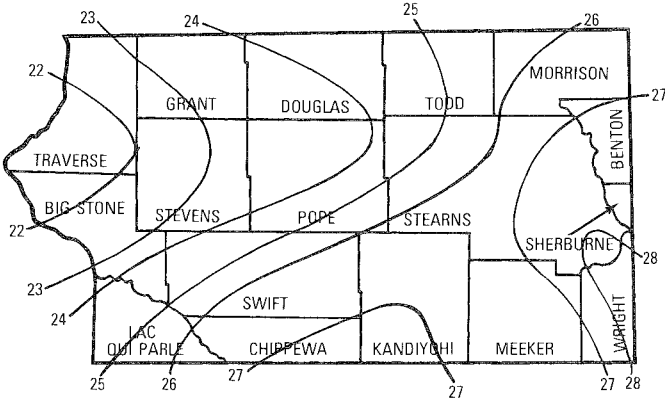


Figure 6. Summer (June, July, August) normal precipitation (1951-70)

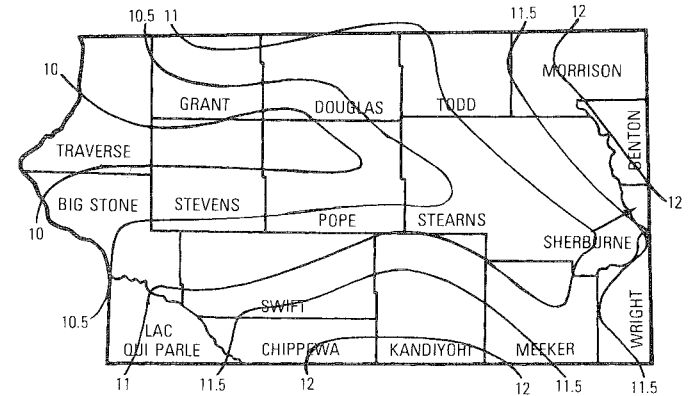


Figure 7. Average number of days with >6 inches of snow on the ground (1951-70)

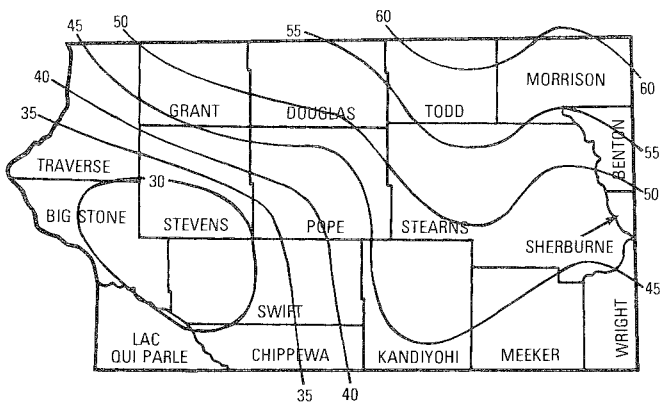
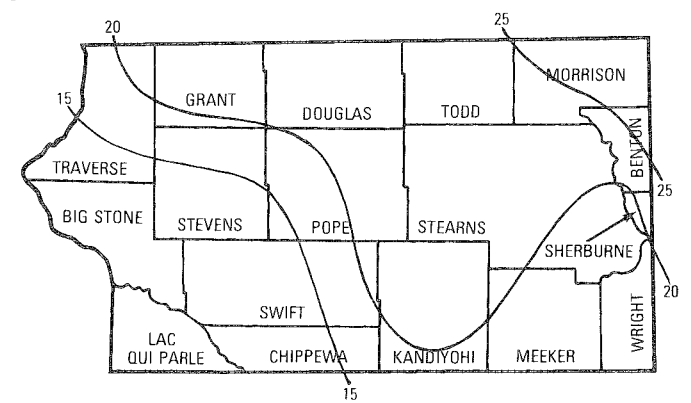


Figure 8. Average number of days with >12 inches of snow on the ground (1951-70)



WOODLAND

The highest woodland concentration occurs in the St. Croix Moraine Complex (9) and Minnesota Valley Outwash (32). Other regions having 10 to 20 percent of the land in woodland are: Todd, Darling, and Brainerd-Pierz drumlin areas (7B, 10B, 10C), Alexandria Moraine Complex (3), and the Crow Wing Outwash Plain. Most of the woodland occurs on droughty soils, flood plains, and land too steep for agricultural use. The stands are now generally understocked.

For some timber interpretations on certain soil landscape units, see table 24. Since the St. Cloud Sheet is primarily an agricultural area the interpretations are specifically for soils which were originally forested. The timber interpretations in respect to seedling mortality, productivity for pulpwood and sawtimber, and species recommendations are based on physical and chemical characteristics of the soils, prevailing water table positions and general climatic considerations. Prevalence of disease and insect control problems are also reflected in the interpretations.

Table 24. Some timber interpretations within geomorphic regions of the St. Cloud Sheet are based on soil characteristics

Geomorphic regions	Soil landscape unit	Seedling mortality	Root restrictions	Forest productivity		Recommended species
				Pulpwood	Sawtimber	
Alexandria Moraine Complex (3) Belgrade-Glenwood Outwash Plain (63)	LLWL	slight to moderate	slight	good to excellent	good to excellent	basswood, oak, green ash, black walnut, white spruce, red pine, white pine
Todd Drumlin Area (7B) Park Rapids-Staples Outwash Plain (8)	LLWL	slight to moderate	slight	good to excellent	good to excellent	green ash, white birch, red pine, white spruce, basswood, white pine
St. Croix Moraine Complex (9) Darling Drumlin Area (10B) Brainerd-Pierz Drumlin Area (10C) Crow Wing Outwash Plain (13) Mississippi Valley Outwash (29)	LLWL LSWL	slight to moderate	moderate	good	good	white spruce, red pine, white birch, aspen, white pine
Alexandria Moraine Complex (3) St. Croix Moraine Complex (9) Mississippi Valley Outwash Plain (29)	SLWL XLWL	slight	slight	fair to good	fair	white spruce, red pine, aspen, white pine
Alexandria Moraine Complex (3) Brainerd-Pierz Drumlin Area (10C) Mississippi Valley Outwash (29)	SSWL	slight	slight	fair	poor	jack pine, white spruce, aspen
St. Croix Moraine Complex (9) Darling Drumlin Area (10B) Brainerd-Pierz Drumlin Area (10C) Park Rapids-Staples Outwash Plain (8)	SSWL XLWL	slight	moderate	fair	poor	jack pine, white spruce, aspen
Todd Drumlin Area (7B) Park Rapids-Staples Outwash Plain (8) St. Croix Moraine Complex (9) Darling Drumlin Area (10B) Crow Wing Outwash Plain (13)	LLPL LSPL SLPL	moderate to severe	moderate to severe	good	fair	black spruce, white spruce, black ash, aspen
Crow Wing Outwash Plain (13)	SSPL	moderate to severe	moderate to severe	fair	poor	black ash, aspen, black spruce, white spruce
All regions for alluvial land (A) Lamoure and LaPrairie are primarily in the Minnesota Valley Outwash (13)	A LLPD LLWD	moderate to severe	moderate to severe	good	fair	basswood, green ash, cottonwood, hackberry, boxelder
All regions	NP, SP LP, P	moderate to severe	severe	fair	poor	black spruce

RECREATION

The recreational use of land and water is increasing with the increasing population (permanent and tourist) of the St. Cloud Sheet area. Recreational use of land takes on many aspects—from intensive playground use to extensive use as in nature and hiking trails.

Table 25 is a general outline of kinds of limitations for various recreational activities as they may be adapted in the several soil landscape units of the St. Cloud Sheet area. In the selection of recreational areas the total landscape generally needs to be considered. In the review of a given area, several soil landscape units may occur and should be evaluated collectively. Also, an association of land and water will be a significant consideration. A study of the map will reveal areas where these associations occur.



