Series 1953, No. 1

Issued September 1958

SOIL SURVEY

Isanti County Minnesota

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
UNIVERSITY OF MINNESOTA AGRICULTURAL EXPERIMENT STATION

How to Use THE SOIL SURVEY REPORT

THIS SURVEY of Isanti County will help you plan the kind of farming that will protect your soils and provide good yields. It describes the soils, shows their location on a map, and tells what they will do under different kinds of management.

Find Your Farm on the Map

In using this survey, start with the soil map, which consists of the 41 sheets bound in the back of this report. These sheets, if laid together, make a large map of the county. You can see towns, roads, rivers, large buildings, and many other landmarks on this map.

To find your farm on the large map, use the index to map sheets. This is a small map of the county on which numbered rectangles have been drawn to show where each sheet of the large map is located.

On the map sheet for your farm, you will notice that boundaries of the soils have been outlined and that there is a symbol for each kind of soil. All areas marked with the same symbol are the same kind of soil, wherever they appear on the map.

Suppose you have found on your farm an area marked with the symbol F. Learn the name of the soil this symbol represents by looking at the map legend. The symbol F identifies Freer silt loam.

Learn About the Soils on Your Farm

Freer silt loam and all the other soils mapped are described in the section, Descriptions of the Soils. Soil scientists walked over the fields and through the woodlands. They dug holes and examined surface soils and subsoils; measured slopes with a hand level; noted differences in growth of crops, weeds, brush, or trees; and, in fact, recorded all the things about the soils that they believed might affect their suitability for farming.

After they mapped and studied the soils, the scientists talked with farmers and others about the use and management each soil should have, and then they placed it in a management group. A management group is a group of similar soils that need and respond to about the same kind of management.

Freer silt loam is in management group 3. Turn to the section, Use, Management, and Productivity of the Soils of Isanti County and read what is said about soils of group 3. You will want to study the table which tells you how much you can expect to harvest from Freer silt loam under two levels of management.

Make a Farm Plan

For the soils on your farm, compare your yields and farm practices with those given in this report. Look at your fields for signs of runoff and erosion. Then decide whether or not you need to change your methods. The choice, of course, must be yours. This survey will aid you in planning new methods, but it is not a plan of management for your farm or any other farm in the county.

If you find that you need help in farm planning, consult the county agricultural agent. Members of the staff of the Minnesota Agricultural Experiment Station and others familiar with farming in your county will also be glad to help you.

Fieldwork for the survey was completed in 1952. Unless otherwise specifically indicated, all statements in this report refer to conditions at that time.

For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington 25, D. C.

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SOIL SURVEY OF ISANTI COUNTY, MINNESOTA

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General Nature of the Area

When Isanti County was first settled, lumbering was the main industry. After the original forests were cut over, agriculture began to increase in importance. Potatoes and navy beans were leading crops in the early years. Dairying is now the prevailing type of agriculture. Dairy products and livestock are major sources of farm income. Corn, oats, rye, soybeans, and tame hay are the principal crops.

Location and Extent

Isanti County, located in east-central Minnesota (fig. 1), has a total area of 442 square miles, or 282,880 acres. Cambridge, the county seat, is situated along the Rum River, slightly east of the center of the county. It is 40 miles north of St. Paul, 100 miles southwest of Duluth, and 45 miles east of St. Cloud. The county is 24 miles across at the southern border and 18 miles across at the northern border, and it extends 22 miles from north to south.

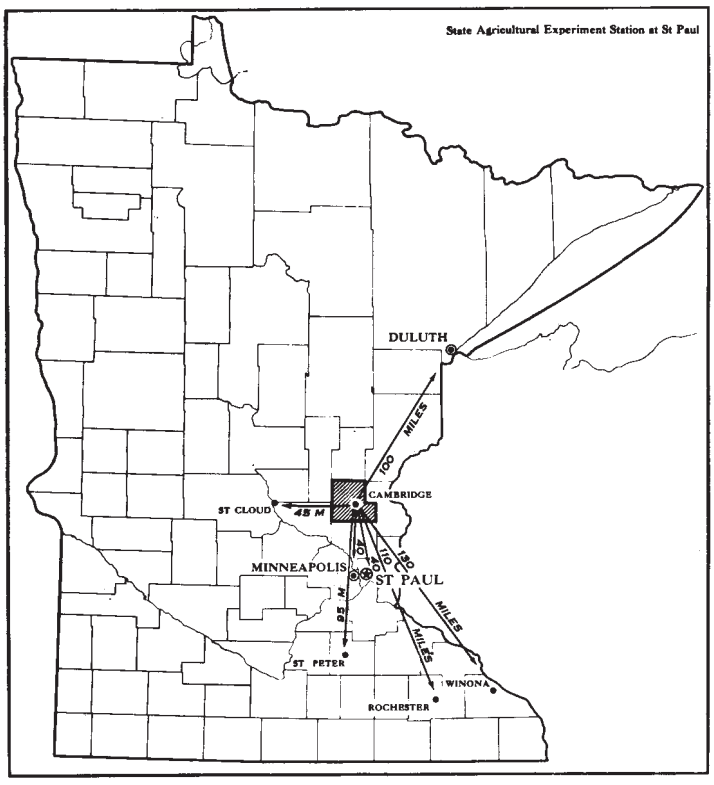

Figure 1.—Location of Isanti County in Minnesota.

Early History

The first white people to enter what is now Isanti County were two French explorers, Radisson and Crosseliers. In 1655 and 1659, they recorded voyages on the stream now called the Rum River. This area was then the home of four tribes of Sioux Indians, known as the Isanyati or Isantees. When Isanti County was set apart from Ramsey County in 1857, it was named after Isanyati.

In 1856, the plat of Cambridge Village, a mile south of the present town of Cambridge, was recorded. The county was organized in 1857. In 1871 a courthouse was built. The first industry was a sawmill; equipment for grinding flour was added later. The extensive stands of lumber, first reported by a lumber cruiser named Daniel Stanchfield, attracted many lumbermen from the New England States. The influence of the New Englanders is shown in the names of towns and townships—Cambridge, Athens, Oxford, and others.

Beginning in the late 1850's, many Swedes immigrated to the county. The present population of the county consists mainly of people of Swedish extraction. Settlement of the county proceeded slowly. The first census in 1860 reported only 284 inhabitants. By 1890, there were 7,607, and in 1940 there were 12,950. According to the 1950 census, the population was 12,123.

The first church, the North Isanti Baptist Church, opened in 1860. In 1864, a Lutheran church was organized in Cambridge. The first school was organized in the early 1860's. For many years classes were held in a private home in Spencer Brook Township.

Physiography, Relief, and Drainage

The landscape of Isanti County is dominated by glacial and postglacial deposits. It is characterized by undulating and rolling morainic hills, outwash sand plains, old glacial lake beds, and numerous bogs, lakes, dry stream channels, and barbed streams. There are no exposures of bedrock.

Two kinds of glacial drift, of slightly different age and markedly different composition, have been deposited in the county. The older is the middle Wisconsin (Cary) drift, commonly called red drift because of the color of the unweathered material. This drift

[1] Fieldwork was done while Soil Survey was part of the Bureau of Plant Industry, Soils, and Agricultural Engineering, United States Department of Agriculture. Soil Survey was transferred to the Soil Conservation Service on November 15, 1952.

material was transported from the region around Lake Superior and Duluth by a glacier that advanced from the northeast. Red drift is stony, generally coarse textured, and low in lime.

The more recent drift was deposited by the Grantsburg sublobe of the Des Moines lobe, which advanced from the northwest during the late Wisconsin (Mankato) glacial age. This material is gray when unweathered, and the deposits are commonly called gray drift. Gray drift was derived mostly from limestone and calcareous shale. It originated northwest of Isanti County. It is less stony than red drift and is normally fine textured; the unweathered drift is relatively high in lime. Except on a few isolated morainic hills, a thin layer of glacial till and outwash material of this later period overlies the older red drift.

About the time of the maximum extension of the Grantsburg sublobe, a large proglacial lake (Lake Grantsburg) was formed between the northern boundary of the glacier and the highlands of the Cary drift plain. The silty lacustrine soils that occur along the northern border of the county developed from sediments deposited in this lake.

The extensive Anoka sand plain, which covers about 60 percent of Isanti County, was formed by the Mississippi River as it followed the retreat of the Grantsburg sublobe when the glaciers melted. This sand plain is characterized by relatively smooth relief, fingerlike depressions, many small isolated bogs, and scattered dunelike knolls of wind-deposited material. The soils are of loamy fine sand texture. In most places, the sand overlies gray drift; the thickness of the sand ranges from a few inches to many feet. The Zimmerman loamy fine sands and fine sands are the most extensive soils developed from these sandy glacial outwash deposits.

Several belts of morainic hills, formed from material deposited during one of the earlier glacial periods, extend across the county. One of the most prominent hills is located in the extreme southwestern corner of the county near the Sherburne and Anoka County lines. The highest elevations in this region are along a crest of ridges that rise abruptly to 100 feet or more above the sand plain.

Another distinct morainic ridge occurs in Maple Ridge Township. The crest of this ridge, the highest point in the county, is 1,150 feet above sea level. Areas of rolling topography also occur in Stanchfield, Springvale, and Cambridge Townships. In Isanti and North Branch Townships there is a relatively smooth moraine. It becomes rolling and steep near the Chisago County line and rises from 40 to 75 feet above the depressions, bogs, and lakes.

The lowest point in the county, 875 feet above sea level, occurs at the point where the North Branch Sunrise River (Hay Creek) crosses the eastern boundary of North Branch Township.

Green Lake, located in Wyanett Township, is the largest lake in the county. Spectacle Lake, also in Wyanett Township, is a popular resort lake. There are many cabins and summer homes along its shores. A cluster of lakes in the southeastern part of the county extends from Typo Lake northeasterly into Chisago County. Small lakes, intermittent ponds, and bogs of various sizes occur throughout the county.

Few natural streams have developed in Isanti County. Nearly all of the county is drained by the Rum River, which enters Isanti County from the west, flows eastward to a point about 3 miles north of Cambridge, and then southward into western Anoka County. It joins the Mississippi River at Anoka. The main tributaries of the Rum River in Isanti County are Spencer Brook, Upper and Lower Stanchfield Creeks, and Cedar Creek. The southeastern part of the county is drained by the North Branch Sunrise River.

Climate

Isanti County has a typical continental climate characterized by wide variations in temperature, low winter precipitation, and normally adequate summer rainfall.

The normal monthly, seasonal, and annual temperature and precipitation for Isanti County are given in table 1. These figures were compiled from records

TABLE 1.—*Normal temperature and precipitation at Cambridge, Isanti County, Minn.*

[ELEVATION, 1,000 FEET]

Month	Temperature [1]			Precipitation [2]			
	Average	Absolute maximum	Absolute minimum	Average	Driest year (1933)	Wettest year (1938)	Average snowfall
	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Inches*
December	17.3	62	−33	0.80	0.46	0.69	8.2
January	10.8	53	−42	.87	.64	.88	8.7
February	13.0	50	−37	.62	.49	.38	8.9
Winter	13.7	62	−42	2.29	1.59	1.95	25.8
March	26.7	78	−31	1.20	1.08	1.47	9.0
April	44.2	92	6	2.68	1.40	3.06	2.5
May	57.7	107	19	3.58	6.38	9.19	.1
Spring	42.9	107	−31	7.46	8.86	13.72	11.6
June	67.1	104	32	4.06	1.42	3.96	0
July	71.7	109	40	3.48	1.86	6.54	0
August	68.9	102	35	3.00	.18	4.31	[3]
Summer	69.2	109	32	10.54	3.46	14.81	[3]
September	59.8	96	21	3.10	2.28	4.24	.1
October	46.8	87	11	1.94	1.89	.51	.5
November	29.1	73	−14	1.27	.72	3.12	6.6
Fall	45.2	96	−14	6.31	4.89	7.87	7.2
Year	42.7	109	−42	26.60	18.80	38.35	44.6

[1] Average temperature based on a 28-year record, through 1955; highest temperature based on a 19-year record, through 1952; lowest temperature based on a 20-year record, through 1952.

[2] Average precipitation based on a 29-year record, through 1955; wettest and driest years based on a 23-year record, in the period 1933-1955; snowfall based on a 20-year record, through 1952.

[3] Trace.

of the United States Weather Bureau station at the Cambridge State Hospital, Cambridge, Minnesota.

The climate is similar throughout the county because of the uniform elevation. The maximum variation in elevation does not exceed 275 feet; local variations are generally much less. The winters are cold and long; summers are generally short and mild. The lowest temperatures occur in January and the highest in July. The average January temperature is 10.8° F., and the average July temperature is 71.7°. The average frost-free season is 138 days in length. Killing frosts have occurred as late as June 2 and as early as September 3.

Most of the precipitation falls during the growing season, from May through September. Rainfall gradually increases during the spring months and remains fairly uniform during the growing season. It diminishes during the late fall and is lowest during the winter months. During winter, most of the precipitation is snow. The average annual precipitation is 26.60 inches, about two-thirds of which falls during spring and summer.

The climate is favorable for forage crops grown for hay and pasture. The growing season is too short for corn, except early maturing hybrids. Generally, enough snow falls during the winter so that there is adequate moisture for fall-sown small grains, even if the spring rainfall is below normal.

Normally, 25 to 30 thunderstorms occur during the year. They provide most of the rainfall during the warm months. There is at least one damaging or excessive rainstorm each year. Tornadoes and ice storms are infrequent.

Vegetation

Isanti County is partly in the northern deciduous forest region and partly in the oak forest region. The entire area, except for a few "oak openings," was originally covered by a dense forest.

The glacial till areas in the northern and eastern parts of Isanti County are in the northern deciduous forest region. These areas were originally covered with hardwoods, chiefly red oak, bur oak, white birch, sugar maple, black ash, basswood, American elm, butternut, ironwood, aspen, and wild plum.

The sand plains and other dry areas are in the oak forest region. The original forest consisted mostly of bur oak, scarlet oak, pin oak, aspen, jack pine, white birch, pin cherry, chokecherry, and sumac. Most of the jack pine grew on the drier uplands. A few areas were covered only with prairie grasses.

Abandoned cropland that is not used for pasture is gradually reverting to forest. Aspen is normally the first tree to become reestablished in such areas; usually it is preceded by witch-hazel and sumac shrubs.

Soil Survey Methods and Definitions

The scientist who makes a soil survey examines soils in the field, classifies the soils in accordance with facts that he observes, and maps their boundaries on an aerial photograph or other map.

FIELD STUDY.—The soil surveyor bores or digs many holes to see what the soils are like. The holes are not spaced in a regular pattern, but are located according to the lay of the land. Usually they are not more than a quarter of a mile apart and sometimes they are much closer together. In most soils such a boring or hole reveals several distinct layers, called horizons, which collectively are known as the soil profile. Each layer is studied to see how it differs from others in the profile and to learn the things about this soil that influence its capacity to support plant growth.

Color is usually related to the amount of organic matter. The more organic matter the soil contains, the darker colored it is, as a rule. Streaks and spots of gray, yellow, and brown in the lower layers generally indicate poor drainage and poor aeration.

Texture, or the content of sand, silt, and clay, is determined by the way the soil feels when rubbed between the fingers, and is later checked by laboratory analysis. Texture determines how well the soil retains moisture, plant nutrients, and fertilizer, and whether it is easy or difficult to cultivate.

Structure, which is the way the individual soil particles are arranged in larger grains and the amount of pore space between grains, gives us clues to the ease or difficulty with which the soil is penetrated by plant roots and by moisture.

Consistence, or the tendency of the soil to crumble or to stick together, indicates whether it is easy or difficult to keep the soil open and porous under cultivation.

Other characteristics observed in the course of the field study and considered in classifying the soil include the following: The depth of the soil over bedrock or compact layers; the presence of gravel or stones in amounts that will interfere with cultivation; the steepness and pattern of slopes; the degree of erosion; the nature of the underlying parent material from which the soil has developed; and acidity or alkalinity of the soil as measured by chemical tests.

CLASSIFICATION.—On the basis of the characteristics observed by the survey team or determined by laboratory tests, soils are classified into phases, types, and series. The soil type is the basic classification unit. A soil type may consist of several phases. Types that resemble each other in most of their characteristics are grouped into soil series.

As an example of soil classification, consider the Dalbo series of Isanti County. This series is made up of two soil types, subdivided into phases, as follows:

Series	*Type*	*Phase*
Dalbo	Silt loam	2 to 7 percent slopes.
		7 to 12 percent slopes.
		12 to 18 percent slopes, moderately eroded.
	Fine sandy loam	2 to 12 percent slopes.

Soil type.—Soils having the same texture in the surface layer and similar in kind, thickness, and arrangement of soil layers are classified as one soil type.

Soil phase.—Because of differences other than those of kind, thickness, and arrangement of layers, some soil types are divided into two or more phases. Slope variations, number of rock outcrops, degree of erosion, depth of soil over the substratum, or natural drainage, are examples of characteristics that suggest dividing a soil type into phases.

The soil phase (or the soil type if it has not been subdivided) is the unit shown on the soil map. It is the unit that has the narrowest range of characteristics. Use and management practices therefore can be specified more easily than for soil series or yet broader groups that contain more variation.

Soil series.—Two or more soil types that differ in surface texture, but are otherwise similar in kind, thickness, and arrangement of soil layers, are normally designated as a soil series. In a given area, however, a soil series may be represented by only one soil type. Each series is named for a place near which it was first mapped.

Miscellaneous land types.—Fresh stream deposits, or rough, stony, and severely gullied land that have little true soil are not classified into types and series, but are identified by descriptive names, such as Beach sand, or Rough broken land, Zimmerman material.

Soil complex.—When two or more soils are so intricately associated in small areas that it is not feasible to show them separately on the soil map, they are mapped together and called a soil complex. The Burnsville-Rodman complex is the only soil complex mapped in this county.

Undifferentiated soil group.—Two or more soils that are not regularly associated geographically may be mapped as a single unit. An example of an undifferentiated group is the mapping unit called Bluffton loam and silty clay loam.

Soil Series and Their Relations

The soil series of Isanti County are in five main groups based on parent material and physiographic position: Soils of the glacial uplands; soils of the glacial lake plains; soils of the glacial outwash plains; soils of the alluvial bottom lands; and organic soils. Some of these groups are divided into subgroups according to differences in profile characteristics and parent material. In addition, there are four miscellaneous land types in the county.

Soils of the Glacial Uplands

The soils of the glacial uplands are subdivided into two groups; soils developed from calcareous material, and soils developed from noncalcareous material.

Soils developed from calcareous material.—This subgroup consists of the Hayden, Ames, and Bluffton soils, and the Burnsville-Rodman complex. These soils occur principally in the northern part of the county, and to a lesser extent in Springvale, Cambridge, Isanti, and North Branch Townships. A small area of these soils is located in the southwestern part of the county. Relief ranges from undulating to rolling. Many small depressions and flats occur. Except for the Burnsville-Rodman complex, which has developed on loose calcareous sand and gravel, all the soils have developed on calcareous glacial till. Free lime has been leached to depths of 36 to 48 inches.

The Hayden silt loams and Hayden fine sandy loams occur on undulating to rolling relief, generally on short complex slopes. These soils have a very dark gray to light yellowish-brown surface soil and a yellowish-brown subsoil. The steeper areas have been severely damaged by erosion.

The Ames soils are imperfectly drained associates of the Hayden soils. They are level to nearly level and generally occur on small upland flats. The surface soil is dark gray to light yellowish brown and the subsoil is mottled dark grayish brown to olive brown. The subsoil is frequently very plastic when wet.

Bluffton soils occupy depressions and flats adjacent to bogs. The surface soil and upper subsoil, to depths of about 12 to 18 inches, are black to very dark gray and are relatively high in organic matter. The subsoil is dark gray mottled with brown. Calcareous glacial till begins at depths of 30 to 48 inches.

The Burnsville-Rodman complex occurs on kames and rolling moraines. The surface soil is yellowish brown and the subsoil is dark yellowish brown. Grayish-brown and yellowish-brown loose calcareous stratified sand and gravel occur at depths ranging from 24 to 48 inches. These soils are droughty and highly erodible.

Soils developed from noncalcareous glacial till.—This subgroup includes the Milaca, Freer, Adolph, Emmert, and Scandia soils. These soils occur only in the extreme southwestern and northwestern parts of the county. The total area is small. The topography is nearly level to steep. Many of the areas are in depressions and bogs. The red, highly siliceous parent material is devoid of lime to a considerable depth, and it contains many pebbles of igneous rock and sandstone. Except for the Adolph soil, these soils are relatively low in organic matter.

The well-drained Milaca soils occur on undulating to steep relief. The surface soil is very dark gray to brown, and the subsoil is faintly mottled with reddish brown. The texture of the surface soil ranges from silt loam to fine sandy loam. Thin layers of sand and gravel commonly occur in the substratum. Many of the steeper slopes, particularly the morainic ridges, are severely eroded.

The imperfectly drained, relatively uneroded Freer soil occurs on nearly level topography. The surface soil is very dark gray to dark grayish brown, and the subsoil is a highly mottled dark brown to strong brown. The substratum is normally a reddish-brown till of stony sandy loam texture.

The very poorly drained Adolph soil occurs in depressed flats and basins on the till plain. The surface soil is generally very dark brown to black silty clay loam, and the subsoil is a dark gray clay loam mottled with reddish brown. The substratum is a reddish-brown and gray sandy clay loam or gravelly loam till.

The Scandia soils are associated with the Milaca soils. They occur principally on rough morainic ridges

in the extreme southwestern part of the county. The upper layers are dark gray to yellowish brown and sandy, and the subsoil is normally a reddish-brown sandy clay loam. Loose gravelly and sandy till begins at depths of 30 to 40 inches. The entire profile is acid. These soils are erodible.

The Emmert soils, like the Scandia, occur on rolling morainic ridges. They are immature, stony, and gravelly. The surface soil is light colored and sandy, and the subsoil is a dark-brown gravelly loamy sand or gravelly sandy loam. The substratum is a heterogeneous mass of sand, gravel, cobblestones, and stones. These soils are droughty and highly erodible.

Soils of the Glacial Lake Plains

The soils of the glacial lake plains developed from calcareous silts and clays of the Mankato substage of the Wisconsin glacial age or from thin deposits of silts and clays overlying noncalcareous red sand and gravel of the Cary substage of the Wisconsin age.

Soils developed from calcareous silts and clays.—This subgroup consists of Dalbo and Brickton soils, which occur only in the northern part of the county in Dalbo, Maple Ridge, and Stanchfield Townships. The relief ranges from nearly level to rolling. The depth to calcareous material ranges from 30 to 48 inches.

The moderately well drained to well drained Dalbo soils occupy gently rolling areas on the lake plain. Generally the surface soil is grayish brown to light brownish gray, and the subsoil is dark brown to dark grayish brown. The texture of the surface soil is silt loam or fine sandy loam. The substratum normally consists of light-gray or light yellowish-brown smooth calcareous slack-water deposits of silt loam texture.

Brickton soils, the imperfectly drained associates of the Dalbo soils, are level to undulating. The surface soil in cultivated areas is commonly a grayish-brown to light brownish-gray silt loam and the subsoil is a dark grayish-brown to olive-brown silty clay loam to silty clay. The substratum consists of yellowish-brown to pale-yellow, well-sorted, calcareous slack-water deposits of very fine sandy loam, silt loam, or silty clay loam texture. Imperfect drainage often delays cultivation on the nearly level areas.

Soils developed from thin deposits of silts and clays overlying sand and gravel.—The Kanabec and Greenbush soils make up this subgroup. They occur only in the northern part of the county along the Kanabec County border. The most extensive areas are near Braham. The topography ranges from level to rolling. These shallow soils are underlain by sand and gravel that begin at depths of 20 to 48 inches. The underlying noncalcareous red sand and gravel are not related to the overlying thin slack-water deposits. These soils generally have been leached of lime.

The moderately well drained to well drained Kanabec soils are more extensive than the Greenbush soils. The surface soil is very dark gray, brown, and pale-brown very fine sandy loam, and the subsoil is a yellowish-brown to strong-brown clay loam. The substratum, which begins at depths of 30 to 48 inches, is a yellowish-brown stratified coarse sandy loam that contains layers of gravel and sand. Kanabec soils are somewhat droughty because of the layers of sand and gravel.

The moderately well drained to well drained Greenbush soils occupy nearly level to undulating slopes. Where cultivated, they have a light-gray to light yellowish-gray silt loam surface layer and a yellowish-brown to reddish-brown clay loam subsoil. The substratum, which begins at depths ranging from 20 to 36 inches, consists of reddish-brown stratified gravel and gravelly sand of the Cary substage. These soils are acid throughout. They are inextensive; only a few areas are mapped.

Soils of the Glacial Outwash Plains

The soils of the glacial outwash plains occupy about 60 percent of Isanti County. They are divided into five subgroups.

Soils developed from deep water-and wind-deposited sands of the Mankato substage.—This subgroup consists of the Zimmerman, Lino, and Isanti soils. These soils have developed from well-sorted sands that are unusually high in quartz. When this material was deposited it was fairly high in lime, but the soils have been leached to a considerable depth.

The Zimmerman soils are remarkably uniform in color and texture because they were well sorted by water and wind when deposited. They occur on nearly level to steep relief. Their smooth slopes differ from the complex, abrupt slopes of the morainic ridges. Natural drainage is excessive. These soils, the most extensive in the county, occur throughout the sand plains. The surface soil is brown to grayish-brown structureless loamy fine sand or fine sand. The subsoil is a very uniform yellowish-brown fine sand. The substratum consists of yellowish-brown fine sands to medium sands and in many places contains many thin horizontal bands of fine material. These soils are commonly droughty. Wind erosion is a serious hazard.

The imperfectly drained to moderately well drained Lino soil occupies slight depressions and draws in the outwash plain. The surface layer is a moderately dark loamy fine sand, and the subsoil is a mottled dark grayish-brown fine sand. The substratum is yellowish-brown fine sand that is many feet thick.

The Isanti soil, the poorly drained associate of the Zimmerman soils, occupies depressions and flats bordering peat bogs. The dark-colored surface layer is moderately high in organic matter. The subsoil is a mottled gray and brown fine sand and has a reddish-brown layer of fine material in many places. This soil generally has a high water table.

Soils developed from water-deposited sand and gravel of the Cary substage.—These inextensive soils occur in a few scattered areas in the northern part of the county along the Kanabec County border and in the southwestern corner.

The well-drained Onamia soil occupies undulating to rolling topography. It is closely associated with the Chetek soils but has a thicker and finer textured solum.

The Warman soils are the very poorly drained as-

sociates of the Chetek and Onamia soils. They occupy depressions in the Cary outwash plains. The surface soil is very dark gray and is high in organic matter. The subsurface layer is a gray silty clay loam which is often plastic when wet. The substratum consists of stratified sand and gravel.

Soils developed from shallow water-deposited sands and gravel of the Cary substage.—This subgroup is made up of the Chetek and Crown soils, which occur principally in the extreme southwestern part of the county near the Sherburne County border.

The well drained to excessively drained Chetek soils occupy undulating to hilly slopes on the pitted outwash plain. These coarse-textured soils have little to moderate profile development. Gravel normally begins at depths of from 15 to 20 inches. The substratum is reddish-brown stratified sand and gravel, and it contains many cobblestones. These soils are very droughty.

The Crown soil is the imperfectly drained to moderately well drained associate of the Chetek soils. It occurs in slight depressions and draws. It has a moderately dark colored surface soil and a coarse gravelly and sandy substratum.

Soils developed from calcareous glacial outwash of the Mankato substage.—This subgroup consists of Hubbard soils, which have developed under prairie grasses on the outwash plain adjacent to the glacial till moraines. These soils are like the Zimmerman soils, except that the surface soil and upper subsoil are darker colored and higher in organic-matter content. The total acreage is small.

Soils developed from water- and wind-deposited sands of the Mankato substage.—Anoka loamy fine sands are the only soils in this subgroup. They occur on the outwash plain, principally adjacent to areas of glacial till. They are most extensive in the vicinity of Cambridge. The topography is nearly level to gently sloping.

The Anoka soils are like the Zimmerman soils, except that bands of reddish-brown fine material occur in the subsoil, between 12 and 42 inches below the surface. The fine material consists of colloidal clay and iron oxides; the texture is a fine sandy loam, and the structure is massive. The thickness of the bands ranges from a few inches to 2 feet. The Anoka soils have better water-holding capacity than Zimmerman soils, but they are droughty in places and are subject to wind erosion.

Soils developed from thin deposits of outwash sand over calcareous glacial till of the Mankato.—This subgroup consists of Braham and Blomford soils, which occur principally adjacent to or within areas of glacial till. Both soils are underlain at depths of 18 to 48 inches by calcareous glacial till.

The well drained to somewhat excessively drained Braham soils occur on gentle to moderately steep slopes. The surface layer and the upper subsoil are somewhat similar to those of the Zimmerman soils. The subsoil consists of mixed sand and weathered glacial till. The calcareous substratum of glacial till is unweathered. This soil is erodible and is droughty in places.

The Blomford soil is the imperfectly drained associate of the Braham soils. It occupies the outwash plain, where it is adjacent to areas of glacial till.

Soils of the Alluvial Bottom Lands

Rum River loam is the only alluvial bottom-land soil mapped in the county. It is an imperfectly drained soil that occurs in the valley of the Rum River, mainly in the western part of the county where the valley is widest. It lies above the present flood plain and is seldom flooded. The surface soil is black to very dark brown loam that is moderately high in organic matter. The subsoil is very dark gray silty clay loam, highly mottled and streaked. The substratum is mottled yellowish-brown fine sand.

Organic Soils

This group consists of the Peat soils. They occur throughout the county on both the sand plain and the till plains.

Peat, deep, consists of partially decomposed plant remains. It occurs in tamarack and spruce bogs and in open sedge-meadow bogs. It is very poorly drained.

Peat, moderately shallow over loam, is underlain by loam at depths of 12 to 36 inches. It occurs on the glacial till plains and the lake plains. Many areas have been drained and are cultivated. A large area of this soil occurs in the western half of Dalbo Township.

Peat, moderately shallow over sand, is underlain by sands at depths of 12 to 36 inches. It occurs in the sand plains. Only a few areas are sufficiently drained to be suitable for cropping.

Miscellaneous Land Types

The miscellaneous land types mapped in the county are Alluvial land, well drained: Alluvial land, poorly drained; Rough broken land, Zimmerman material; and Beach sand. These land types are not suited to crops but afford limited grazing.

Soil Associations

A soil association is an area of land comprised of one or more kinds of soil occurring in a characteristic pattern on a characteristic type of landscape. The association may consist of soils that are similar or that differ widely in important features. Each area of a soil association, however, has a certain repeating pattern of the same important soil type or types.

The location and extent of each of the six soil associations recognized in Isanti County are shown in figure 2.