An inviting hiking trail in one of central Minnesota's recreation areas.

Table 25. Degree and kinds of limitations for specified recreational uses

Landscape unit	Description	Playground, athletic field and intensive play areas	Picnic areas, parks and extensive play areas	Bridle paths, nature and hiking trails	Golf course fairways
SSWD	Sandy over sandy, well-drained, dark-colored soils.	Moderate to severe—difficult to maintain vegetation. Moderate—sandy surface soil. Moderate—2-6% slopes. Severe—over 6% slopes.	Moderate—difficult to maintain vegetation sandy surface soil. Moderate—6-12% slopes. Severe—above 12% slopes.	Moderate—sandy surface soil. Moderate—12-18% slopes. Severe—over 18% slopes.	Severe—difficult to maintain vegetation; low natural fertility. Moderate—sandy surface soil. Moderate—6-12% slopes. Severe—12% slopes.
SSPD	Sandy over sandy, poorly drained, dark-colored soils	Moderate—high water table.	Moderate—high water table.	Moderate—high water table.	Moderate—high water table and low natural fertility.
SSWL	Sandy over sandy, well-drained, light-colored soils.	Moderate to severe—difficult to maintain vegetation. Moderate—sandy surface soil. Moderate—2-6%. Severe—over 6% slope.	Moderate—difficult to maintain vegetation. Moderate—6-12% slopes. Severe—over 12% slopes.	Moderate—sandy surface soil. Moderate—12-18% slopes. Severe—over 18% slopes.	Moderate to severe—low natural fertility; difficult to maintain vegetation. Moderate—sandy surface soil. Moderate—6-12% slopes. Severe—over 12% slopes.
SSPL	Sandy over sandy, somewhat poorly drained, light colored soils	Moderate—high water table.	Moderate—high water table.	Moderate—high water table.	Moderate—high water table and low natural fertility.
SLWD	Loamy over sandy, well-drained, dark-colored soils.	Slight—0-2% slopes. Moderate—2-6% slopes.	Slight.	Slight.	Slight.
SLPD	Loamy over sandy, poorly drained, dark-colored soils.	Severe—high water table. Moderate—surface soil is sticky and soft when wet.	Severe—high water table. Moderate—surface soil is sticky and soft when wet.	Severe—high water table. Moderate—surface soil is sticky when wet.	Moderate—high water table.

Table 25 (continued). Degree and kinds of limitations for specified recreational uses

Landscape unit	Description	Playground, athletic field and intensive play areas	Picnic areas, parks and extensive play areas	Bridle paths, nature and hiking trails	Golf course fairways
SLWL	Loamy over sandy, well-drained, light colored soils.	Slight—0-2% slopes. Moderate—2-6% slopes. Severe—over 6% slopes.	Slight—2-6% slopes. Severe—over 12% slopes.	Slight—2-12% slopes. Severe—over 18% slopes.	Slight—2-6% slopes. Moderate—6-12% slopes. Severe—over 12% slopes.
LSWD	Sandy over loamy well-drained dark-colored soils.	Moderate—0-2% slopes vegetation difficult to maintain in some places. Severe—over 6% slopes.	Moderate—vegetation difficult to maintain in some places. Moderate—6-12% slopes. Severe—over 12% slopes.	Slight—2-12% slopes. Moderate—12-18% slopes. Severe—over 18% slopes.	Moderate—vegetation may be difficult to maintain in some spots. Moderate—6-12% slopes. Severe—over 12% slopes.
LSWL	Sandy over loamy, well-drained, light-colored soils.	Moderate—few surface stones; vegetation difficult to maintain in some places. Moderate—2-6% slopes. Severe—over 6% slopes.	Moderate—vegetation difficult to maintain in some places. Moderate—6 to 12% slopes. Severe—over 12% slopes.	Slight—2 to 12% slopes. Moderate—12 to 18% slopes. Severe—over 18% slopes.	Moderate—vegetation may be difficult to maintain in some spots. Moderate—6-12% slopes. Severe—over 12% slopes.
LSPL	Sandy over loamy poorly drained light-colored soils.	Moderate—high water table.	Moderate—high water table.	Moderate—high water table.	Moderate—high water table.
LLWD	Deep loamy well-drained, dark-colored soils.	Moderate—2-6% slopes. Severe—over 6% slope.	Moderate—surface soil on eroded areas is sticky when wet. Slight—2-6% slopes. Moderate—6-12% slopes. Severe—over 12% slopes.	Moderate—surface soil on eroded areas is sticky when wet. Slight—2-12% slopes. Moderate—12-18% slopes. Severe—over 18% slopes.	Slight—2-6% slopes. Moderate—6-18% slopes. Severe—over 18% slopes.
LLPD	Deep silty or loamy poorly drained, dark-colored soils.	Severe—high water table; frequently ponded. Moderate—surface soil is sticky and soft when wet.	Severe—high water table; frequently ponded. Moderate—surface soil is sticky and soft when wet.	Severe—high water table; frequently ponded. Moderate—surface soil is sticky and soft when wet.	Severe—high water table; frequently ponded; surface soil is sticky and soft when wet.
XLWD	Loamy over mixed sandy and loamy, well-drained, dark-colored soils.	Slight—0-2% slopes. Moderate—2-6% slopes. Severe—over 6% slopes.	Moderate—6-12% slopes. Severe—over 12% slopes.	Slight—2-12% slopes. Moderate—12-18% slopes. Severe—over 18% slopes.	Slight—2-6% slopes. Moderate—6-12% slopes. Severe—over 12% slopes.
XLWL	Loamy over mixed sandy and loamy, well-drained, light-colored soils.	Slight—0-2% slopes. Moderate—2-6% slopes. Severe—over 6% slopes.	Moderate—6-12% slopes. Severe—over 12% slopes.	Slight—2-12% slopes. Moderate—12-18% slopes. Severe—over 18% slopes.	Slight—2-6% slopes. Moderate—6-12% slopes. Severe—over 12% slopes.
A	Alluvial land.	Moderate to severe—occasionally to frequently flooded.	Moderate to severe—occasionally to frequently flooded.	Moderate to severe—occasionally to frequently flooded.	Moderate to severe—occasionally to frequently flooded.
M	Marsh—organic and mineral soils with water on them more than 9 months.	Severe—high water table; ponded most of the year.	Severe—high water table; ponded most of the year.	Severe—high water table; ponded most of the year.	Severe—high water table; ponded most of the year.

Table 25 (continued). Degree and kinds of limitations for specified recreational uses