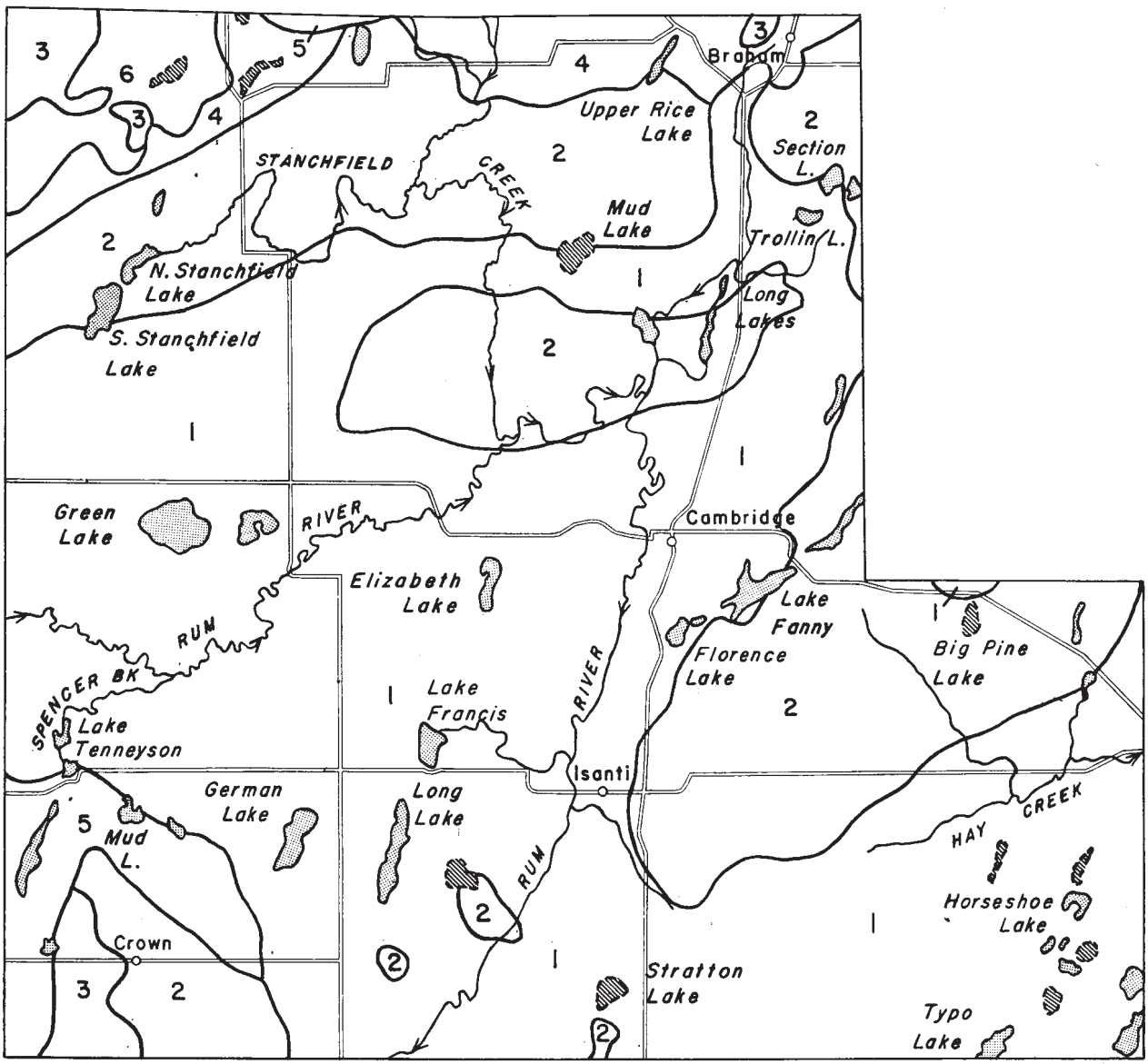

Figure 2.—**Soil associations in Isanti County, Minnesota.**

1. **Zimmerman-Lino association (Anoka sand plain).**
2. **Hayden-Bluffton association (Mankato till plain).**
3. **Milaca-Freer association (Cary till plain).**
4. **Dalbo-Brickton association (glacial lake plain).**
5. **Onamia-Chetek association (Cary outwash plain).**
6. **Peat.**

Zimmerman-Lino Association (Anoka Sand Plain)

This is the most extensive association in the county. It occupies the relatively smooth Anoka sand plain that covers about 60 percent of the county. In general, the topography is level to sloping, but narrow strips of soil on steeper slopes extend into the areas along the drainageways and around bogs.

The Zimmerman and Lino soils are the most extensive soils in the association. They were derived from sorted fine sand that was deposited during the retreat of the Mankato ice sheet.

Also a part of the association, but less extensive, are the Isanti, Anoka, Braham, and Blomford soils. The Isanti soil occupies flat, poorly drained areas and is generally wet. Many small areas of peat occur in depressions. The Anoka soils, associates of the Zimmerman, contain clay bands interbedded with layers of sand. They are somewhat more drought resistant than the Zimmerman soils. The Braham and Blomford soils have developed from thin deposits of outwash sand that overlies calcareous glacial till.

All the soils in this association are acid. The upland soils are commonly droughty. They are very low in fertility, but they are easily worked and respond very well to improved management practices.

Hayden-Bluffton Association (Mankato till plain)

The Hayden-Bluffton association occupies the undulating to rolling glacial till plain of the Mankato substage, which is at a somewhat higher elevation than the Anoka sand plain. These are grayish-brown forest soils of the uplands, and they have limy clay loam subsoils.

The Hayden soils dominate in the association. They occupy the undulating parts of the till plain. The Ames soils occupy the upland flats. The Bluffton soils occur in wet depressions within areas of the Hayden soils. A minor part of the association consists of the Burnsville-Rodman complex, which occupies rolling and hilly areas on the rough moraines. These soils were derived partly from sand and gravel and are commonly droughty. Dairying is the principal type of farming on these soils.

Milaca-Freer Association (Cary till plain)

The Milaca-Freer association occupies the level to rolling glacial till plain of the Cary substage, which is inextensive in Isanti County. This association occurs only in the extreme northern and southwestern parts of the county. The Cary glacial till is generally acid and coarse textured.

The Milaca soils, the most extensive in this association, are well-drained sandy loams and silt loams with reddish-brown sandy loam or sandy clay loam subsoils. The Freer soil is an imperfectly drained associate of the Milaca soils. It occupies gentle depressions and flats on the upland till plain. Minor soils in this association are the Scandia, Emmert, and Adolph. Scandia and Emmert soils are generally coarse-textured and somewhat droughty. They occupy kames, eskers, or rolling moraines. The Adolph soil occupies depressions in the till plain.

All the soils in this association are acid, and most of them are coarse textured. Stones are common on the surface and in the profile. Mixed farming and dairying are the prevailing types of agriculture.

Dalbo-Brickton Association (glacial lake plain)

The Dalbo-Brickton association occurs in the extreme northern part of Isanti County, in the southern part of the area once occupied by glacial Lake Grantsburg. The topography is generally smooth. The Dalbo soils occupy undulating and rolling areas on the lake plain. The Brickton soils occur on nearly level flats. Both of these soils developed from calcareous lake-laid deposits that were high in silt. The upper layers in many places lack lime, but there is an abundance of lime in the substrata. Drainage is inadequate in many places.

Of minor extent in the association are the Kanabec and Greenbush soils, which developed from thin deposits of silts and clays overlying Cary sand and gravel (fig. 3).

This association is composed of soils that are good for agriculture if properly managed. Dairying is the principal type of farming.

Figure 3.—**Thin deposits of lacustrine silts overlying coarse-textured red outwash—typical of Kanabec and Dalbo soils in northern half of the county. Note laminations in lacustrine deposits.**

Onamia-Chetek Association (Cary outwash plain)

The Onamia-Chetek association occurs generally on the lower pitted outwash plain, adjacent to areas of the Milaca-Freer association. The soils were derived from glacial outwash of the Cary substage. The association is of small extent. The Onamia soil, a well-drained fine sandy loam, is fairly deep. The Chetek soils are very shallow, excessively drained loamy sands. Included in the association are areas of Crown and Warman sands, both of which occur in the depressions that are characteristic of the outwash plain. Crown loamy sand is imperfectly drained to moderately well drained. The Warman soils are dark colored and wet.

The dominant soils in this association are sandy and relatively low in water-holding capacity; consequently, they are less productive than the soils of the glacial till plains or the lake plain.

Peat

Peat occurs in low-lying wet areas and is unsuitable for farming unless it is drained and treated with phosphate and potash. Peat consists of plant remains in various stages of decomposition. Only the extensive areas of peat are shown on the soil association map, but many small spots are scattered throughout the other soil associations. Summer frosts, floods, and fires are crop hazards on peat soils.

Descriptions of the Soils

In the following pages the soils and miscellaneous land types mapped in Isanti County are described in

TABLE 2.—*Approximate acreage and proportionate extent of soils mapped*

Soil	Area	Extent	Soil	Area	Extent
	Acres	*Percent*		*Acres*	*Percent*
Adolph silty clay loam	211	0.1	Hubbard loamy fine sand, 2 to 7 percent slopes	996	0.4
Alluvial land, well drained	2,945	1.0	Hubard loamy fine sand, 7 to 12 percent slopes	67	(1)
Alluvial land, poorly drained	5,448	1.9	Isanti loamy fine sand	10,203	3.6
Ames fine sandy loam	4,729	1.7	Kanabec very fine sandy loam, 2 to 7 percent slopes	694	.3
Ames silt loam	3,434	1.2	Kanabec very fine sandy loam, 7 to 12 percent slopes	30	(1)
Anoka loamy fine sand, 0 to 2 percent slopes	188	.1	Lino loamy fine sand	21,596	7.6
Anoka loamy fine sand, 2 to 7 percent slopes	13,343	4.7	Milaca silt loam, 2 to 7 percent slopes	653	.2
Anoka loamy fine sand, 7 to 12 percent slopes	3,410	1.2	Milaca silt loam, 7 to 12 percent slopes	530	.2
Anoka loamy fine sand, 7 to 18 percent slopes, moderately eroded	1,227	.4	Milaca silt loam, 12 to 18 percent slopes, moderately eroded	17	(1)
Beach sand	92	(1)	Milaca fine sandy loam, 2 to 7 percent slopes	10	(1)
Blomford loamy fine sand	1,510	.5	Milaca fine sandy loam, 7 to 12 percent slopes	140	.1
Bluffton loam and silty clay loam	10,216	3.6	Milaca fine sandy loam, 7 to 12 percent slopes, moderately eroded	14	(1)
Braham loamy fine sand, 2 to 7 percent slopes	3,480	1.2	Milaca fine sandy loam, 12 to 18 percent slopes	184	.1
Braham loamy fine sand, 7 to 12 percent slopes	764	.3	Milaca fine sandy loam, 12 to 25 percent slopes, severely eroded	128	.1
Braham loamy fine sand, 7 to 12 percent slopes, moderately eroded	194	.1	Onamia fine sandy loam, 2 to 12 percent slopes	52	(1)
Braham loamy fine sand, 12 to 18 percent slopes, moderately eroded	69	(1)	Peat, deep	52,413	18.5
Brickton silt loam	2,091	.7	Peat, moderately shallow over loam	3,647	1.3
Brickton silt loam, clayey subsoil variant	1,434	.5	Peat, moderately shallow over sand	2,537	.9
Burnsville-Rodman complex, 2 to 7 percent slopes	143	.1	Rough broken land, Zimmerman material	512	.2
Burnsville-Rodman complex, 7 to 12 percent slopes, moderately eroded	371	.1	Rum River loam	2,086	.7
Burnsville-Rodman complex, 12 to 18 percent slopes, moderately eroded	276	.1	Scandia fine sandy loam, 2 to 7 percent slopes	422	.1
Chetek loamy sand, 2 to 7 percent slopes	2,251	.8	Scandia fine sandy loam, 7 to 18 percent slopes	1,323	.5
Chetek loamy sand, 7 to 12 percent slopes	461	.2	Scandia fine sandy loam, 7 to 12 percent slopes, moderately eroded	47	(1)
Chetek loamy sand, 7 to 12 percent slopes, moderately eroded	156	.1	Scandia fine sandy loam, 12 to 25 percent slopes, severely eroded	182	.1
Chetek loamy sand, 12 to 18 percent slopes, moderately eroded	76	(1)	Scandia gravelly sandy loam, 2 to 7 percent slopes	93	(1)
Crown loamy sand	327	.1	Scandia gravelly sandy loam, 7 to 18 percent slopes	74	(1)
Dalbo silt loam, 2 to 7 percent slopes	4,319	1.5	Scandia gravelly sandy loam, 7 to 12 percent slopes, moderately eroded	160	.1
Dalbo silt loam, 7 to 12 percent slopes	811	.3	Scandia gravelly sandy loam, 12 to 25 percent slopes, severely eroded	29	(1)
Dalbo silt loam, 12 to 18 percent slopes, moderately eroded	27	(1)	Warman sandy loam and loam	770	.3
Dalbo fine sandy loam, 2 to 12 percent slopes	709	.3	Zimmerman loamy fine sand and fine sand, 0 to 2 percent slopes	1,056	.4
Emmert loamy fine sand, 12 to 25 percent slopes	86	(1)	Zimmerman loamy fine sand and fine sand, 2 to 7 percent slopes	46,600	16.5
Emmert loamy fine sand, 12 to 25 percent slopes, moderately eroded	68	(1)	Zimmerman loamy fine sand and fine sand, 7 to 12 percent slopes	6,855	2.4
Emmert loamy fine sand, 18 to 25 percent slopes, severely eroded	81	(1)	Zimmerman loamy fine sand and fine sand, 12 to 18 percent slopes	418	.1
Freer silt loam	328	.1	Zimmerman fine sand, 0 to 2 percent slopes	444	.2
Greenbush silt loam, 0 to 2 percent slopes	57	(1)	Zimmerman fine sand, 2 to 7 percent slopes	5,307	1.9
Greenbush silt loam, 2 to 7 percent slopes	63	(1)	Zimmerman fine sand, 2 to 7 percent slopes, moderately eroded	1,724	.6
Hayden silt loam, 2 to 7 percent slopes	8,384	3.0	Zimmerman fine sand, 7 to 12 percent slopes	1,672	.6
Hayden silt loam, 2 to 7 percent slopes, moderately eroded	36	(1)	Zimmerman fine sand, 7 to 12 percent slopes, moderately eroded	3,314	1.2
Hayden silt loam, 7 to 12 percent slopes	3,921	1.4	Zimmerman fine sand, 7 to 12 percent slopes, severely eroded	58	(1)
Hayden silt loam, 7 to 12 percent slopes, moderately eroded	408	.1	Zimmerman fine sand, 12 to 18 percent slopes	77	(1)
Hayden silt loam, 12 to 18 percent slopes	325	.1	Zimmerman fine sand, 12 to 18 percent slopes, moderately eroded	475	.2
Hayden silt loam, 12 to 18 percent slopes, moderately eroded	256	.1	Water	8,938	3.2
Hayden fine sandy loam, 2 to 7 percent slopes	14,523	5.2	Mines and pits	30	(1)
Hayden fine sandy loam, 2 to 7 percent slopes, moderately eroded	70	(1)	Total	282,880	100.0
Hayden fine sandy loam, 7 to 12 percent slopes	8,277	2.9			
Hayden fine sandy loam, 7 to 12 percent slopes, moderately eroded	2,698	1.0			
Hayden fine sandy loam, 12 to 18 percent slopes	894	.3			
Hayden fine sandy loam, 12 to 18 percent slopes, moderately eroded	672	.2			
Hubbard loamy fine sand, 0 to 2 percent slopes	444	.2			

[1] Less than 0.1 percent.

detail. At the back of this report is a map that shows the location and distribution of each soil and land type, and also a tabular supplement to the soil map in which are summarized the principal characteristics of each soil and land type. The approximate acreage and proportionate extent of each soil and land type are given in table 2.

Adolph Soils

Adolph silty clay loam is the only soil of the Adolph series that was mapped in Isanti County.

Adolph silty clay loam (Ad).—This soil has developed from noncalcareous red glacial till. It occupies depressions, shallow valleys, and flats that border peat bogs. Extensive areas occur in Dalbo Township and the western part of Stanford Township. This soil commonly occurs in close association with Scandia, Milaca, and Freer soils. The natural vegetation consisted of swamp grasses and water-tolerant trees, chiefly elm, ash, basswood, willow, alder, and poplar.

Profile of virgin soil:

0 to 9 inches, black silty clay loam; thin layer of muck and well-decomposed organic matter at surface; fine granular structure.
9 to 35 inches, dark-gray plastic heavy silty clay loam; highly mottled; well-developed coarse blocky structure.
35 inches +, reddish-brown, noncalcareous, granitic till of sandy clay loam texture; large quantities of grit and small pebbles; massive structure.

Texture, color, and depth to glacial till vary somewhat. Boulders are numerous in some places, but in other places there are none.

This soil is very poorly drained, but some areas have been artificially drained. Normally, only areas that occur within fields of better drained soils are cultivated. This soil is moderately productive if adequately drained, but artificial drainage is not always economically feasible.

Little of this soil is cultivated. Most of the acreage that is included in farms is used for pasture or wild hay. Pasture plants usually continue to grow during dry periods because the soil below a depth of 4 feet is nearly saturated with water. Because this soil occurs in low-lying positions, crops are likely to be damaged by early fall and late spring frosts. The soil is in management group 4.

Alluvial Land

Alluvial land is a miscellaneous land type that is mapped in Isanti County in two units: Alluvial land, well drained, and Alluvial land, poorly drained.

Alluvial land, well drained (A).—This mapping unit occurs on bottom lands of the Rum River, Stanchfield Creek, and smaller streams. It is frequently flooded, particularly in spring. The light colored to moderately dark colored soil material ranges in texture from silty clay loam to fine sand. In the valley of the Rum River, the surface layer generally consists of fine sand washed from Zimmerman soils on the adjacent sandy outwash plain. This land type is more or less stratified throughout; it has alternating layers of fine sands and coarse sands. In places the profile contains layers of finer textured material. Much of this land type is hummocky because the streams have formed terraces and natural levees.

Most areas of Alluvial land, well drained, are in pasture or in hay crops. On the larger, higher lying, better drained areas, corn and soybeans are grown. This land type is in management group 12.

Alluvial land, poorly drained (Aw).—This mapping unit, consisting of mixed alluvium, occurs on poorly drained bottom lands along the Rum River and smaller streams. Much of it is dissected by old river channels, oxbows, sloughs, and marshes, especially in the relatively wide valley of the Rum River.

This land type is normally dark colored and ranges in texture from silty clay loam to loamy fine sand. In places it is overlain by a thin layer of peat or muck. Mapped with this land type are small areas of Isanti loamy fine sand, Bluffton silty clay loam, and Peat soils.

Because the soil material is nearly saturated the year around, it is not well suited to agriculture. A few areas are used for pasture in extremely dry years. This land type is in management group 12.

Ames Soils

Two soils of the Ames series are mapped in Isanti County—Ames silt loam and Ames fine sandy loam. These are imperfectly drained soils that occur adjacent to drainageways and bogs and on upland flats of the gray calcareous till plains. They are associated with the Hayden soils. In many places these soils contain accumulations of surface soil material that has washed from the surrounding higher lying areas.

Ames silt loam (Y).—This nearly level soil is associated with the Hayden silt loams. It occupies flats and slight depressions in the uplands. The areas are generally small, but they occur in all of the regions underlain by calcareous glacial till. Runoff is slow and internal drainage is moderate to slow. Artificial drainage is needed for most crops.

Profile description of cultivated soil:

0 to 4 inches, gray silt loam; fine granular structure; low in organic matter; a few stones and pebbles on the surface; slightly acid.
4 to 16 inches, dark grayish-brown fine silt loam, mottled with light gray and brown; well-developed fine platy structure; medium acid.
16 to 36 inches, dark grayish-brown gritty silty clay loam mottled with red and yellowish brown; very plastic; impervious to water; subangular blocky structure; strongly acid.
36 inches +, dark-brown calcareous till of clay loam texture; many soft lime nodules; pebbles common; moderately alkaline; depth to carbonates ranges from 30 to 60 inches.

This soil is too wet to be suitable for alfalfa. Except for alfalfa, the same crops are grown as on the associated Hayden soils. This soil is in management group 3.

Ames fine sandy loam (Ys).—This soil, the imperfectly drained associate of the Hayden fine sandy

loams, occupies flats and slight depressions in the calcareous glacial till plain. It is covered by a thin layer of sand. Except for the texture of its surface layer, it is similar to Ames silt loam. External drainage is slow, and internal drainage is moderate to slow.

If artificially drained, this soil is suitable for corn (grown mostly for silage) and tame hay. It is not well suited to small grains, which are likely to lodge, nor to alfalfa. This soil is in management group 3.

Anoka Soils

The Anoka soils developed from water-deposited sands of the outwash plains. Anoka loamy fine sand is the only type mapped in Isanti County. Most of it occurs adjacent to areas of glacial till, but isolated areas have been mapped in other locations. Extensive areas occur in Isanti, Cambridge, and Wyanett Townships. The original vegetation consisted of bur oak, scarlet oak, pin oak, red oak, jack pine, aspen, and white birch.

The Anoka loamy fine sands are characterized by horizontal bands of finer textured materials, which occur at depths ranging from 12 to 42 inches (fig. 4). These layers are extremely variable in thickness and in depth from the surface, but all of them are a fine sandy loam in texture and dark yellowish brown in color. Locally these soils are called "sand with a hardpan." Occasionally they are droughty, but less so than the Zimmerman soils.

Anoka loamy fine sand, 0 to 2 percent slopes (G).—This nearly level soil occurs most extensively east of Cambridge. There are small scattered areas in the southern and western parts of the county. Characteristic of this soil are bands of fine sandy loam material between 30 and 36 inches below the surface. These bands range in thickness from a mere film to 24 inches. They improve the water-holding capacity of the soil.

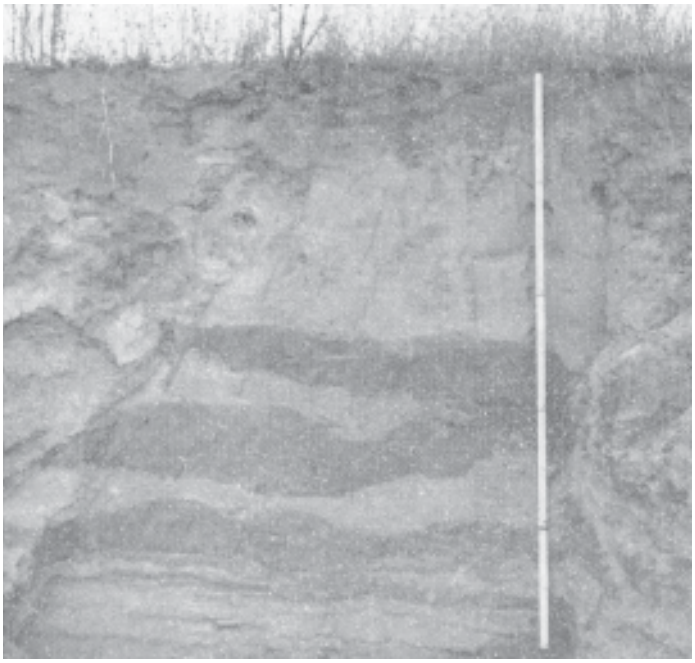

Figure 4.—**Profile of Anoka loamy fine sand, 2 to 7 percent slopes, showing bands of fine material. Bands range from a few inches to 2 feet in thickness and occur from 2 to 4 feet below the surface.**

Profile description of cultivated soil:

0 to 8 inches, very dark grayish-brown loamy fine sand; structureless (single grain); very loose and friable; low in organic matter; medium acid.

8 to 32 inches, yellowish-brown loamy fine sand; structureless (single grain); color and texture nearly uniform; strongly acid.

32 to 54 inches, dark yellowish-brown fine sandy loam; friable when moist, hard when dry; cementation strong when dry but very weak when wet; this layer contains more colloidal iron and clay than layers above and below; it is a continuous horizontal fragipan; light-gray coatings along breakage planes of structural units; coarse blocky to massive structure; medium acid.

54 inches +, light yellowish-brown fine sand to medium sand; structureless; a few very thin veins of fine material (clay and iron) approximately parallel to layer above; slightly acid.

Moisture is generally ample for crops except in extremely dry years. The soil warms up early in the spring, and corn can be planted early. The frost-free period is normally long enough so that corn will mature. This mellow sandy soil is easy to till. Row crops can be cultivated within a short time after rains. Water erosion is practically negligible. Occasionally, windblown soil damages young seedlings. On extremely windy days, newly planted seeds may be blown out of the soil.

Corn, oats, rye, hay crops, and soybeans are grown. This soil, if well managed, is particularly well suited to truck crops. Potatoes at one time were a major crop, and high yields were obtained, but continuous production of potatoes rapidly depleted the fertility of the soil. However, potatoes still can be grown profitably if enough commercial fertilizer is used. Cucumbers, tomatoes, and green peas are grown for canning. Yields are good if rainfall is well distributed during the growing season. This soil is in management group 9.

Anoka loamy fine sand, 2 to 7 percent slopes (Gu).—This soil, the most extensive of the Anoka loamy fine sands, occurs principally in Cambridge, Isanti, and Wyanett Townships. The surface soil is a loose mellow loamy fine sand. The bands of fine material occur at depths of from 2 to 4 feet, and they are from 4 inches to 2 feet thick.

Where the bands are within 2 feet of the surface and are 12 inches or more thick, they materially improve the water-holding capacity; where they are thin and occur at depths of more than 4 feet, they have less effect on the water-holding capacity. There is little runoff. Permeability is rapid, although movement of water through the soil is somewhat restricted by the bands of finer material. Water erosion is seldom a problem, but the loose surface soil occasionally blows during dry periods if it is not protected by a growing crop.

Most of this soil is cultivated. Corn, oats, rye, soybeans, and tame hay are the chief crops. Potatoes and truck crops are also grown to some extent. This soil is in management group 9.

Anoka loamy fine sand, 7 to 12 percent slopes (Gp).—This soil occurs adjacent to drainageways and on the margins of depressions and bogs in the outwash plains. It is less extensive than Anoka fine sandy loam, 2 to 7 percent slopes. It is similar to Anoka fine sandy loam, 0 to 2 percent slopes, but the horizontal bands are less pronounced and vary considerably in thickness and in depth from the surface.

The water-holding capacity is not as good as that of the more gently sloping Anoka soils. Although runoff is moderate, areas not covered by vegetation are likely to erode. Wind erosion damages cultivated fields. Some of the many uncleared areas are in permanent pasture or woodlots. This soil is in management group 9.

Anoka loamy fine sand, 7 to 18 percent slopes, moderately eroded (Gy).—This inextensive soil normally occurs in narrow elongated strips adjacent to drainageways, depressions, and bogs in the outwash plains. It is similar to Anoka loamy fine sand, 0 to 2 percent slopes, except that much of the surface soil has been lost through water and wind erosion. Erosion has resulted from cultivating the steeper slopes. Blowouts occur in many exposed areas, and shallow gullies have formed in places.

Crops are the same as are grown on other soils of the sandy outwash plains. Yields are generally low because this soil is droughty, eroded, and low in fertility. Control of erosion is necessary for successful crop production. On exposed areas, windbreaks are very effective in protecting the soil against wind erosion. Existing woodlots may serve as windbreaks, or strips of jack pine may be planted for that purpose. This soil is probably best suited to permanent pasture or forest. It is in management group 11.

Beach Sand

This is a miscellaneous land type. The total acreage is small.

Beach sand (U).—This mapping unit consists of coarse-textured deposits that occur along the shores of most of the lakes in the county. In places the deposits occupy low ridges or bars some distance back from the present lakeshore.

Continuous strips of Beach sand surround Green Lake in Wyanett Township and Elizabeth Lake in Springvale and Bradford Townships. These deposits consist of coarse, water-worked sand, gravel, and stones and have little or no profile differentiation.

None of this land type is cultivated. Most of the better drained, smoother areas are used for homesites or campsites. Beach sand is in management group 14.

Blomford Soil

Only one soil of the Blomford series—Blomford loamy fine sand—was mapped in Isanti County.

Blomford loamy fine sand (N).—This imperfectly drained soil has developed from thick to moderately thick deposits of outwash and lake-laid sands that overlie calcareous glacial till or slack-water material. It occupies nearly level to gently undulating areas in the transitional zone between the sand plains and the glacial till moraines. Many areas of this soil are in the northern part of Wyanett Township on a nearly level sand plain adjacent to a till moraine. Other areas occur on the sandy outwash plain and on glacial till.

Natural drainage is imperfect; surface runoff is slow to very slow. Permeability is rapid in the upper layers but moderately slow in the lower layers. Because of its topographic position and the nature of the underlying material, this soil holds more water than the other sandy soils with which it is associated. Even in extremely dry years, it supplies enough moisture for crops.

Profile description of cultivated soil:

0 to 3 inches, dark grayish-brown friable loamy fine sand; low in organic matter.
3 to 17 inches, light brownish-gray loamy fine sand; slight mottling in lower part.
17 to 30 inches, pale-brown fine sandy loam mottled with light gray and brown.
30 to 42 inches, dark yellowish-brown partially weathered glacial material of sandy clay loam; mottles of reddish brown and red.
42 inches +, very dark grayish-brown highly calcareous glacial till of silty clay loam texture; mottled with gray; some pebbles and small stones.

The underlying material ranges in texture from a heavy loam to a silty clay loam and begins at depths of 18 to 48 inches.

This soil is used for pasture and for silage corn, grain corn, soybeans, potatoes, small grains, and hay. It is particularly well suited to soybeans. Yields from soybeans are very good if the soil is well managed. This soil is in management group 6.

Bluffton Soils

One undifferentiated group of soils of the Bluffton series was mapped in Isanti County.

Bluffton loam and silty clay loam (Bc).—The soils of this undifferentiated group were derived from calcareous glacial till. They occupy small depressions, poorly drained flats, narrow strips along drainageways in the upland, and narrow margins around peat bogs. Most of the areas are small, except those on flats adjacent to large peat bogs. These soils are associated with the Hayden and Dalbo soils. The native vegetation consists of black ash, elm, paper birch, and tamarack.

Natural drainage is poor. Permeability is slow because of the large amount of fine material in the surface layer and subsoil. These soils receive much of the runoff from the surrounding higher land and frequently are saturated for long periods, particularly in the spring. Consequently, artificial drainage is necessary except during extremely dry years.

Profile of Bluffton silty clay loam in virgin area:

0 to 16 inches, black silty clay loam; high in organic matter; fine granular structure; slightly plastic when wet, hard when dry; neutral.
16 to 30 inches, very dark gray silty clay; many yellowish-brown mottles; slight olive cast when moist; very plastic when wet; massive; neutral.

30 inches +, dark grayish-brown calcareous till of clay loam texture; mottled with yellowish brown; sand grains, pebbles, and small stones common; massive; slightly plastic when wet; moderately alkaline.

Parent material begins at depths of 30 to 48 inches, depending on the topographic position and the thickness of the overburden that has been carried in from the surrounding higher land. Textures range from heavy loam to silty clay loam. Areas that occur in association with slack-water deposits contain the largest amounts of clay. Some areas are covered with a thin coat of peat or muck.

Many small narrow areas of these soils occur within larger areas of Hayden, Dalbo, and other soils, and these areas are farmed along with the associated soils. In other cleared places, very good pastures or wild hay meadows are maintained. If artificially drained, these soils are among the best in the county for corn and soybeans. However, small grains are likely to lodge, potatoes may be killed by early and late frosts, and many crops fail because of excessive moisture during the growing season. These soils are in management group 4.