Landscape unit	Description	Playground, athletic field and intensive play areas	Picnic areas, parks and extensive play areas	Bridle paths, nature and hiking trails	Golf course fairways
P, NP, LP, SP	Organic soils—peat and muck.	Severe—high water table; seasonally ponded; soft organic surface soil.	Severe—high water table; seasonally ponded; soft organic surface soil.	Severe—high water table; seasonally ponded; soft organic surface soil.	Severe—high water table; seasonally ponded; soft organic surface soil.
R	Large exposed bedrock areas	Severe—bedrock exposed.	Moderate—bedrock exposed.	Slight—bedrock exposed.	Severe—bedrock exposed.
LLWL	Deep silty or loamy well-drained, light-colored soils.	Moderate—surface soil on eroded areas is sticky when wet. Moderate—2-6% slopes. Severe—over 6% slopes.	Moderate—surface soil on eroded areas is sticky when wet. Moderate—2-6% slopes. Severe—over 6% slopes.	Moderate—surface soil on eroded areas is sticky when wet. Slight—2-12% slopes. Severe—over 18% slopes.	Moderate—surface soil on eroded areas is sticky when wet. Slight—2-6% slopes. Moderate—6-12% slopes. Severe—over 12% slopes.
LLPL	Deep silty or loamy poorly drained, light-colored soils.	Severe—high water table; occasional ponding. Moderate—slow permeability surface soil is sticky when wet.	Severe—high water table; occasional ponding. Moderate—surface soil is sticky when wet.	Severe—high water table, occasional ponding. Moderate—surface soil is sticky when wet.	Moderate—high water table; occasional ponding.
LCWD	Clayey over loamy, well-drained, dark-colored soils.	Moderate—surface soil is sticky and soft when wet. Severe—very slow permeability. Moderate—2-6% slopes.	Moderate—surface, soil is sticky and soft when wet. Moderate—6 to 12% slopes.	Moderate—surface soil is sticky and soft when wet.	Moderate—surface soil is sticky and soft when wet. Moderate—6-12% slopes.
LCPD	Clayey over loamy well-drained, dark-colored soils.	Severe—high seasonal water table; poor trafficability; slow permeability.	Severe—high seasonal water table; poor trafficability.	Severe—high seasonal water table. Moderate—surface soil is sticky and soft when wet.	Severe—high seasonal water table. Moderate—surface soil is sticky and soft when wet.
CLPD	Loamy over clayey, poorly drained, dark-colored soils.	Severe—poor natural drainage.	Severe—poor natural drainage.	Severe—poor natural drainage.	Moderate—poor natural drainage; high water table.
CCWD	Clayey over clayey, well drained, dark-colored soils.	Severe—slippery and sticky when wet; slow to very slow permeability.	Severe—slippery and sticky when wet; slow to very slow permeability.	Severe—slippery and sticky when wet; slow to very slow permeability.	
CCPD	Clayey over clayey, well drained, dark-colored soils.	Severe—poor natural drainage, frequently ponded, slippery and sticky when wet, very slow permeability.	Severe—poor natural drainage, frequently ponded, slippery and sticky when wet, very slow permeability.	Severe—poor natural drainage, frequently ponded, slippery and sticky when wet, very slow permeability.	Severe—high water table, frequently ponded, slippery and sticky when wet, very slow permeability.
YLPD	Intermixture of clayey over clayey, loamy over clayey, and loamy over loamy, poorly drained, dark-colored soils.	Severe—poor natural drainage, frequently ponded, slippery and sticky in spots when wet. Moderate—slow permeability in places.	Severe—poor natural drainage, slippery and sticky in spots when wet.	Severe—poor natural drainage, slippery and sticky in spots when wet.	Severe—slippery and sticky in spots when wet. Moderate—high water table.

INFORMATION FOR THE ENGINEER

Because soil landscape units include several major and minor series, it is impossible to give specific engineering data such as engineering classification, particle size, liquid limit, plasticity index, percolation rates, shrink-swell potential, and corrosivity. These can be obtained from onsite investigation. Table 26 gives an approximate range in the American Association of State Highway Officials (AASHO) and unified classifications of materials in the respective soil landscape units.

Engineers may find this map useful for locating sources of sand and gravel. Large peat areas which may cause difficulties in road location can be observed or avoided. Landscape units with clay will likely have high shrink-swell potential.

Prime sources of gravel will be found in the Park Rapids-Staples Outwash Plain (8), Mississippi Valley Outwash (29), Minnesota Valley Outwash (32), Belgrade-Glenwood Outwash Plain (63), and Appleton-Clontarf Outwash Plain (65). Within the Alexandria Moraine Complex (3), St. Croix Moraine Complex (9), Big Stone Moraine (51), and Osakis Till Plain (55) pockets of sand and gravel occur in small outwash areas and smaller pockets especially in landscape units XLWD and XLWL. Some gravel is located in the beach line along the east side of the Agassiz Lacustrine Plain.

Bedrock often is used to supplement sand and gravel in areas of short supply. However, the overburden of glacial drift is too deep over most of the St. Cloud Sheet for this to be an economical source of gravel, especially with the plentiful supply of glacial gravel.

Table 26. Approximate engineering classification of materials at the surface and at 5 feet in the soil landscape units delineated in the St. Cloud Sheet

Soil landscape unit	AASHO ¹		UNIFIED ²	
	Surface	5 feet +	Surface	5 feet +
SSWD	A-3, A-2, A-4	A-3, A-1	SP, SP-SM, SM,	SP, SP-SM, GP, GW, SW
SSWL	A-1, A-2	A-1, A-2	SP-SM, SM	GW, SP, GP, SP-SM
SSPD	A-2	A-2, A-3	SM	SP-SM
SSPL	A-2	A-2	SP-SM	SP-SM
SLWD	A-2, A-4, A-6	A-2, A-1	SM, OL, ML, CL, ML-CL, SC	SP, SW, GP, SM, GW, GP-GM
SLWL	A-4, A-6, A-2	A-1	SM, ML-CL, CL, SC	GW
SLPD	A-6, A-4, A-2, A-5, A-7	A-2, A-3, A-1	OL, CL, SM, SC, ML, MH, CH	SP-SM, GP, GC or SC, SM
LSWD	A-2	A-2	SM, SP-SM	SM
LSWL	A-2	A-2, A-4, A-6	SP-SM, SP, SM	SM-SC, SM, SC, ML, CL, ML-CL
LSPL	A-2	A-2, A-4,	SP-SM, SP, SM	SM-SC, SM, SC, ML
LLWD	A-6, A-7, A-4, A-7-5	A-6, A-4	OL, CL, ML, OH	CL, ML-CL
LLWL	A-4, A-6, A-7, A-2-4	A-6, A-4, A-2-4	ML, SM, SC, CL, SC-SM ³	CL, SC-SM
LLPD	A-6, A-7, A-4, A-2	A-6, A-2, A-4, A-7	OL, CL, ML, CH, SM-CL ³	CL, SM-CL
LLPL	A-2, A-2-4, A-4, A-6	A-2, A-4, A-2-4, A-6	SP, SM, ML, CL	SM, ML, ML-CL, CL
LCWD	A-7	A-7	MH, CH	CL
LCPD	A-7	A-7	OH, CH	CL
CLPD	A-7	A-7	CH, MH or OH, MH ³	CH, CL
CCWD	A-7	A-7	OH, CH, MH, CH ³	CH
CCPD	A-7	A-6, A-7	OH, CH, MH, CH ³	CH, CL
A	variable	variable	variable	variable
P	A-8	A-8, A-6, A-4, A-2	Pt	PT, CL, ML, OL, SP-SM
NP	A-8	A-8	Pt	PT
LP	A-8	A-6, A-4	Pt	CL, ML, OL
SP	A-8	A-2	Pt	SP-SM
M				

¹American Association of State Highway Officials Standard Specification for Highway Materials and Methods of Sampling and Testing. 1961.

²Waterways Experiment Station, Corp. of Engineers. The Unified Soil Classification System Tech. Memo. 3-357, Vol. 2. 1953.

³The surface 1 to 2 feet of these soil landscape units has considerable organic matter. The unified classification is OL or OH. This material should be removed and stockpiled for use as topsoil on cuts and embankments.



Site preparation for building construction often subjects the land to a period of increased erosion.

APPENDIX A

Short Description of Soil Series

Classified at the Subgroup Category of Soil Taxonomy.

Aastad—Dark - colored, moderately well - drained clay loam 16 to 24 inches thick over clay loam underlain at 25 to 34 inches by calcareous clay loam till (Pachic Udic Haploboroll).

Adolph—Light-colored, poorly drained silt loam 30 to 50 inches thick over mildly alkaline, reddish brown sandy loam till (Typic Haplaquoll).

Alluvial land—Consists of recent alluvium of variable textures and of variable drainage on flood plains (Unclassified).

Ames—Light-colored, somewhat poorly to poorly drained loam 8 to 16 inches thick over heavy clay loam subsoil. Calcareous loam till occurs below 36 to 48 inches (Typic Albaquoll).