Braham Soils

The Braham soils have developed from thin to moderately thick deposits of water- and wind-sorted outwash sand, 18 to 48 inches deep, that overlies calcareous glacial till or lacustrine deposits. All of the Braham soils mapped in Isanti County are loamy fine sands. They consist of thin deposits of material like that of the Zimmerman soils, overlying parent material like that of the Hayden and Dalbo soils. Internal drainage is moderate where the sand layer is thin, but rapid where the sand layer is thick. The soils are droughty, but less so than the Zimmerman soils. The slope range is from 2 to 18 percent.

Braham loamy fine sand, 2 to 7 percent slopes (Nu).—This soil occurs mostly along the borders of sandy outwash plains and glacial till moraines. Surface drainage is medium to slow. Internal drainage is somewhat restricted in the nearly level areas, but in areas where the slope is strongest, drainage is good.

Profile description:

0 to 4 inches, grayish-brown loamy fine sand; very loose and friable; relatively low in organic matter; medium acid.

4 to 20 inches, yellowish-brown loamy fine sand; loose; structureless; strongly acid.

20 to 35 inches, yellowish-brown fine sand; slight mottling in lower part of layer; strongly acid.

35 to 45 inches, dark yellowish-brown partially weathered till of clay loam texture; contains thin stratified layers alternately fine and coarse in texture; many stones, pebbles, and coarse grains of sand; brown and gray mottles common; slightly acid to neutral.

45 inches +, light yellowish-brown highly calcareous glacial till of heavy silt loam to clay loam texture; many small lime nodules; pebbles common; moderately alkaline.

The color, texture, and thickness of the layers in the profile vary. In areas where this soil grades to Hayden soils, the surface layer of outwash sands is somewhat thinner than where it grades to Zimmerman soils.

This soil is friable and easily worked. It warms up early in spring, so that crops start to grow early. Most of it has been cultivated. The principal crops are corn, oats, rye, barley, and alfalfa. Some potatoes, cucumbers, beans, and tomatoes are grown. Natural fertility is low, but the soil responds to fertilization. During dry windy periods in spring, young plants are liable to be damaged by drifting sand. Wind erosion can be controlled by suitable management practices. Mixed farming and dairying are the principal types of agriculture. This soil is in management group 9.

Braham loamy fine sand, 7 to 12 percent slopes (Np).—This soil occurs in narrow areas adjacent to depressions or peat bogs. It is associated with Zimmerman and Hayden soils. It is similar to Braham loamy fine sand, 2 to 7 percent slopes, except that it is extremely variable in depth to the calcareous substratum. On many of the west-facing slopes adjacent to Zimmerman soils, the layer of sand overlying the calcareous material is fairly thick.

This soil is low in plant nutrients and organic matter. The surface layer is very friable and permeable. Water is absorbed rapidly, and little or none runs off after heavy rains; nevertheless, the water-holding capacity is low.

This soil is fair for crops and pasture. It is suited to the same crops as Hayden fine sandy loam, 7 to 12 percent slopes, but it requires more intensive management because of low fertility, the hazard of wind erosion, and the limited moisture supply during dry seasons.

Good yields can be obtained if fertilizer and lime are applied to the soil and if rainfall is adequate during the growing period. The organic-matter content can be increased by applying manure or by turning under legumes or cover crops of small grains. Many areas are in forest or permanent pasture. Good pastures are more difficult to maintain than on some of the more fertile soils. Lime and phosphate are needed to establish and maintain pasture stands. This soil is in management group 9.

Braham loamy fine sand, 7 to 12 percent slopes, moderately eroded (Nd).—This soil occurs mainly adjacent to depressions, peat bogs, and small drainageways. Much of the surface soil and part of the subsoil have been removed by water and wind erosion. Blowouts caused by wind erosion occur in exposed places. The loose sandy surface layer is low in organic matter and very low in water-holding capacity.

All of this soil has been cleared and put into cultivation or permanent pasture. At present only a small part is cultivated. Much of this soil is used for the same crops as other phases of Braham loamy fine sand, but because of droughtiness and erosion, yields are very low. Drifting sand damages young seedlings in the spring. The less strongly sloping areas are fairly well suited to alfalfa and other deep-rooted legumes. This soil is better suited to fruit crops or forest than to cultivated crops. The steeper slopes are best suited to timber. Norway pine and jack pine have been planted to stabilize badly eroded areas. This soil is in management group 9.

Braham loamy fine sand, 12 to 18 percent slopes,

moderately eroded (Nx).—This inextensive soil normally occurs in very narrow tracts adjacent to drainageways or peat bogs. It is associated with other phases of Braham loamy fine sand or with Zimmerman and Hayden soils. In many places it lies on the windward side of till moraines near the adjoining sand plain.

Because of the strong slopes, this soil is not well suited to cultivated crops. If it is cultivated, the rotation should consist mostly of small grains and hay crops, which will help to check wind erosion and to maintain and increase productivity. This soil is best suited to forest or permanent pasture. Norway pine and jack pine can be established easily and are effective in controlling erosion. This soil is in management group 11.

Brickton Soils

The Brickton series is represented in Isanti County by Brickton silt loam. Brickton silt loam, clayey subsoil variant, is also mapped.

Brickton silt loam (Bk).—This light-colored, imperfectly drained soil has developed from silty and clayey lake-laid deposits that are associated with the calcareous gray drift of the late Wisconsin age. It occurs in glacial lakebeds on level to nearly level relief. Extensive areas of this soil occur in the northwestern part of the county in Dalbo Township, adjacent to a large peat bog. Other areas are associated with Dalbo soils in Maple Ridge and Stanchfield Townships. The natural vegetation consists of black ash, American elm, ironwood, sugar maple, red oak, basswood, and other hardwoods. The surface layer is uniformly smooth, stone-free silt loam. The subsoil is silty clay.

Profile description of virgin soil:

0 to 4 inches, very dark gray, smooth, friable silt loam; considerable organic matter at surface; fine granular structure; slightly acid.
4 to 10 inches, light brownish-gray friable silt loam; light gray to white when dry; very pronounced thin platy structure; medium acid.
10 to 15 inches, very dark-grayish brown silty clay loam; medium subangular blocky structure; plastic when wet, hard when dry; numerous mottles; strongly acid.
15 to 30 inches, olive-brown silty clay; coarse blocky structure; strongly mottled with gray and reddish brown; very plastic and sticky when wet; strongly acid.
30 inches +, light olive-brown heavy silt loam; smooth calcareous lacustrine silts; massive; moderately alkaline.

The thickness and texture of the subsoil and the underlying calcareous material vary. Where this soil grades to Bluffton silty clay loam, the surface layer is generally somewhat darker colored and slightly finer textured. In most places, lime occurs within 3 feet of the surface.

Drainage is imperfect, because runoff is very slow and percolation is retarded by the clayey subsoil. Artificial drainage, either by bedding or by open ditches, is needed to make the soil suitable for crops. This soil cannot be worked when it is wet; consequently, planting is likely to be delayed. Crops do not ordinarily fail because of short periods of dry weather, but yields are lower than the average if the season is either wetter or drier than normal. All kinds of farm machinery can be used on this level stone-free soil, but considerable power is needed to prepare the soil for cropping. Water and wind erosion are not serious.

This soil is well suited to hay if adequately drained, and is particularly good for permanent pasture if enough lime and phosphate are used. Common hay crops are clover (chiefly alsike) or clover mixed with bromegrass and timothy. This soil is in management group 3.

Brickton silt loam, clayey subsoil variant (Bv).—This soil has developed from parent material similar to that of Brickton silt loam, but it has a finer texture. The largest areas are in the northeastern part of Dalbo Township and the north-central part of Stanchfield Township. Smaller areas occur in association with Brickton silt loam on the glacial lake plain. The lake-laid materials range in texture from fine clay to sand. They are interbedded in many places and some of the layers vary greatly in texture.

Natural drainage is imperfect to poor. Runoff is practically negligible and permeability is slow to very slow. Artificial drainage is needed to make the soil suitable for crops. Shallow open ditches or dead furrows are commonly used to provide drainage. In some places tile drains have been installed.

Because this soil is wet and cold in the spring, planting may have to be delayed so long that yields, particularly of corn, are somewhat reduced. A common rotation consists of corn, oats, and hay. Yields are about the same as on Brickton silt loam. Soybeans are becoming an important crop on this soil because they tolerate excess moisture. Management requirements for this soil include crop rotation, turning under all available organic matter, liming, and growing hay crops that will tolerate high acidity and excessive moisture. This soil is in management group 3.

Burnsville-Rodman Complex

The Burnsville-Rodman complex consists of well drained to excessively drained soils on undulating to strongly rolling moraines. The slopes are generally short. These soils are underlain mostly by glacial drift consisting of calcareous, coarse-textured, stratified, loose sand and gravel. Extensive areas of these soils occur on the hummocky ridge east of Cambridge, near the Chisago County line. The natural vegetation consists of mixed hardwoods, mainly oaks.

These soils vary in texture and thickness of the layers and in depth to the underlying calcareous material. In some places there is practically no profile development; in other places the soil layers are distinct. Gravel is at the surface in some places, and gray calcareous clayey till, containing pockets of noncalcareous red till or outwash sands, is exposed in other places. In areas where water erosion has removed part of the surface layer, the soil is very low in organic matter. Many areas are too gravelly or sandy or too hilly to be cultivated; they are used for woodland pasture.

Burnsville-Rodman complex, 2 to 7 percent slopes (V).—Approximately 60 percent of this mapping unit

consists of Burnsville soils, and approximately 40 percent of Rodman soils. Most of the complex is cultivated. Because of the porous surface layer and underlying loose sand and gravel, internal drainage is rapid and these soils are very droughty. Crops are about the same as those grown on Hayden fine sandy loam, but yields are lower because of droughtiness. Alfalfa is well suited because its roots reach the available moisture. These soils are in management group 2.

Burnsville-Rodman complex, 7 to 12 percent slopes, moderately eroded (Vd).—This mapping unit consists approximately 60 percent of Rodman soils and 40 percent of Burnsville soils. Nearly two-thirds of the surface layer has been lost through erosion. The slopes are complex and generally hummocky. These soils are very droughty.

The layers of gravel and sand, cross-bedded in many places, lie at depths of from 15 to 30 inches. Pockets of calcareous material occur in the underlying material. A few small uneroded areas are mapped with this unit.

Crops are damaged by drought in years of low rainfall. Because of the complex slopes, droughtiness, and erodibility, these soils are not suited to most crops. They are suitable for hay crops, permanent pasture, and forest. These soils are in management group 11.

Burnsville-Rodman complex, 12 to 18 percent slopes, moderately eroded (Vx).—This mapping unit consists approximately 80 percent of Rodman soils and 20 percent of Burnsville soils. Much of the surface layer has been removed by water and wind erosion. In many places the subsoil and the underlying sand and gravel are exposed.

Because of the strong complex slopes, the erosion hazard, and droughtiness, these soils should not be cultivated but should be used for permanent pasture or forest. These soils are in management group 11.

Chetek Soils

The Chetek series—represented in Isanti County by members of one soil type, Chetek loamy sand—consists of well drained to excessively drained soils. Chetek loamy sands have developed on stratified sand and gravel of noncalcareous red drift. They occur mostly on the level to gently rolling pitted outwash plains in the southwestern corner of the county near Crown (fig. 5).

The surface soil is generally a loamy sand, and the subsoil is normally a sandy loam. A few areas are included that have a sandy loam surface soil. The depth to the coarse-textured substratum is normally less than 20 inches. Drainage is somewhat excessive in the areas that are on rolling slopes. Surface runoff is slow and permeability is rapid.

The Chetek loamy sands are associated with Onamia soil, but they are not so deep. In some areas the surface soil is dark colored and resembles that of the Hubbard soils. In a few places the solum is very shallow and is underlain by gray calcareous till. A few areas of Braham loamy sand have been mapped adjacent to these soils, where depth to the calcareous till is less than 3 feet.

Figure 5.—**Profile of Chetek loamy sand, 2 to 7 percent slopes, in the southwestern part of the county. Coarse gravelly outwash material begins at depths of 12 to 15 inches.**

Chetek loamy sand, 2 to 7 percent slopes (C).—The generally smooth relief of the outwash plains on which this soil occurs is broken by many isolated shallow pits (kettles) and depressions that contain peat. These low spots are most numerous and conspicuous in the southwestern part of Spencer Brook Township and the western part of Stanford Township. This is the most extensive Chetek soil in the county. It is associated with Crown loamy sand and Warman sandy loam and loam, both of which have developed from similar parent material. The vegetation consisted of Jack pine, Norway pine, and white pine, but poplar, birch, red oak, and sumac now cover the uncleared areas.

The surface soil consists of loose sand. The underlying material is somewhat variable, but it normally consists of stratified sand and gravel, and there are many cobblestones in places.

Profile description of cultivated soil:

0 to 6 inches, very dark grayish-brown loamy sand; large grains of sand and small pebbles on surface.
6 to 18 inches, dark yellowish-brown loamy fine sand; very friable.
18 to 30 inches, yellowish-brown gravelly sandy loam; weakly cemented with clay; many pebbles.
30 inches +, brownish-yellow to reddish-brown fine sand and loose fine gravel; acid to a depth of more than 6 feet.

The color of the subsoil ranges from yellowish brown to reddish brown. The depth to the coarse-textured substratum ranges from 15 to 20 inches. The size and number of pebbles and cobblestones vary. Gray calcareous till occurs at depths of 3 to 4 feet in many places, particularly in nearly level areas. In such places, the water-holding capacity is better than the average for this soil and productivity is higher.

Most of this soil is cultivated. It is suited to most

of the crops grown in the county, but yields are generally low because of low fertility and low water-holding capacity. Good stands of legumes are fairly common. This soil is in management group 5.

Chetek loamy sand, 7 to 12 percent slopes (Cp).—This soil is similar to Chetek loamy sand, 2 to 7 percent slopes, except that its surface layer is thinner in places. It occurs in narrow strips along the margins of peat bogs. The more extensive areas are north and east of Crown, on the pitted outwash plain. Because it is droughty and erodible, this soil is less suitable for crops than Chetek loamy sand, 2 to 7 percent slopes. It is in management group 5.

Chetek loamy sand, 7 to 12 percent slopes, moderately eroded (Cd).—This soil occurs in association with other Chetek soils on short slopes adjacent to pits (kettles) in the outwash plains. Nearly two-thirds of the surface soil has been removed by water and wind erosion, and in many places the subsoil is exposed. There are cobblestones on the surface in the severely eroded places, and small gullies in the more severely eroded rolling areas. Outcrops of glacial till are common.

Most of this soil has been cultivated. The same crops are grown as on the uneroded Chetek soils. Yields, however, are likely to be lower because of low fertility and the eroded condition of the soil. This soil is in management group 5.

Chetek loamy sand, 12 to 18 percent slopes, moderately eroded (Cx).—This soil normally occurs along the borders of peat bogs. It has lost much of its surface layer through erosion. In small areas used as woodlots or permanent pasture, erosion has been negligible. Because of strong slopes, erodibility, and droughtiness, this soil is not well suited to crops. It can best be used for hay crops, permanent pasture, and forest. It is in management group 11.

Crown Soil

Only one soil of the Crown series—Crown loamy sand—was mapped in Isanti County.

Crown loamy sand (Cw).—This level to gently undulating soil has developed from stratified, noncalcareous, red outwash deposits of the Cary substage. It occurs in association with Chetek soils, most commonly in swales and slight depressions on the extensive outwash plain in the southwestern part of the county. Most of the areas are small. The profiles of Crown and Lino soils are almost identical, but the surface layer of the Crown soil is slightly darker colored and the substratum contains coarse sand and fine gravel.