Arveson—Dark-colored, poorly and very poorly drained calcareous fine sandy loam 10 to 14 inches thick over strongly calcareous fine sandy loam, underlain at 14 to 24 inches by slightly calcareous fine sand. (Typic Calciaquoll).

Arvilla—Dark-colored, somewhat excessively drained sandy loam to loam surface and subsoil. The substrata

below 14 to 25 inches consists of calcareous coarse sand and gravel (Udic Haploboroll).

Barnes—Dark-colored, well-drained loam 12 to 23 inches thick over calcareous loam till (Udic Haploboroll).

Barrows—Moderately dark-colored, poorly and very poorly drained loam to sandy loam 6 to 10 inches thick over gray strongly to medium acid sandy loam till (Mollic Haplaquept).

Bearden—Dark - colored, somewhat poorly drained slightly alkaline silty clay loam or silt loam 7 to 16 inches thick over moderately alkaline silty clay loam or silt loam (Aeric Calciaquoll).

Biscay—Dark-colored, poorly drained loam 28 to 36 inches thick over mildly alkaline, coarse sand (Typic Haplaquoll).

Blowers—Light-colored, moderately well-drained, medium acid sandy loam 14 to 22 inches thick over sandy clay loam or clay loam subsoil 12 to 18 inches thick. When dry, the subsoil becomes slightly cemented (fragipan), thereby restricting water movement. Below 24 to 40 inches the till is calcareous sandy loam (Aquic Fragiboralf).

Bluffton—Moderately dark-colored, very poorly drained, medium acid loam to clay loam 18 to 24 inches thick over calcareous loam or clay loam till (Typic Haplaquoll).

- Borup—Dark-colored, poorly drained, mildly alkaline very fine sandy loam to sandy clay loam 24 to 36 inches thick over calcareous fine sand or loamy fine sand (Typic Calciaquoll).
- Braham—Light-colored, well to excessively drained, slightly acid loamy fine sand 20 to 40 inches thick over medium to slightly acid sandy clay loam or loam subsoil. Calcareous loam till occurs below 40 to 50 inches (Arenic Eutrochrept).
- Brainerd—Light-colored, moderately well-drained, strongly to very strongly acid sandy loam 18 to 30 inches thick over strongly acid somewhat cemented (fragipan) sandy loam. Below 40 to 60 inches the till is slightly acid, slightly cemented sandy loam (Aquic Fragiocrept).
- Brophy—Dark-brown, very poorly drained, slightly decomposed, near neutral organic material derived primarily from Hypnum mosses, and more than 51 inches thick (Hemic Borofibrst).
- Burkhardt—Dark-colored, excessively drained, sandy loam about 20 inches thick over stratified coarse sand and fine gravel (Typic Hapludoll).
- Burnsville—Light-colored, excessively drained, sandy loam about 13 inches thick over loam about 7 inches thick over calcareous gravelly coarse sand and gravel (Typic Hapludalf).
- Cathro—Black, very poorly drained, near neutral, highly decomposed organic layers derived primarily from herbaceous plants 16 to 50 inches thick underlain by sandy loam mineral (Terric Borosaprist).
- Chetek—Light-colored, somewhat excessively drained, medium acid sandy loam over heavy sandy loam underlain at 16 to 20 inches by reddish brown medium acid gravelly sandy loam (Eutric Glossoboralf).
- Clarion—Dark-colored, well-drained loams 30 to 40 inches thick over calcareous loam till (Typic Hapludoll).
- Clontarf—Dark-colored, moderately well-drained, sandy loam 20 to 32 inches thick over neutral sand (Pachic Udic Haploboroll).
- Colo—Dark-colored, poorly drained, silty clay loam alluvium (Cumulic Haplaquoll).
- Colvin—Dark - colored, poorly drained, mildly alkaline silty clay loam 7 to 16 inches thick over moderately alkaline silty clay loam (Typic Calciaquoll).
- Cordova—Dark-colored, poorly to somewhat poorly drained silty clay loam 24 to 50 inches thick over calcareous clay loam till (Typic Argiaquoll).
- Dassel—Dark-colored, poorly to very poorly drained, slightly acid fine sandy loam 30 to 40 inches thick over slightly acid sand or loamy sand (Typic Haplaquoll).
- Deerwood—Black, very poorly drained, highly decomposed, calcareous organic soil material 4 to 16 inches thick over sand, but commonly stratified sand and gravel (Histic Humaquept).
- Dickinson—Dark-colored, well to somewhat excessively drained fine sandy loam 24 to 36 inches thick over slightly acid loamy sand and sand (Typic Hapludoll).
- Doland—Dark-colored, well-drained silt loam about 24 inches thick over calcareous loam till (Udic Haploboroll).
- Dorset—Moderately dark-colored, well and somewhat excessively drained sandy loam 12 to 26 inches thick over calcareous gravelly coarse sand (Mollic Eutroboralf).
- Dovray—Dark-colored, poorly and very poorly drained clay or silty clay 20 to 50 inches thick underlain by calcareous clay or silty clay (Cumulic Haplaquoll).
- Emmert—Light-colored, excessively drained slightly acid gravelly coarse loamy sand 12 to 28 inches thick over reddish brown, neutral gravelly coarse sand (Typic Udorthent).
- Estelline—Dark - colored, well and moderately well-drained silt loam 24 to 36 inches over calcareous fine sand (Pachic Udic Haploboroll).
- Estherville — Dark - colored, somewhat excessively drained, slightly acid sandy loam or loam 15 to 24 inches over calcareous coarse sand and gravel (Typic Hapludoll).
- Fairhaven—Dark-colored, well-drained, slightly acid silt loam underlain at 22 to 40 inches by limy coarse sand and gravel (Typic Hapludoll).
- Fargo—Dark-colored, poorly drained silty clay or clay 16 to 24 inches thick over limy clay or silty clay (Vertic Haplaquoll).
- Flak—Light - colored, well - drained, slightly to medium acid fine sandy loam 14 to 28 inches thick over medium acid somewhat cemented (fragipan) sandy loam underlain by slightly acid, somewhat cemented sandy loam till below 28 to 50 inches (Typic Fragiocrept).
- Flom—Dark-colored, poorly and somewhat poorly drained silty clay loam or clay loam 20 to 30 inches thick over calcareous clay loam till (Typic Haplaquoll).
- Forada—Dark-colored, poorly and very poorly drained loam to sandy loam 22 to 40 inches over calcareous coarse sand (Typic Haplaquoll).
- Fordville—Dark - colored, well - drained loam 24 to 30 inches over limy sand and gravel (Pachic Udic Haploboroll).
- Forman—Dark-colored, well-drained 11 to 26 inches thick over calcareous clay loam till (Udic Argiboroll).
- Fossum—Dark-colored, poorly or very poorly drained, moderately alkaline sandy loam to loamy sand 12 to 20 inches thick over moderately alkaline sand (Typic Haplaquoll).
- Freeon—Light - colored, moderately well - drained, strongly acid silt loam 15 to 30 inches thick over strongly acid loam subsoil. Reddish brown, slightly acid sandy loam till occurs below 24 to 50 inches (Typic Glossoboralf).
- Freer—Light-colored, strongly acid silt loam 15 to 30 inches over strongly acid loam underlain at 36 to 54 inches by reddish brown slightly acid sandy loam till (Aeric Ochraqualfs).
- Fulda—Dark-colored, poorly drained silty clay loam about 13 inches thick over silty clay which is calcareous below 20 to 30 inches (Typic Haplaquoll).
- Glencoe—Dark - colored, very poorly drained, clay loam 24 to 35 inches thick over loam to clay loam calcareous till (Cumulic Haplaquoll).
- Glyndon—Dark-colored, moderately well or somewhat poorly drained, moderately alkaline loam about 28