Profile description:

0 to 8 inches, very dark gray friable loamy sand; moderately high in organic matter; medium acid.
8 to 25 inches, dark grayish-brown, well-sorted loamy fine sand, slightly mottled; many pebbles in lower part of layer; medium acid.
25 to 45 inches +, brown to reddish-brown loamy sand; pebbles concentrated near top of layer; overlies substratum of coarse sand and fine gravel; strongly acid.

The depth to and the composition of the underlying layer of stratified sand and gravel vary.

This soil has a more favorable moisture supply and a higher organic-matter content than the Chetek soils. It is less erodible because it is nearly level. Most areas are well enough drained to be suitable for crops. Some areas may need improved drainage, which can be provided by open ditches. Most of this soil occurs in small fingerlike depressions within areas of Chetek soils, and is generally cropped in about the same way as the Chetek soils. It is well suited to clover and alfalfa. Corn and small grains are normally included in crop rotations. Yields are generally higher than on Chetek soils. This soil is in management group 6.

Dalbo Soils

The Dalbo series consists of well drained to moderately well drained soils developed from highly calcareous silts and clays deposited by glacial lakes. The largest areas of these soils occur in Stanchfield, Maple Ridge, and Dalbo Townships, most commonly along the Kanabec County line between Lory Lake and Braham. The relief is generally undulating to gently rolling, but a few areas are on stronger slopes. In general, the parent material consists of light yellowish-brown or light-gray calcareous slack-water deposits of smooth fine silt loam texture.

These soils have stronger slopes and are better drained than the associated Brickton soils. They are similar to the Hayden soils in profile characteristics, but they have developed from different parent material and contain fewer pebbles and stones.

Dalbo silt loam, 2 to 7 percent slopes (D).—This soil occupies fairly large areas in the basin of glacial Lake Grantsburg. It is the most extensive of the Dalbo soils mapped in the county. Before these areas were cleared for farming, they supported a dense stand of hardwoods—American elm, black ash, red oak, bur oak, basswood, sugar maple, and ironwood. Surface drainage and internal drainage are medium.

Profile description in cultivated area:

0 to 4 inches, grayish-brown friable silt loam, relatively low in organic matter; fine granular structure; neutral.
4 to 10 inches, light brownish-gray silt loam; well-developed thin platy structure; light-gray coatings of fine material on structural aggregates; slightly acid.
10 to 17 inches, very dark grayish-brown silty clay loam; has a few yellowish-brown and gray mottles; well-developed fine subangular blocky structure; very plastic when wet, hard when dry; strongly acid.
17 to 32 inches, very dark grayish-brown silty clay loam, with a few yellowish-brown and gray mottles; well-developed coarse subangular blocky structure; very plastic when wet, hard when dry; strongly acid.
32 to 44 inches +, light yellowish-brown, calcareous, slack-water material of heavy silt loam texture; contains no stones and pebbles but many soft lime concretions; moderately alkaline.

The thickness of the layers and the depth to calcareous material vary. The texture of the substratum ranges from very fine sand to silty clay loam.

This is one of the most productive soils in the county. More than 80 percent of it is under cultivation. Dairy farming predominates. Corn (chiefly for silage and fodder), oats, red clover, and alfalfa are the principal crops. Yields are high. Alfalfa

yields are probably the highest in the county. Erosion is negligible, tilth is good, and productivity is easily maintained. This soil is in management group 1.

Dalbo silt loam, 7 to 12 percent slopes (Dp).—This soil occurs adjacent to drainageways and peat bogs throughout the lake-plain region. It is similar to the other phases of Dalbo silt loam, but in many places the calcareous material is closer to the surface. A few small eroded areas are mapped with this soil.

In general, this soil occurs in fields in which Dalbo silt loam, 2 to 7 percent slopes, predominates, and it is cropped in the same way. Less of this soil has been cleared. Many areas are in permanent pasture or forest. If this soil is poorly managed, erosion may do serious damage. This soil is in management group 2.

Dalbo silt loam, 12 to 18 percent slopes, moderately eroded (Dx).—This soil occupies steep narrow slopes adjacent to drainageways and peat bogs. Much of the surface layer has been lost through water erosion. Sheet and gully erosion have taken place in most areas. Mapped with this soil are a few areas that are less severely eroded.

This soil is better suited to forest or permanent pasture than to cultivated crops. It is in management group 10.

Dalbo fine sandy loam, 2 to 12 percent slopes (Df).—This inextensive soil is similar to the Dalbo silt loams, except that its surface layer is a fine sandy loam and the depth to calcareous material is greater. A few isolated areas are mapped in Springvale, Maple Ridge, and Stanchfield Townships.

Practically all this soil is cultivated to corn, oats, clover, and alfalfa. Yields are similar to those obtained on the Dalbo silt loams but are lower in extremely dry years. This soil is in management group 1.

Emmert Soils

The soils of the Emmert series are generally shallow and weakly developed. They occur on eskers, kames, and rough moraines. Relief is rolling to steep. The most extensive areas are in the extreme southwestern part of the county near the Sherburne County boundary. The parent material was noncalcareous red glacial till deposited during the Cary substage by swift-moving streams that flowed under the glacier. The underlying material is a heterogeneous deposit of sand, gravel, cobblestones, and stones. Drainage is excessive, and the soils are too droughty to be suitable for most crops.

Emmert loamy fine sand, 12 to 25 percent slopes (E).—This soil normally occurs on rolling moraines. Internal drainage is rapid because of the porous surface soil and underlying loose gravel and sand. Most areas are forested with oak, maple, yellow birch, elm, poplar, and cherry.

Profile description of cultivated soil:

0 to 3 inches, light-brown or pale-brown loamy fine sand; very little organic matter; pebbles scattered over the surface; slightly acid.

3 to 30 inches, yellowish-brown to dark-brown loose loamy sand; contains gravel, coarse sand, and stones; material is very loose and contains little fine material; layer has thick cross-bedded lenses of coarse sand and pockets of gravel; slightly acid.

The underlying material ranges in texture from gravelly sand to loamy sand; cobblestones and stones occur in places.

This soil is of little agricultural value, but some of it is used for pasture. It is highly erodible when cultivated. Many areas are used as sources of roadbed material. This soil is in management group 11.

Emmert loamy fine sand, 12 to 25 percent slopes, moderately eroded (Eh).—This soil occurs in the morainic areas. Nearly two-thirds of the surface soil and part of the subsoil have been removed by water erosion. Otherwise, this soil is similar to Emmert loamy fine sand, 12 to 25 percent slopes.

Many of the areas that have been improperly cultivated are severely eroded. These areas are extremely droughty and contain very little organic matter. They are therefore poor for either crops or pasture. Pastures are generally not well managed. This soil is best used for forests or as a source of roadbed material. It is in management group 11.

Emmert loamy fine sand, 18 to 25 percent slopes, severely eroded (Es).—This soil occurs on kames, eskers, and recessional moraines. All of the surface soil and much of the subsoil have been lost through erosion. The slopes are very complex; slopes of less than 18 percent occur in places. Many gullies, some 8 to 10 feet deep, have developed in cleared areas. As a result, most of the cultivated soil has been abandoned. Because of steep slopes, erodibility, and droughtiness, this soil is best used for forests. It is in management group 11.

Freer Soil

Freer silt loam is the only soil of the Freer series mapped in Isanti County.

Freer silt loam (F).—This soil developed from noncalcareous red glacial till of the Cary substage. It occurs in small areas, chiefly in the northwestern part of Dalbo Township and the western part of Stanford Township. Slopes are less than 2 percent. External drainage is slow and internal drainage moderate to slow. The present vegetation consists of elm, basswood, ash, sugar maple, and red oak.

Profile description:

0 to 4 inches, very dark gray silt loam; fine granular structure; medium acid.

4 to 10 inches, dark grayish-brown silt loam; laminated; light gray when dry; some mottles; thin platy structure; medium acid.

10 to 16 inches, brown silty clay loam, mottled with strong brown and pale brown; subangular blocky structure; plastic when wet; strongly acid to medium acid.

16 to 32 inches, dark-brown silty clay loam; mottled with light brownish gray and strong brown; very plastic when wet; blocky structure; strongly acid.

32 to 50 inches +, strong-brown gritty sandy clay loam mottled with light brownish gray; many small pebbles, stones, and lenses of coarse sand; strongly acid to medium acid.

In places this soil contains thin silt caps. In general, it is very uniform, but the upper layers vary somewhat

in thickness. This soil is cultivated to the same crops as the associated Milaca and Adolph soils. The rotation commonly consists of a hay crop, corn (for silage and fodder), and oats. The nearly flat areas need artificial drainage to make them suitable for alfalfa. This soil is better suited to silage corn and hay crops than the Milaca soils. It is in management group 3.

Greenbush Soils

Only two soils of the Greenbush series were mapped in Isanti County.

Greenbush silt loam, 0 to 2 percent slopes (X).—This inextensive, moderately well drained soil occurs on level flats and in slight depressions in the extreme northeastern corner of Dalbo Township. It has developed on thin deposits of lake-washed or modified till that overlie noncalcareous red glacial outwash of the Cary substage. Depth to sand and gravel ranges from 20 to 36 inches.

Surface drainage is moderately slow and there is little runoff. Underdrainage is rapid because of the sandy and gravelly substratum. Because this soil is less well drained than Greenbush silt loam, 2 to 7 percent slopes, its yellowish-brown subsoil layer is somewhat more mottled.

Yields of general farm crops are good. Corn, oats, and hay are the most common crops. This soil is much less affected by drought than Greenbush silt loam, 2 to 7 percent slopes, but in extremely dry years it does not supply enough moisture for crops. This soil is in management group 8.

Greenbush silt loam, 2 to 7 percent slopes (Xu).—This inextensive, moderately well drained to well drained soil occupies smooth undulating topography in the Cary outwash region. It occurs only in Dalbo Township near the Kanabec County line. It has developed from thin deposits of lake-washed or modified till overlying red sands and gravel. Internal drainage is medium, and underdrainage is rapid.

Profile description of virgin soil:

0 to 4 inches, very dark brown, smooth, friable silt loam; fine granular structure; a few stones on surface.
4 to 14 inches, brown friable silt loam; well-developed thin platy structure; stone free.
14 to 25 inches, dark yellowish-brown silty clay loam; well-developed medium subangular blocky structure; slightly plastic when wet, hard when dry.
25 inches +, reddish-brown stratified sand and gravel; some pebbles up to 3 inches in diameter; depth to acid sand and gravel outwash ranges from 20 to 36 inches.

The crops commonly grown on Dalbo, Hayden, and Milaca soils are grown on this soil. Corn, small grains, and hay are the chief crops; hay crops are best suited. The water-holding capacity is comparable to that of the associated glacial soils. Yields are about the same as on the associated soils, except in abnormally dry years. This soil is in management group 8.

Hayden Soils

The Hayden soils are the most extensive of the soils that have developed from gray calcareous glacial till of the late Wisconsin age. They are probably the best agricultural soils in the dairy-farming region of east-central Minnesota. They are generally well drained, their natural fertility is comparatively high, and their productivity is easily maintained.

Two types of Hayden soils were mapped in the county. Hayden silt loams are more fertile than Hayden fine sandy loams. Their subsoil holds moisture well, but the surface soil tends to bake if it is not cultivated soon after a rain.

Hayden fine sandy loams are coarser textured than Hayden silt loams because they have developed partly from a layer of wind- or water-deposited sand up to 18 inches deep. They are more permeable and can be cultivated under a wider range of moisture conditions. The Hayden fine sandy loams occur near areas of sandy outwash in the morainic region north of the Rum River in Springvale and Cambridge Townships, on the till plains of North Branch and Isanti Townships, and on the outer margins of till areas.

Hayden silt loam, 2 to 7 percent slopes (B).—This soil, the most extensive of the Hayden series, stretches east to west across the north-central part of the county. Other large areas occur on a rather smooth ground moraine southeast of Cambridge in Isanti and North Branch Townships. The soil is associated with Ames and Bluffton soils and the other Hayden silt loams. The natural vegetation consists of sugar maple, basswood, red oak, bur oak, black ash, white birch, and elm.

Profile description:

0 to 3 inches, very dark gray silt loam; fine granular structure; low in organic matter; medium acid.
3 to 8 inches, grayish-brown silt loam; very friable and floury; thin platy structure with coatings of light-gray fine material; medium acid.
8 to 28 inches, yellowish-brown clay loam; subangular medium blocky structure with coatings of light-gray fine material; a few small pebbles; slightly plastic when wet, hard when dry; strongly acid.
28 to 42 inches, yellowish-brown clay loam with dark yellowish-brown splotches on the structural particles; well-developed coarse blocky structure; many root channels coated with gray fine material; medium acid.
42 to 50 inches +, light yellowish-brown calcareous till of loam to silt loam texture; contains a few pebbles and lime concretions and numerous brownish-red rust spots.

The upper soil layers vary in thickness and degree of development. The depth to calcareous till ranges from 36 to 48 inches.

Because of the undulating relief, surface drainage is medium, but internal drainage is somewhat restricted in places. Erosion is not severe, but some areas are slightly sheet eroded. Because the surface soil is loose and friable, this soil is easily cultivated, a good seedbed is easily prepared, moisture is readily absorbed, and roots penetrate easily. The subsoil holds moisture well, and therefore crops generally are not damaged during short dry periods.

Most of this soil is cultivated. It is well suited to alfalfa; at least two cuttings can be made each season. Mixed clover is grown extensively for hay. Corn and small grains produce very good yields. This soil is in management group 1.

Hayden silt loam, 2 to 7 percent slopes, moderately eroded (Bu).—Nearly two-thirds of the surface layer and part of the subsoil of this soil have been lost

through erosion. Because subsoil material is mixed with the surface layer, this soil is low in organic matter and the tilth is poor. The present surface layer ranges from yellowish-brown smooth friable silt loam to reddish-brown silty clay loam.

This soil is suited to the same crops as Hayden silt loam, 2 to 7 percent slopes, but yields are much lower and it is difficult to produce good stands of alfalfa and clover. This soil is in management group 1.

Hayden silt loam, 7 to 12 percent slopes (Bp).—This soil is similar to Hayden silt loam, 2 to 7 percent slopes, in most profile characteristics, but it has thinner layers and is not so deep to calcareous till. Little if any erosion is apparent.

Most areas of this soil are in forest or pasture. If the soil is cultivated, it is essential to use a cropping system that will protect against erosion. Otherwise, much of the surface soil will be lost under continued cultivation, and productivity will decrease. Because surface runoff is rapid, the moisture supply is less favorable than that of Hayden silt loam, 2 to 7 percent slopes; consequently, crop yields generally are much lower. This soil is in management group 2.

Hayden silt loam, 7 to 12 percent slopes, moderately eroded (Bd).—Nearly two-thirds of the original surface layer and part of the subsoil of this soil have been removed by erosion. Places where the reddish-brown subsoil is exposed are called "galled spots." Shallow gullies have developed in places, but as a rule they do not interfere with cultivation. The surface soil ranges from grayish-brown heavy silt loam to reddish-brown silty clay loam. It is very low in organic matter and somewhat compact. Because of the effects of erosion, fertility is low and tilth is poor.

Practically all of this soil has been cultivated, but many areas are now idle. Alfalfa, hay mixtures, corn, and oats are grown, but yields are materially lower than for Hayden silt loam, 2 to 7 percent slopes. Special management practices are necessary to control erosion and to improve and maintain fertility. This soil is in management group 2.

Hayden silt loam, 12 to 18 percent slopes (Br).—This relatively uneroded soil normally occurs adjacent to streams or peat bogs. In general, slopes are short, less than 200 feet in many places. Slopes of more than 18 percent occur in places. The soil is shallower over the calcareous till and has thinner layers than the less strongly sloping Hayden silt loams.

Practically all areas of this soil are in forest or pasture. Because of the hazard of erosion, the soil is not suited to cropping. If it is cultivated, the rotation should consist mainly of hay and other close-growing crops. This soil is in management group 2.