- inches thick over moderately alkaline loamy fine sand (Aeric Calcicquoll).
- Guckeen—Dark-colored, moderately well-drained, medium acid silty clay loam about 12 inches thick over medium acid silty clay or clay about 36 inches thick. Below is calcareous silty clay loam (Aquic Hapludoll).
- Hamerly—Dark-colored, somewhat poorly or moderately well-drained, moderately alkaline loam about 8 inches thick over moderately alkaline loam till containing a high concentration of lime. (Aeric Calcicquoll).
- Hangaard—Dark-colored, poorly and somewhat poorly drained, mildly alkaline sandy loam or loam 7 to 20 inches thick over limy gravelly coarse sand (Typic Haplaquoll).
- Hanska—Dark-colored, poorly drained loam or sandy loam 18 to 34 inches thick over sand. The sand is limy below 30 to 55 inches (Typic Haplaquoll).
- Hattie—Dark-colored, well and moderately well-drained mildly alkaline clay over moderately alkaline clay subsoil underlain at about 24 inches by limy clay till. (Uderitic Haploboroll).
- Hayden—Light-colored, well-drained loam over slightly acid clay loam over calcareous loam glacial till (Typic Hapludalf).
- Hecla—Dark-colored, moderately well-drained loamy fine sand 10 to 20 inches thick over mildly alkaline loamy fine sand frequently underlain at 30 to 54 inches by buried limy fine sandy loam soil which is dark colored in the upper 8 inches (Aquic Haploboroll).
- Hegne—Dark-colored, poorly drained, mildly alkaline silty clay over mildly alkaline silty clay containing a high concentration of lime (Typic Calcicquoll).
- Holdingsford—Light-colored, well-drained, slightly to medium acid fine sandy loam or loam 14 to 28 inches thick over medium acid somewhat cemented (fragipan) fine sandy loam or slightly acid clay loam (Typic Fragiudalfs).
- Hubbard—Dark-colored, somewhat excessively drained, slightly to medium acid loamy coarse sand about 14 inches thick over slightly acid coarse sand (Udorthentic Haploboroll).
- Huntsville—Dark-colored, well to moderately well-drained, mildly alkaline silt loam about 54 inches thick over mildly alkaline loam alluvium (Cumulic Hapludoll).
- Isan—Dark-colored, poorly and very poorly drained, medium acid sandy loam or loamy sand about 16 inches thick over medium acid sand (Typic Haplaquoll).
- Lamoure—Dark-colored, poorly drained moderately alkaline silty clay loam or silt loam about 43 inches thick over a buried dark-colored heavy loam over mildly alkaline sandy loam alluvium (Cumulic Haplaquoll).
- Langhei—Dark-colored, well-drained, moderately alkaline loam about 6 inches thick over moderately alkaline loam till (Typic Udorthent).
- LaPrairie—Moderately, dark-colored, moderately well-drained, mildly to moderately alkaline silt loam about 30 inches thick over moderately alkaline silt loam. Below 40 inches strata of sand and clay may occur (Cumulic Udic Haploboroll).
- Lester—Moderately dark-colored, well-drained, medium acid light clay loam about 13 inches thick over medium to slightly acid clay loam subsoil over strongly calcareous loam till (Mollic Hapludalf).
- LeSueur—Dark-colored, moderately well to somewhat poorly drained light clay loam about 19 inches thick over medium acid clay loam subsoil about 20 inches thick over calcareous loam till (Aquic Argiudoll).
- Lino—Light-colored, somewhat poorly drained, medium acid fine sand about 45 inches thick over slightly acid fine sand (Aquic Udipsamment).
- Lura—Dark-colored, poorly drained, slightly acid silty clay about 35 inches thick over neutral light silty clay about 10 inches thick over neutral to calcareous clay loam till (Cumulic Haplaquoll).
- McIntosh—Dark-colored, moderately well or somewhat poorly drained, moderately alkaline silt loam 24 to 40 inches thick over calcareous loam till (Aeric Calcicquoll).
- Maddock—Moderately dark-colored, well-drained loamy fine sand about 30 inches thick over calcareous fine sand (Udorthentic Haploboroll).
- Markey—Very dark brown mildly alkaline, highly decomposed organic soil, primarily from herbaceous plants, 24 to 42 inches thick over mildly alkaline sand (Terric Borosaprist).
- Marna—Dark-colored, poorly drained, slightly acid silty clay about 20 inches thick over slightly acid to neutral clay subsoil about 20 inches thick over calcareous clay loam till (Typic Haplaquoll).
- Marquette—Light-colored, somewhat excessively drained, neutral loamy sand about 9 inches thick over mildly alkaline gravelly sandy loam underlain at about 14 inches by calcareous gravelly coarse sand (Psammentic Eutroboralf).
- Marysland—Dark-colored, poorly drained, moderately alkaline loam about 12 inches thick over moderately alkaline loam containing a higher concentration of lime underlain at 20 to 40 inches by calcareous sand (Typic Calcicquoll).
- Mayer—Dark-colored, poorly drained, calcareous loam about 18 inches thick over calcareous sandy clay loam subsoil underlain at about 30 inches by calcareous fine gravel and coarse sand (Typic Haplaquoll).
- Menahga—Light-colored, excessively drained medium acid coarse and medium sand (Typic Udipsamment).
- Milaca—Light-colored, well-drained, medium to strongly acid fine sandy loam 14 to 24 inches thick over strongly to medium acid reddish brown fine sandy loam which is slightly cemented (fragipan) (Typic Fragiocrept).
- Millerville—Dark-brown, very poorly drained slightly acid to neutral, moderately decomposed organic soil derived mostly from herbaceous plants 16 to 51 inches thick over calcareous loamy material with about 10 percent snail shells (Limnic Borohemist).
- Mooselake—Dark reddish brown, very poorly drained, medium, acid, moderately decomposed organic soil more than 51 inches thick (Typic Borohemist).
- Mora—Light-colored, moderately well-drained, slightly acid fine sandy loam 18 to 32 inches thick over slightly

- cemented (fragipan) reddish brown slightly acid fine sandy loam. (Aquic Fragiboralf).
- Nebish—Light-colored, well-drained, slightly acid loam to fine sandy loam about 10 inches thick over slightly to medium acid sandy clay loam subsoil 12 to 18 inches thick. At 22 to 28 inches the till is calcareous loam (Typic Eutroboralf).
- Nessel—Light-colored, moderately well-drained, slightly acid loam about 18 inches thick over medium to strongly acid clay loam or heavy loam subsoil about 36 inches thick over calcareous loam till (Glossaquic Hapludalf).
- Nicollet—Dark-colored, moderately well to somewhat poorly drained, slightly to medium acid light clay loam over strongly calcareous loam till (Aquic Hapludoll).
- Nokasippi—Moderately dark-colored, very poorly drained, strongly to medium acid loamy fine sand or fine sand about 24 inches thick over medium to slightly acid light loam or sandy loam subsoil about 24 inches thick over reddish brown slightly cemented (fragipan) neutral sandy loam till (Typic Haplaquoll).
- Nokay—Light-colored, somewhat poorly drained, strongly acid fine sandy loam 22 to 36 inches thick over strongly acid slightly cemented (fragipan) sandy loam subsoil underlain by dark brown, medium acid slightly cemented (fragipan) sandy loam till (Aeric Fragiaqualf or possibly Aeric Ochraqualf).
- Nutley—Dark-colored, well-drained, moderately alkaline silty clay or clay 14 to 26 inches thick over calcareous clay (Udertic Haploboroll).
- Nymore—Moderately dark-colored, somewhat excessively drained, strongly acid loamy sand grading to sand at about 10 inches. Below about 32 inches the sand is medium acid (Typic Udipsamment).
- Omega—Light-colored, somewhat excessively drained, very strongly acid loamy sand about 10 inches thick over medium acid sand underlain at about 22 inches by light reddish brown, neutral fine sand (Spodic Udipsamment).
- Paddock—Light-colored, somewhat poorly drained, moderately acid sandy loam over moderately acid slightly cemented (fragipan) sandy clay loam subsoil over moderately calcareous sandy loam till (Aeric Ochraqualf or possibly Aeric Fragiaqualf).
- Parent—Moderately dark-colored, very poorly drained fine sandy loam about 40 inches thick over reddish brown, neutral fine sandy loam till (Typic Haplaquoll).
- Parnell—Dark-colored, very poorly drained, slightly acid to neutral silty clay loam about 55 inches thick over calcareous silty clay loam till (Typic Argiaquoll).
- Perella—Dark-colored, poorly drained silty clay loam about 24 inches thick over calcareous silt loam (Typic Haplaquoll).
- Pomroy—Light-colored, well- and moderately well-drained, medium acid fine sand about 28 inches thick over brown slightly cemented (fragipan), slightly acid sandy loam (Typic Fragiochrept or Eutrochrept).
- Quam—Dark-colored, very poorly drained, neutral silty clay loam about 38 inches thick over calcareous clay loam till (Cumulic Haplaquoll).
- Rauville—Dark-colored, very poorly drained, calcareous silty clay loam about 45 inches thick over calcareous stratified sand, gravel, and clay loam alluvium (Cumulic Haplaquoll).
- Renshaw—Dark-colored, somewhat excessively drained loam 10 to 20 inches thick over calcareous sand and gravel (Udic Haploboroll).
- Rifle—Reddish brown to black, very poorly drained, neutral, moderately decomposed organic soil primarily herbaceous fibers and over 51 inches thick (Typic Borohemist).
- Rockwood—Light-colored, well-drained, medium acid sandy loam over sandy clay loam subsoil, slightly cemented (fragipan), 30 to 40 inches thick over calcareous sandy loam till (Typic Eutroboralf).
- Roliss—Dark-colored, poorly and very poorly drained, mildly alkaline loam about 16 inches thick over calcareous clay loam till (Typic Haplaquoll).
- Runeberg —Light-colored, very poorly drained, medium acid sandy loam over medium acid sandy clay loam subsoil, over calcareous sandy loam till (Typic Ochraqualf).
- Salida—Dark-colored, excessively drained gravelly sandy loam or gravelly loamy sand 7 to 12 inches thick over calcareous gravelly coarse sand (Entic Hapludoll).
- Sartell—Light-colored, excessively drained, medium acid fine sand over strongly acid fine sand over medium acid brown fine sand (Typic Udipsamment).
- Seelyeville—Very dark brown, very poorly drained, neutral or slightly acid, highly decomposed organic soil materials that are more than 51 inches thick and derived primarily from herbaceous plants (Euic Typic Borosaprist).
- Shible—Dark-colored, well drained fine sandy loam about 12 inches thick over heavy sandy loam subsoil underlain at 20 to 36 inches by fine sand. Depth to weakly calcareous sand ranges from 40 to 60 inches (Udic Argiboroll).
- Sinai—Dark-colored, moderately well and well-drained silty clay over calcareous silty clay (Pachic Udic Haploboroll).
- Sioux—Dark-colored, excessively drained, loam about 5 inches thick over calcareous gravelly loam over calcareous gravelly sand (Udorthentic Haploboroll).
- Sletten—Dark-colored, very poorly drained, calcareous silty clay loam (Typic Haplaquoll).
- Storden—Dark-colored, well-drained, slightly calcareous loam about 7 inches thick over calcareous loam till (Typic Udorthent).
- Svea—Dark-colored, moderately well-drained loam 20 to 30 inches thick over calcareous loam till (Pachic Udic Haploboroll).
- Sverdrup—Dark-colored, somewhat excessively drained sandy loam about 16 inches thick over calcareous medium sand (Udic Haploboroll).
- Talcot—Dark-colored, very poorly drained, slightly calcareous light clay loam about 30 inches thick over calcareous gravelly sand (Typic Haplaquoll).
- Tara—Dark-colored, moderately well-drained silt loam 20 to 40 inches thick over calcareous loam till (Pachic Udic Haploboroll).

Tonka—Dark-colored, poorly drained, slightly to medium acid silt loam or loam 16 to 24 inches thick over medium acid silty clay loam underlain at 28 to 40 inches by calcareous loamy till (Argiaquic Argialboll).

Vallers—Dark-colored, poorly drained, calcareous silty clay loam about 12 inches thick over strongly calcareous clay loam over calcareous loam till (Typic Calciaquoll).

Venlo —Dark-colored, very poorly drained non-calcareous fine sandy loam about 12 inches thick over non-calcareous fine sand over slightly calcareous fine sand (Typic Haplaquoll).

Wadena—Dark-colored, well-drained, slightly acid loam 24 to 40 inches thick over calcareous coarse sand and fine gravel (Typic Hapludoll).

Watab—Light-colored, somewhat poorly drained, strongly acid loamy fine sand about 15 inches thick over

strongly to medium acid fine sandy loam 20 to 42 inches thick underlain by slightly cemented (fragipan) slightly acid reddish brown sandy loam till (Aquic Fragiochrept or Eutrochrept).

Waukon—Moderately dark-colored, well-drained loam about 9 inches thick over clay loam 20 to 32 inches thick over calcareous loam till (Mollic Eutroboralf).

Webster—Dark-colored, poorly drained clay loam 24 to 36 inches thick over calcareous loam till (Typic Haplaquoll).

Winger—Dark-colored, poorly drained calcareous silty clay loam about 7 inches thick over strongly calcareous silt loam to silty clay loam underlain at 24 to 40 inches by calcareous loam till (Typic Calciaquoll).

Zimmerman—Light-colored, excessively drained, acid loamy fine sand to fine sand about 60 inches thick over fine to medium sand (Alfic Udipsamment).

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WATER RESOURCES—SURFACE AND GROUND WATER

Information in this section has been abstracted from Hydrologic Investigations Atlases published by the U.S. Geological Survey and the Minnesota Department of Natural Resources.

From data available approximately 90 percent of the water used in the St. Cloud Sheet area comes from ground water supplies. Most of the ground water comes from glacial drift. Only a few municipal wells extend into underlying sandstone. The glacial drift over most of the St. Cloud Sheet is 200 to 400 feet thick, but varies from no glacial drift to over 500 feet thick. Over most of the Sauk River watershed, the drift ranges from 100 to 200 feet thick. Bedrock outcrops in the vicinity of St. Cloud and Cold Spring, Stearns County and in a few places along the Minnesota Valley Outwash.

The most readily available ground water occurs in outwash plains. Several irrigation systems are operating in the Belgrade-Glenwood Outwash Plain (63), in the vicinity of Brooten and Belgrade.

The moraines generally are the next best source for available ground water. Ice contact and buried sand and gravel veins are more common in moraines than in till plains and drumlin fields. Outwash sand and gravel areas occurring in moraines, although generally relatively small in size, are generally good sources.

Ground water is available in till and lake plains, drumlin fields, and bedrock, but generally in smaller amounts and recharge is slower. See table 27 for additional information on ground and surface water uses.

Water naturally is more dependable from the larger rivers than smaller streams and tributaries because the flow is more even. Table 28 gives discharge data for several rivers and tributaries. It lists the watershed area, years of record, maximum, minimum, and average discharge. For some pertinent data and information for several lakes refer to table 29.

The water quality is quite similar in the drift and the underlying formations. Dissolved solids range from 150 to 600 milligrams per liter (mg/l), but more commonly between 250 and 500 mg/l. The water is hard to very hard ranging from 120 to 500 mg/l. In most of the St. Cloud Sheet the range is 250 to 500 mg/l. Iron concentrations vary from 0.02 to 7.7 mg/l, but the more common range is 0.08 to 2.5 mg/l. Manganese concentrations range from 0 to 0.81 mg/l. Most samples analyzed ranged from 0.03 to 0.2 mg/l. Concentrations of 0.30 mg/l of iron and 0.05 mg/l of manganese impart taste and color to the water. Incrustations of well screens and staining is a common problem of higher concentrations.