Hayden silt loam, 12 to 18 percent slopes, moderately eroded (Bx).—This soil occurs on rolling morainic regions of calcareous gray till, normally on short slopes that border streams or peat bogs. Slopes of more than 18 percent gradient occur in places. Nearly two-thirds of the surface layer and part of the subsoil have been lost through erosion. The color and texture of the surface soil vary according to the extent of erosion. This soil is extremely low in organic matter.

Most of this soil has been cultivated, but only a few small areas are now being cropped. Yields are very low. Abandoned fields, covered with wild grasses, weeds, and low bushes, are common. The areas are too steep for general farm crops and are best used for permanent pasture or woodlots. Lime and commercial fertilizer must be applied to establish good pastures. This soil is in management group 10.

Hayden fine sandy loam, 2 to 7 percent slopes (T).—This soil is similar to Hayden silt loam, 2 to 7 percent slopes, except for surface texture. It is more permeable than the silt loams, and it can be cultivated more easily and under a wider range of moisture conditions. Because of the single-grain structure, however, it is less resistant to erosion.

Profile description of virgin soil:

0 to 4 inches, dark-gray to gray friable fine sandy loam; relatively low in organic matter; single grain structure; slightly acid.
4 to 10 inches, pale-brown to yellowish-brown friable fine sandy loam; thin platy structure; medium acid.
10 to 17 inches, yellowish-brown loam to silt loam; friable; fine subangular blocky structure; medium acid.
17 to 38 inches, dark yellowish-brown clay loam; well-developed medium subangular blocky structure; contains some small glacial pebbles; plastic when wet, hard when dry; slightly permeable to moisture and plant roots; strongly acid.
38 to 60 inches +, yellowish-brown calcareous till of heavy loam texture; contains many lime concretions, stones, and pebbles; massive structure.

The soil varies in texture and thickness of layers and in depth to calcareous till. In many areas the surface layer is a loamy fine sand, 12 to 18 inches thick. In places calcareous till is at depths of 4 feet or more.

Because of the clay in the subsoil, enough moisture is retained so that plants are seldom adversely affected by extended dry weather. The soil is well drained, and water seldom stands on the surface. Early spring planting is possible; this is particularly important if corn is grown for grain.

Practically all of this productive soil is cultivated. The most common rotation consists of corn, oats, and 2 years of a clover and alfalfa mixture. Alfalfa is particularly well adapted to this soil and is one of the principal forage crops. In favorable seasons it often yields 3 tons an acre from two cuttings. Oats, rye, other small grains, and corn yield well. Most of the corn is cut green, some of it for silage, but in favorable years it is allowed to mature. Stands of alfalfa are usually improved by applications of ground limestone. Barnyard manure is commonly used on this soil, and commercial fertilizer is usually applied to corn. This soil is in management group 1.

Hayden fine sandy loam, 2 to 7 percent slopes, moderately eroded (Tu).—This soil occurs in association with other Hayden fine sandy loams. Most of the virgin surface soil and part of the subsoil have been removed by erosion. Where the reddish-brown subsoil is exposed, fertility is lower and tilth is less favorable than in less severely eroded areas. Most of the erosion losses have been caused by poor soil management.

Most of the general farm crops are grown, but yields are considerably lower than on Hayden fine sandy loam, 2 to 7 percent slopes. Better management of this soil would include plowing under organic

matter, using commercial fertilizer and lime, and controlling erosion. This soil is in management group 1.

Hayden fine sandy loam, 7 to 12 percent slopes (Tp).—This soil occurs on short slopes, normally in small areas adjacent to drainageways, depressions, and peat bogs. It is similar to Hayden fine sandy loam, 2 to 7 percent slopes, except that the layers are thinner and the depth to calcareous till is less. In addition, it is somewhat more droughty. Surface drainage and internal drainage are very rapid.

Many areas of this soil are in forest or permanent pasture. The soil is probably better suited to forest or to alfalfa and small grains than to cultivated crops. If cultivated, it is very likely to erode. It is cultivated less intensively than Hayden fine sandy loam, 2 to 7 percent slopes, and yields are generally lower. This soil is in management group 2.

Hayden fine sandy loam, 7 to 12 percent slopes, moderately eroded (Td).—This soil occurs in narrow strips adjacent to streams and bogs. Most of the surface layer and part of the subsoil have been removed by erosion. Although the reddish-brown subsoil is exposed in places, the profile is generally similar to that of Hayden fine sandy loam, 2 to 7 percent slopes.

Much of this soil is cultivated to the same crops as other Hayden fine sandy loams, but because of erosion and the effects of a less favorable moisture supply, yields are lower. Yields of corn and small grains are much lower than on Hayden fine sandy loam, 7 to 12 percent slopes. Alfalfa and other hay crops do well if the soil is limed and a satisfactory seedbed is prepared. Areas that have been severely eroded are better suited to forest or permanent pasture than to crops. Most of the less severely eroded areas are in the same fields as the uneroded Hayden fine sandy loams. This soil is in management group 2.

Hayden fine sandy loam, 12 to 18 percent slopes (Tr).—Most of this soil lies adjacent to bogs and drainageways. The larger areas are in North Branch Township on the rolling moraines near the Chisago County line, and in Springvale Township. Slopes of more than 18 percent occur in places.

Most areas are in forest, but some are in permanent pasture. When cultivated this soil is likely to be seriously damaged by erosion. After a few years of cultivation, yields decline rapidly and the soil acquires the characteristics of Hayden fine sandy loam, 12 to 18 percent slopes, moderately eroded. This soil is in management group 2.

Hayden fine sandy loam, 12 to 18 percent slopes, moderately eroded (Tx).—This soil occurs in narrow strips adjacent to streams and peat bogs. Erosion has removed most of the surface soil, and in many places the subsoil is exposed. The present surface soil is grayish-brown heavy silt loam to reddish-brown silty clay loam to a depth of 6 inches. It is very low in organic matter. Slopes of more than 18 percent occur in places. Numerous "galled spots" and small gullies occur and, as a result, tilth is extremely poor.

Yields of cultivated crops are very low. Some areas of this soil are idle, but most are in woodlots or permanent pasture. The use of lime and fertilizer will improve the quality and quantity of pasture. This soil is in management group 10.

Hubbard Soils

The soils of the Hubbard series developed on sandy outwash plains from the calcareous gray outwash of the Mankato substage. They occur most extensively in North Branch Township, on the east side of a large moraine, between areas of Zimmerman soils and areas of Hayden soils. Scattered areas occur in other parts of the county, where they are adjacent to finer textured soils derived from the same parent material.

These soils have a darker colored surface layer and a coarser substratum than the Zimmerman soils. The surface soil is normally a loamy fine sand, but in places it is a sandy loam. In some places the subsoil layers show some textural differences, but generally the layers are differentiated by color rather than by texture. The moderately dark color of the surface soil in virgin areas indicates that the native vegetation was prairie grasses.

Hubbard loamy fine sand, 0 to 2 percent slopes (H).—This soil, the most extensive phase of Hubbard loamy fine sand, occurs on the nearly level to level outwash plains. The largest areas are in North Branch Township near the Chisago County line. Although the parent material consists of calcareous material, the soil is acid to a depth of at least 5 or 6 feet.

Profile description of uncultivated soil:

0 to 10 inches, black to very dark brown loamy fine sand; moderately high in organic matter; very friable; fine granular structure; slightly acid.
10 to 25 inches, very dark grayish-brown loamy sand; loose and friable; slightly acid.
25 to 40 inches, dark yellowish-brown fine sand and medium sand; a few small pebbles; medium acid.
40 inches +, dark yellowish-brown gravelly medium sand and coarse sand; coarseness increases with depth; medium to slightly acid.

Surface color ranges from dark brown to black, the depth of the surface layer from 4 to 12 inches, and the texture from loamy fine sand to fine sand. The depth to calcareous material ranges from 4 to 8 feet.

Because this soil has a much higher content of organic matter and a higher water-holding capacity than the associated Zimmerman soils, it generally produces higher yields. However, in dry years yields are low. The chief crops are rye, oats, corn, soybeans, and tame hay. Rye is grown extensively because it is less likely to be damaged by drought than other crops. Water erosion is negligible because of the nearly level topography, but wind erosion is often a hazard. The rotation should include legumes to maintain and build up the organic-matter content. Commercial fertilizers and manure will increase yields of all crops, especially corn. This soil is in management group 5.

Hubbard loamy fine sand, 2 to 7 percent slopes (Hu).—This soil occurs on the outwash plains in association with the other Hubbard soils. The profile is essentially the same as that of Hubbard loamy fine sand, 0 to 2 percent slopes, but this soil is generally lower in organic matter. Wind erosion damages exposed areas during dry windy seasons. This soil has a higher organic-matter content and a better moisture supply than many of the sandy soils of the county.

This soil is cropped in about the same way as Hubbard loamy fine sand, 0 to 2 percent slopes, but be-

cause it is more droughty, yields are lower. The yields on this soil are much lower than those obtained on finer textured soils derived from glacial till. This soil is in management group 5.

Hubbard loamy fine sand, 7 to 12 percent slopes (Hp).—This inextensive soil occurs on the sandy outwash plains adjacent to peat bogs and depressions. It is similar to other Hubbard loamy fine sands but contains less organic matter. Droughtiness is the principal hazard. Rotations should be used that will at least partially maintain the supply of organic matter and thereby keep the water-holding capacity of the soil from diminishing.

Because of strong slopes, droughtiness, and susceptibility to erosion, this soil is cultivated less than the other Hubbard loamy fine sands. Cultivated fields must be protected against wind erosion. This soil is in management group 5.

Isanti Soil

Only one soil of the Isanti series—Isanti loamy fine sand—was mapped in Isanti County.

Isanti loamy fine sand (Is).—This is a poorly drained dark-colored soil that has developed from sandy outwash material. It occurs throughout the sandy plains, generally on flats or in small circular depressions near peat bogs. The water table is normally high and is frequently near the surface except in extremely dry years. Surface drainage is poor, and, because of the high water table, internal drainage is only fair. The native vegetation consisted chiefly of marshgrasses, sedges, and water-tolerant bushes and trees.

Profile description of Isanti loamy fine sand in a wild-hay meadow:

0 to 2 inches, very dark gray to black muck containing little mineral matter; medium acid.
2 to 10 inches, very dark gray to black mucky loamy fine sand; very loose; structureless; strongly acid.
10 to 30 inches, grayish-brown loamy fine sand, with distinct mottles of brown and reddish brown; grayish streaks; strongly acid.
30 to 45 inches, light-gray to grayish-brown fine sand, with brown mottles; coarseness increases with depth; slightly acid.

The organic-matter content of the surface layer varies, and so does the texture of the subsoil. In places the muck layer may be 10 inches thick, but it is normally much less. The degree of acidity generally decreases with depth; the substratum may be neutral.

Only a small acreage of this soil is in cultivation, primarily because of poor drainage, low fertility, and strong acidity. Corn, soybeans, oats, and hay crops are grown. In favorable years yields are higher than on the strongly sloping Zimmerman soils. Some of the cultivated areas are included in larger fields of Lino and Zimmerman soils. The large flats are not suitable for crops unless they are artificially drained. Some areas lack suitable outlets for drainage. This soil is in management group 7.

Kanabec Soils

The Kanabec soils occur on lake plains or outwash plains. They developed from lacustrine silts and clays that overlie loose sand and gravel. They are similar to the associated Dalbo soils but are more acid and have a coarser textured substratum. The surface soil is generally of a very fine sandy loam texture, but in a few places it is a silt loam. Slopes range from nearly level to gently rolling. Drainage is moderately good to good. Only two soils of this series were mapped in Isanti County.

Kanabec very fine sandy loam, 2 to 7 percent slopes (K).—This soil occurs principally on the lake plain in the vicinity of Braham. Most of it is on slopes of 2 to 4 percent. Drainage is moderately good. The native vegetation was hardwood forest consisting of basswood, elm, ash, red oak, and maple.

Profile description of a cultivated soil:

0 to 3 inches, very dark gray very fine sandy loam; fine granular structure; low in organic matter; medium to slightly acid.
3 to 10 inches, brown to pale-brown very fine sandy loam to silt loam; well-developed thin platy structure; medium to slightly acid.
10 to 24 inches, dark-brown smooth clay loam slightly mottled with light gray and strong brown; well-developed medium subangular blocky structure; strongly acid.
24 to 32 inches, yellowish-brown clay loam to sandy clay loam, mottled with gray and strong brown; medium blocky structure; mixed lacustrine and sandy outwash material; medium acid.
32 to 45 inches, yellowish-brown coarse sandy loam made up of layers of noncalcareous fine sand and gravel; extremely variable in composition and thickness; medium acid.

The depth to sand and gravel varies from 2 to 4 feet. Many areas of this soil are cultivated to corn, oats, rye, and tame hay. Yields are slightly lower than on the Dalbo soils because this soil is more acid and has a less favorable moisture supply. Corn normally follows hay in the rotation, but it occasionally follows oats or rye. Most of the manure available is used on the cornfields. The use of commercial fertilizers is increasing. Lime is needed for alfalfa and clover crops. This soil is in management group 8.

Kanabec very fine sandy loam, 7 to 12 percent slopes (Kp).—Most of this soil occurs on slopes adjacent to depressions or peat bogs in the lake plains. It is essentially like Kanabec very fine sandy loam, 2 to 7 percent slopes, except that the surface layer is thinner, the depth to stratified sand and gravel is somewhat less, and drainage is better.

If intertilled crops are grown extensively, soil may be lost through water erosion. Most areas are used for pasture and hay crops and have eroded very little. Yields are somewhat lower than on the associated soils of the lake plains. This soil is in management group 8.

Lino Soil

Lino loamy fine sand is the only soil of the Lino series mapped in Isanti County.

Lino loamy fine sand (L).—This imperfectly drained

to moderately well drained soil has developed from water-deposited outwash sands. It is associated with Zimmerman and Isanti soils. It occurs on level to gently undulating relief in swales and slight depressions in the outwash plains. An aerial photograph shows that these areas form a distinct braided pattern that is typical of the glacial outwash plains. The fact that most of the areas do not have drainage outlets indicates that the glacial outwash is of relatively recent origin and has been affected little or not at all by stream action. Each fingerlike area of this soil is small, but the combined acreage is large.

Profile description of uncultivated soil:

0 to 4 inches, very dark gray loamy fine sand; moderate to small amount of organic matter; structureless (single grain); very loose and friable; strongly acid to medium acid.
4 to 16 inches, very dark grayish-brown fine sand; structureless (single grain); many indistinct fine mottles; medium acid to slightly acid.
16 to 48 inches +, dark-brown loose fine sand; color and texture very uniform to depth of more than 4 feet; no mottles; coarseness increases with depth; slightly acid.

The surface soil ranges from very dark gray to dark grayish brown. The degree of mottling in the subsoil varies. In places the substratum is dark brown and contains colloidal organic matter, but in other places it is yellowish brown. The organic-matter content of this soil is slightly higher than that of the Isanti soil.

Because it contains more organic matter and occurs in lower topographic positions, this soil has a better moisture supply than the Zimmerman soils. Little rainfall is lost through runoff. The water table, during the greater part of the year, is not so low that there is likely to be a shortage of moisture. Consequently crops are less liable to be damaged by drought than those grown on Zimmerman soils.

Practically all cultivated areas of this soil are within fields of Zimmerman soils and are usually cropped in the same way. The principal crops are corn, oats, rye, soybeans, and hay. The hay crops are a mixture of clover and timothy, or clover or alfalfa grown alone. Lime is necessary for alfalfa and clover. In most areas natural drainage is good enough so that the soil is suitable for cropping, but drainage may be improved by the use of open ditches. This soil is in management group 6.