Table 27. Characterization of water resources, St. Cloud Sheet Area, according to principal uses

		Surface water				Ground water			
		Small rivers and tributaries	Large rivers	Small lakes and sloughs	Large lakes	Ice-contact sand and gravel occurs in moraines	Outwash sand and gravel	Buried lenses of sand and gravel	Cretaceous or bedrock
Municipal and Industrial Supply	Availability	Fair	Fair	Inadequate storage capacity	Good	Adequate well yield, recharge commonly rapid. Limited distribution.	Adequate well yields. Recharge rapid.	Well yields commonly adequate. Wide distribution. Recharge slow.	Well yields probably inadequate. Recharge probably inadequate.
	Treatment	Necessary	Necessary	Necessary	Necessary	Commonly hard and high in iron.	Commonly hard and high in iron.	Commonly hard and high in iron.	May be softer than glacial drift water.
	Flow	Some tributaries have no flow for short periods	Adequate inflow	Inadequate inflows	Some have limited inflow				
	Storage	Necessary	Necessary	Inadequate may dry up during droughts	Additional storage possible				
Rural domestic and stock supply	Availability	Fair*	Fair*	Fair—may dry up during droughts	Fair—adequate storage capacity.	Adequate well yields	Adequate well yields	Adequate well yields	Adequate well yields
	Quality	Adequate for stock	Suitable for stock	Suitable for stock	Adequate inflow suitable for stock	Recharge commonly rapid	Recharge rapid	Adequate recharge	Adequate recharge
	Treatment	Necessary for domestic use	Necessary for domestic use	Necessary for domestic use	Necessary for domestic use	Commonly hard and high in iron.	Commonly hard and high in iron.	Commonly hard and high in iron.	May be softer than glacial drift water.
Irrigation supply	Availability	Poor*, storage necessary	Fair*, storage necessary	Poor—may dry up during droughts, inadequate storage capacity.	Adequate for limited use, additional storage possible.	Adequate well yields. Recharge commonly rapid. Distribution limited to marginal agricultural land.	Adequate well yields. Recharge rapid. Limited distribution.	Well yields may be adequate. Recharge probably inadequate. Wide distribution.	Well yields often inadequate. Recharge inadequate. Water quality may be harmful to crops.
	Quality	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable	Suitable	

Attractive, scenic lakes are common in the St. Cloud Sheet area, but eutrophication from runoff of nutrients is a problem that needs increased attention.



Table 27 (continued). Characteristics of water resources, St. Cloud Sheet Area, according to principal uses

		Surface water			Ground water		
		Small rivers and tributaries	Large rivers	Small lakes and sloughs	Large lakes		
Recreation	Suitability	Hunting and fishing	Hunting, fishing, and water sports	Hunting	Fishing, hunting and water sports		
	Location	Favorable	Favorable		Lake shore resorts & cottages		
	Variation	In flow floods	In flow floods	Shallow, may dry up during droughts			
Fish and wildlife habitat	Suitability	Wildlife	Wildlife and fish	Excellent habitat for wildlife	Excellent habitat		
	Flow variations	Undesirable floods	Floods				

* Available only to riparian lands.

Table 28. Discharge data for some streams in the St. Cloud Sheet

Stream	Location (near)	Watershed sq. miles	Years of record	Discharge(cfs)*		
				Maximum	Minimum	Average
Pomme de Terre River	Appleton	905	1931-63	5,050	No flow	92.6
Mad Creek	Morris	137		600	No flow	
Minnesota River	Lac Qui Parle	4,050	1943-63	19,700	No flow	648
Minnesota River	Montevideo	6,180	1909-64	24,500	No flow	616
Chippewa River	Watson	2,050	1910-17, 1931-36	9,700	No flow	58.4
Chippewa River	Milan	1,870	1938-64	6,930	No flow	231
Chippewa River	Benson	1,270	May 1949-Dec. 1951	2,230	3.2	185

Table 28 (continued). Discharge data for some streams in the St. Cloud Sheet

Stream	Location (near)	Watershed sq. miles	Years of record	Discharge(cfs)*		
				Maximum	Minimum	Average
Shakopee Creek	Benson	352	1950-54	2,681	No flow	96.6
Mississippi River	Royalton	11,600	1934-71	37,700	254	4177
Sauk River	St. Cloud	925	1902-12, 1930-31 1934-71	9,100	0.3	254
Platte River	Royalton	338	Records incomplete 1929-36	1,450	0.6	
Crow River	Rockford	2,520	1910-17, 1931, 1934-70	22,400	1.8	596
North Fork Crow River	Regal	215	1944-54	2,120	No flow	
Middle Fork Crow River	Spicer	179	1950-70	408	No flow	48.7

*Cubic feet per second.

Table 29. Surface area, maximum and average depth, outlet control and classification of some lakes in the St. Cloud Sheet

Lake	County	Surface area (acres)	Depth (feet)		Outlet control	Fish and game classification
			Maximum	Average		
Barrett		517	25	8	Wooden stop logs in concrete dam	Walleyed pike and rough fish
Artichoke	Big Stone	2,011	13		Natural channel	Game and rough fish, migratory waterfowl
Emily	Pope	2,377	5	4	Dam washed out, may be replaced	Migratory waterfowl resting area; rough fish and northern pike
Minnewaska	Pope	7,110	32	17	Dam	Migratory waterfowl nesting and resting area; large-mouth bass, panfish, walleyes
Norway	Kandiyohi	2,764	35		Natural	Northern pike lake—walleyes; bass, panfish
Florida	Kandiyohi	598	40	16	Dam*	Large-mouth bass, panfish, rubble, walleyes some northern pike.
Florida slough	Kandiyohi	1,644	6	4	Natural	Waterfowl lake—some northern pike, panfish
Reno	Pope	2,612	23	17	Natural	Walleyes—some northern pike, panfish
Chippewa	Douglas	1,225	96	24	Dam	Walleyes, northern pike, migratory waterfowl resting area
Lobster	Douglas	1,438	55			
Red Rock Main lake	Douglas	708	18	10	No outlet	Bullheads, panfish, some walleyes, bass
Calhoun	Kandiyohi	1,396	13		Dam	No classification
Diamond	Kandiyohi	1,697	27	20	Dam	Warm water game fish
Elizabeth	Kandiyohi	1,153	8	<5	Dam	Bullhead
Green	Kandiyohi	5,821	110	30	Dam	Warm water game fish
Mud		2,516	8	4	Dam	Waterfowl-muskrat-fish
Nest	Kandiyohi	1,019	40	15	Dam	Warm water game fish
Wagona	Kandiyohi	1,792	17	7	Natural	Marginal fish-game
Francis	Meeker	1,172	15	9	Dam	Warm water game fish
Ripley	Meeker	1,060	22	13	Natural	Warm water game fish
Washington	Meeker	2,524	17	5	Dam	Rough fish-warm water game fish
Rice	Stearns	1,568	41	11	Natural	Warm water game fish
Koronis	Stearns	3,471	132		Dam	Walleye

*Concrete Florida slough since Shakopee Creek directed into lake (1958).

GLOSSARY—ST. CLOUD SHEET

Aquifers—Underground water bearing sand and gravel veins.

Alluvium (alluvial deposits)—Soil material, such as sand, silt, or clay deposited on land by streams.

Calcareous—Material having a high percentage of lime carbonate.

Cretaceous—Geologic time prior to glaciers.

Drift—(glacial drift)—Any deposit in a glaciated area originating as a result of glaciation.

Esker—A ridge of sand and gravel deposited by a subglacial stream flowing in an ice tunnel.

Fragipan—A subsoil layer, somewhat compacted or cemented, which restricts downward movement of water.

Ground moraine—Glacial debris consisting chiefly of unsorted material that occurs in wide areas and has a gently irregular surface. The debris is deposited underneath and at the margin of a glacier during the active recession of the ice sheet.

Ice-contact—Outwash material laid down where one side fixed by presence of glacial ice.

Lacustrine—Deposits formed on the bottom of lakes.

Limy—See calcareous.

Melt water—The water which flows on, in, or out of a glacier.

Moraine—Unconsolidated rock and mineral debris deposited by glacial ice. It commonly consists of a heterogeneous mass of unsorted material, but that deposited by glacial melt water is sorted. See also ground moraine and terminal moraine.

Natural drainage—The conditions that existed during the development of the soil, as opposed to altered drainage which is commonly the result of artificial drainage or irrigation, but may be caused by the sudden deepening of channels or the blocking of drainage outlets.

Six classes of natural drainage are recognized in this report.

Excessively drained soils are commonly very porous and rapidly permeable (sandy and gravelly) and have a low moisture-storage capacity.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well-drained soils commonly have a moderately and slowly permeable layer in or immediately beneath the rooting zone. They have uniform color in the upper rooting zone and are mottled below 16 to 20 inches.

Somewhat poorly drained soils are wet for significant periods, and are commonly mottled below a depth of 6 to 16 inches.

Poorly drained soils are wet for longer periods. They are dark gray or black and are generally mottled within a depth of 18 inches. In some soils, mottling may be absent or nearly absent.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the

rooting zone below the surface soil.

Outwash plain—A plain formed by deposition of sorted and stratified material by glacial melt waters.

Peat—A dark brown or black residuum produced by the partial decay of plants growing in wet places.

Permeability—The ability of the soil to transmit air or water.

Reaction—The degree of acidity or alkalinity of soil expressed in pH values or in words as follows:

	pH
Extremely acid	below 4.5
Very strongly acid	4.5-5.0
Strongly acid	5.1-5.5
Medium acid	5.6-6.0
Slightly acid	6.1-6.5
Neutral	6.6-7.3
Mildly alkaline	7.4-7.8
Moderately alkaline	7.9-8.4
Strongly alkaline	8.5-9.0
Very strongly alkaline	9.1 and higher

Relief—In geology, the difference in height from the lowest parts to the highest parts of an area.

Subsoil—Roughly, the part of the soil profile between the subsurface and the substratum.

Substratum—A layer beneath the subsoil consisting of material, frequently of dissimilar materials, from which soils were formed.

Subsurface—Soil layer immediately below the surface soil or plow layer ranging from 6 to 12 inches thick.

Surface soil—Ordinarily the plow layer or the surface 5 to 12 inches.

Terminal moraine—Glacial debris heaped in the form of a belt or zone of hills and basins at the terminus or margin of a glacier. It marks the maximum extent of the ice during a major advance.

Terrace (geological)—An old sandy and gravelly alluvial plain, ordinarily level or nearly level bordering a river. They are seldom subject to overflow.

Texture, soil—The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles as related to the three classes used in this report, follow:

S—sand and loamy sand (also includes gravel).

L—sandy loam, loam, silt loam, silt, sandy clay loam, and clay loam.

C—silty clay loam, sandy clay, silty clay, and clay.

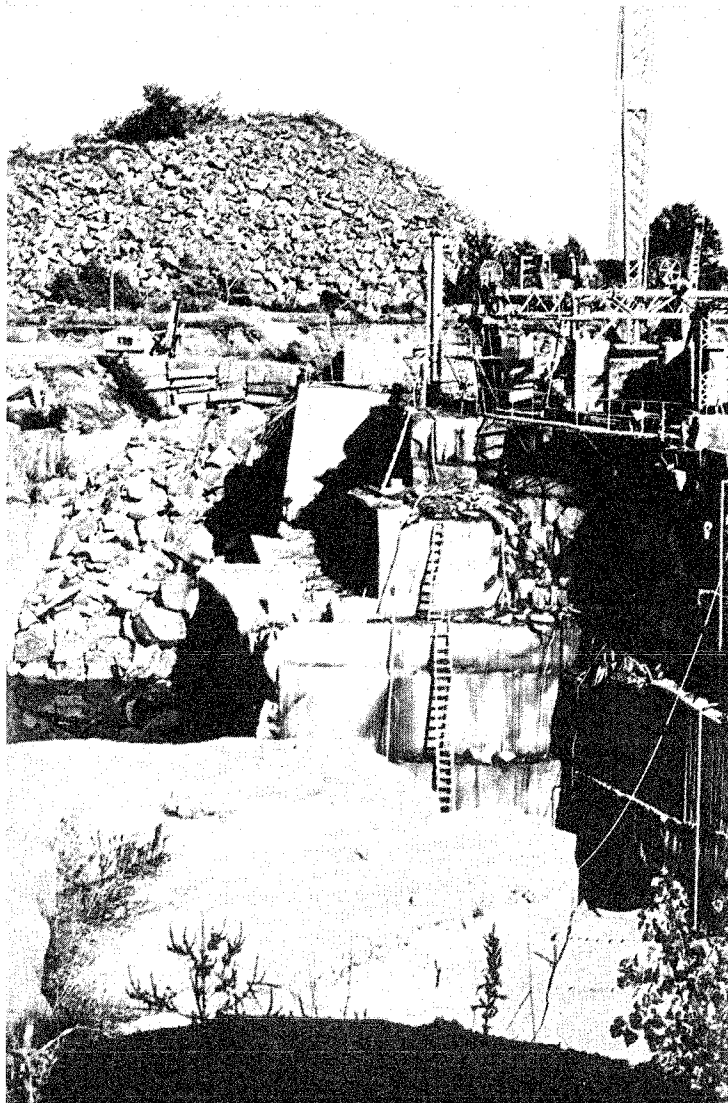
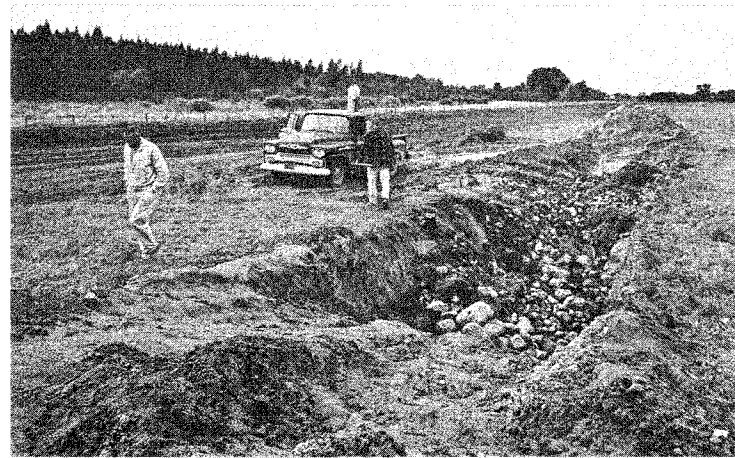
Till—Unstratified and unsorted glacial drift deposited directly by a glacier.

Till plain—See ground moraine.

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This Waukon soil profile shows the influence of forest vegetation. However, the organic matter content is relatively high as indicated by the LLWD soil landscape unit.

This profile of a Rockwood soil has dense layers which are called agipans and are almost impervious to root penetration.



Surface boulders are common on many of the till derived soils. They are particularly common in the drumlin areas and at this site are being buried in a pit.

Granite bedrock is near the surface or outcrops in central and eastern parts of Stearns County and is the basis of an extensive building stone industry.

Irrigation acreage in the St. Cloud Sheet has increased markedly since 1970. Close to 400,000 acres are irrigated in the state and one of the most important areas of irrigation is on the Brooten-Belgrade Outwash Plain.