Milaca Soils

The Milaca soils have developed from noncalcareous red glacial till of the Cary substage of the Wisconsin age. The till contains ferruginous sandstones, reddish quartzite, and many kinds of crystalline rock.

Two types of Milaca soils were mapped in Isanti County—Milaca silt loam and Milaca fine sandy loam. These soils occupy an area of only a few square miles in the county. The Milaca silt loams occur in less strongly sloping areas and are generally less stony; consequently, they are better agricultural soils than the Milaca fine sandy loams. The fine sandy loams occur in the rolling and hilly morainic areas.

Milaca silt loam, 2 to 7 percent slopes (M).—This soil occurs only in the upland areas in the extreme northwestern part of the county, mainly on slight knolls or smooth moraines that lie above the surrounding areas. Surface runoff is medium and permeability is moderate. Erosion is seldom a hazard. The native vegetation consisted of white pine and mixed hardwoods. Aspen, white birch, red oak, white oak, basswood, red maple, and sugar maple now predominate.

Profile description of virgin soil:

0 to 2 inches, dark-gray silt loam; fine granular structure; low in organic matter but contains some decomposed leaves and roots; slightly acid.
2 to 9 inches, yellowish-brown very friable silt loam; weakly developed thin platy structure; slightly acid.
9 to 15 inches, brown silt loam; well-developed medium platy structure; medium acid.
15 to 42 inches, reddish-brown sandy clay loam; coarse blocky to massive structure; slightly plastic when wet, hard when dry; many igneous and sandstone pebbles; strongly acid.
42 inches +, dark reddish-brown noncalcareous sandy till of sandy clay loam texture; massive; contains lenses and pockets of sand and gravel; boundary indistinct; slightly acid.

The degree of stoniness varies. The texture of the underlying till ranges from sandy loam to sandy clay. The sandy clay loam is dominant. In places the surface layer is a silt loam. Some areas are mantled with a thin coating of silty material deposited either by wind or by water.

This soil is not so productive as the Hayden soils but is well suited to dairying, which is the prevailing type of farming. The main crops are oats, corn, hay, and silage. This soil is in management group 1.

Milaca silt loam, 7 to 12 percent slopes (Mp).—This inextensive soil occurs in upland areas, most of which are adjacent to bogs and depressions. Surface runoff is medium to somewhat rapid, and internal drainage is slow. The soil is erodible, especially on the more strongly sloping areas. Much of it is in forest. The cultivated areas are used mostly for the crops commonly grown on the other phases of Milaca silt loam. This soil is in management group 2.

Milaca silt loam, 12 to 18 percent slopes, moderately eroded (Mx).—This soil occurs on short slopes adjacent to bogs and depressions in the upland. Most of the surface soil and some of the subsoil have been lost through water erosion. Where the reddish-brown subsoil is exposed, tilth is poorer and fertility is lower than in the less severely eroded spots. This soil is similar to the more gently sloping phases of Milaca silt loam, except that the layers in the profile are thinner.

Some of the less severely eroded and less strongly sloping areas of this soil are cultivated with other phases of Milaca silt loam, but most of this soil is best suited to pasture or hay crops. Crop yields are generally low. This soil is in management group 10.

Milaca fine sandy loam, 2 to 7 percent slopes (Mf).—This soil is confined to the rolling sandy moraines in the southwestern part of the county, near the boundaries of Sherburne and Anoka Counties. It generally occurs on flat ridgetops in areas of choppy relief. The till from which this soil has been formed is very loose in some places, and in others it is a complex mixture

of red and gray drift material. This soil is similar to the Milaca silt loams, but it is more stony and normally is coarser textured. Stones and boulders are numerous on and below the surface. The uncleared areas support a stand of mixed hardwoods consisting of red maple, sugar maple, white birch, red oak, bur oak, hazel, and green ash. White pine was once abundant; many stumps remain.

Profile description:

0 to 3 inches, very dark gray sandy loam; very little organic matter; fine granular structure; slightly acid.
3 to 11 inches, brown very fine sandy loam; well-developed thin platy structure; aggregates coated with light-gray fine material; medium acid.
11 to 20 inches, reddish-brown heavy loam to light clay loam; fine subangular blocky structure; firm when moist; medium acid.
20 to 47 inches, dark reddish-brown sandy clay loam; well-developed blocky structure; aggregates hard, somewhat indurated when dry, plastic when wet; stones and pebbles common; strongly acid.
47 to 75 inches +, yellowish-red till of sandy loam to sandy clay loam texture; massive in places, single grain in pockets; many stones, pebbles, and rocks; medium acid.

This soil varies in the color and texture of the layers and in the degree of stoniness.

Areas from which the stones have been removed are cropped in the same way as Milaca silt loam, 2 to 7 percent slopes. Yields are generally lower during periods of subnormal rainfall, because this soil is droughty. This soil is in management group 1.

Milaca fine sandy loam, 7 to 12 percent slopes (Mn).—This soil occurs in the rolling morainic regions in association with the other phases of Milaca fine sandy loam. All the slopes are complex and relief is choppy. Because of stoniness, droughtiness, and susceptibility to erosion, only a few areas of this soil are cultivated. Most areas are uncleared and are used as woodlots or pasture. This soil is in management group 2.

Milaca fine sandy loam, 7 to 12 percent slopes, moderately eroded (Md).—This soil is like Milaca fine sandy loam, 2 to 7 percent slopes, except that the surface layers are thinner. Erosion resulting from continued cultivation of row crops has removed much of the surface soil. Some areas have been severely damaged by sheet and gully erosion. Compared to the uneroded phases of Milaca fine sandy loam, this soil has poor tilth and is low in organic matter; consequently, it produces lower yields. This soil is in management group 2.

Milaca fine sandy loam, 12 to 18 percent slopes (Mr).—This soil occurs in the uneroded rolling morainic regions of the red glacial till. Nearly all of it is in forest. It is unsuitable for cultivation because of steep complex slopes, erodibility, and droughtiness. It is better suited to permanent pasture or forest. This soil is in management group 10.

Milaca fine sandy loam, 12 to 25 percent slopes, severely eroded (Ms).—This soil occurs on very complex slopes in rolling morainic areas of red drift in the southwestern part of the county. Nearly all of the surface soil and part of the subsoil have been lost through sheet and gully erosion. Erosion has been caused by poor management. The organic-matter content is very low, tilth is poor, and fertility is low. This soil is unsuited to cultivation and should be reforested or used for grazing. It is in management group 10.

Onamia Soil

Onamia fine sandy loam is the only soil of the Onamia series mapped in Isanti County.

Onamia fine sandy loam, 2 to 12 percent slopes (ON).—This well-drained soil has developed from water-deposited sands and gravel derived from noncalcareous red glacial drift. It occurs on undulating to gently rolling outwash plains and terraces in the northern part of the county along the Kanabec County line. It is associated with Kanabec and Milaca soils. Only a few small areas are mapped.

Profile description of virgin soil:

0 to 4 inches, dark-gray fine sandy loam; fine granular structure; slightly acid.
4 to 10 inches, grayish-brown fine sandy loam; thin platy structure; medium acid.
10 to 25 inches, reddish-brown clay loam; medium subangular blocky structure; slightly plastic when wet; medium acid.
25 inches +, reddish-brown stratified sand and gravel; many large pebbles; slightly acid.

This moderately coarse textured soil is underlain at depths of 20 to 40 inches by stratified gravel. It is similar to the Chetek loamy sands, except that the layers of gravel are at greater depths and the surface layer is not so coarse textured. Internal drainage is rapid.

This soil is cropped and managed in about the same way as the associated Milaca soils, but yields are generally lower. Because of the coarse substratum, the soil does not hold enough moisture so that hay crops and small grains will do well during dry years. In extremely dry years, crop yields are very low. This soil is in management group 8.

Peat Soils

Three organic soils are mapped in Isanti County: Peat, deep; Peat, moderately shallow over loam; and Peat, moderately shallow over sand.

Peat, deep (P).—This organic soil consists mainly of partially decomposed plant remains that have accumulated in poorly drained areas. Areas of peat are numerous in the sandy outwash plains and in the till plains and lake plains. They occupy low-lying flats, wet depressions, and former lakes and ponds. Particularly in the sand plains, peat occurs in abandoned channels of marginal glacial streams. The most extensive area, a former glacial lake, is in the northwestern part of Dalbo Township. Most of the peat bogs are covered with a thick layer of moss, and they support a growth of spruce and tamarack trees and shrubs. In parts of the sandy outwash areas, the bogs contain only sedges and wild grasses (fig. 6). Many of the bogs occur in a pattern approximately parallel to the direction of the movement of the early glaciers.

The surface layer normally consists of a dark-brown, spongy, fibrous mass of roots of heath shrubs and mosses. This material grades to a brown mass of

Figure 6.—**Peat, deep, in an open bog of sedge vegetation. Water table is high most of the year. Muskrat mounds in middle distance.**

roots, stems, and woody material in various stages of decomposition; this layer is 3 to 10, or more feet in depth. In places the peat is underlain by calcareous loams, either till or lake deposits, but in other places it is underlain by sand.

Only a small part of this soil is cultivated. Among the crops grown are tame hay, corn, potatoes, oats, truck crops, and soybeans. If adequately drained and properly fertilized, this soil produces high yields in favorable years. Occasionally, crops are seriously damaged by summer frosts. This soil is in management group 13.

Peat, moderately shallow over loam (Pc).—This soil occurs in wet depressions and bogs throughout the glacial till plains and lake plains. The peat is from 12 to 36 inches thick; the underlying material is generally a calcareous loam.

Normally, this soil is too wet for cropping unless it is artificially drained. In general, the areas are similar in color, structure, and degree of decomposition, but in a few places the uppermost 6 inches or less is a black muck.

Included in this mapping unit are areas that were once similar to Peat, deep, but that have been burned over. A large area in the northwestern quarter of Dalbo Township was burned in 1919–20, and then drained. It is now cultivated to corn, truck crops, and small grains.

Very high yields of potatoes, cabbage, onions, and carrots are produced in favorable seasons. However, there is always danger of frost damage to sensitive crops. This soil should be fertilized with phosphorus and potash for best results. Wind erosion occasionally causes damage during extremely dry years. This soil is in management group 13.

Peat, moderately shallow over sand (Ps).—This fairly well decomposed dark-brown peat occurs throughout the sandy outwash regions. It is in small areas adjacent to Zimmerman and Chetek soils. The depth to sand ranges from 12 to 36 inches. In many places narrow rims of this soil surround areas of Peat, deep, and are mapped as Peat, deep, because they are too narrow to be mapped separately.

This soil is too wet for cropping unless it is artificially drained. Open ditches are the most economical means of draining the bogs. In years of subnormal rainfall, farmers in the sandy, droughty sections of the county rely on areas of this soil for pastures and for wild hay.

Areas that are adequately drained and fertilized are sometimes cropped to soybeans, small grains, and truck crops. Frost is always a hazard, but serious damage occurs only occasionally. This soil is in management group 13.

Rough Broken Land

This is a miscellaneous land type. There is almost no evidence of profile development.

Rough broken land, Zimmerman material (ZL).—This miscellaneous land type occurs on rather steep slopes on the sand plain. It lies adjacent to the channels of the Rum River and its tributaries. Most of the areas support a cover of mixed hardwoods. Local relief normally ranges from 25 to 100 feet or more. Soil slipping is common. The soil material is a fine sand resembling that of the Zimmerman soils. Runoff is very rapid, and narrow V-shaped gullies have formed. This land type is used to a limited extent for grazing and timber. It is in management group 14.

Rum River Soil

The Rum River series is represented in Isanti County by one soil, Rum River loam.

Rum River loam (R).—This dark-colored soil occurs on flood plains, mainly in old abandoned channels of the Rum River. It is flooded only occasionally because it is slightly higher than the bottom land. In general, this soil is imperfectly drained to poorly drained. The texture of the surface layer and subsoil is somewhat finer than that of the associated sandy alluvial land. The subsoil is commonly a silty clay loam.

Profile in a cultivated field:

0 to 6 inches, very dark brown friable loam; moderately high in organic matter; medium acid.
6 to 24 inches, very dark gray silty clay loam; plastic when wet, hard when dry; many mottles of yellowish brown and gray; strongly acid.
24 to 30 inches, very dark gray sandy clay loam mottled with light gray; contains light-gray streaks; medium acid.
30 to 48 inches, yellowish-brown fine sand mottled with gray and strong brown; coarseness increases with depth; medium acid.

The texture of the subsoil and the depth to the sandy layer vary.

This fairly productive soil is particularly well suited to corn and soybeans. The moisture supply is generally adequate, because of the high water table. This soil affords good grazing during dry periods when pastures on the adjacent sandy soils are poor. Frosts that occasionally occur during the growing season

damage corn and soybeans. This soil is in management group 12.

Scandia Soils

The Scandia soils have developed from red drift or a mixture of red and gray drift. They occur on complex slopes of rough moraines, mainly in the western half of Stanford Township, south of Blue Lake. Drainage is somewhat excessive to excessive.

These soils are similar to the Milaca soils but have a coarse, very loose substratum. The Scandia gravelly sandy loams contain gravel in quantities that interfere with cultivation.

Scandia fine sandy loam, 2 to 7 percent slopes (S).—This soil occurs in the rough morainic region in the extreme southwestern corner of the county. Much of it is on flat ridgetops. Drainage is somewhat excessive, but the soil is not so droughty as the more strongly sloping Scandia soils. Many areas support stands of mixed hardwoods.

Profile description of virgin soil:

0 to 2 inches, very dark gray fine sandy loam; very little organic matter.
2 to 7 inches, dark grayish-brown fine sandy loam; thin platy structure.
7 to 17 inches, dark-brown sandy clay loam; many pebbles; slightly sticky when wet, hard when dry.
17 to 25 inches, strong-brown sandy clay loam; weak blocky structure; contains streaks of sand and gravel.
25 inches +, strong-brown sorted fine sand and medium sand; stratified; veins and pockets of gravel; coarseness increases with depth; acid.

This soil varies in color, in degree of development of the subsoil, and in depth to the stratified coarse-textured substratum.

Most areas are only slightly eroded, but erosion can become severe in the more rolling areas, especially if clean-cultivated crops are grown. Crops are the same as are grown on the Milaca fine sandy loams. Droughtiness often limits yields. This soil is in management group 2.

Scandia fine sandy loam, 7 to 18 percent slopes (Sp).—This soil occurs on morainic ridges in the southwestern part of the county. It is associated with other Scandia soils and with Milaca fine sandy loams. All the slopes are very short and choppy. Because of droughtiness and the hazard of erosion, few areas are cultivated. This soil is not well suited to intertilled crops, but some areas are used for grazing. Occasionally, alfalfa and other legumes are grown, but the stands often fail. This soil is in management group 11.

Scandia fine sandy loam, 7 to 12 percent slopes, moderately eroded (Sd).—This soil occurs on morainic ridges, mainly in the southwestern part of the county. It is similar to Scandia fine sandy loam, 2 to 7 percent slopes, but its surface layer is generally much thinner and contains less organic matter. Most of the surface layer and part of the subsoil have been lost through erosion. In many places water erosion has resulted from improper management.

Because this soil is generally droughty, crop yields are usually limited. The soil should not be planted to clean-cultivated crops but should be used for permanent pasture and woodlots. This soil is in management group 10.

Scandia fine sandy loam, 12 to 25 percent slopes, severely eroded (Ss).—This soil occurs on rolling morainic areas in the southwestern part of the county in association with other Scandia soils. All of the surface layer and part of the subsoil have been lost through water erosion. The slopes are very complex and are generally short. Many gullies, from a few inches to several feet deep, have formed on the steeper slopes.

To prevent severe gully erosion, this droughty soil must be kept in pasture or woodland. If it is used for pasture, a good sod should be maintained to prevent further erosion. This soil is in management group 11.

Scandia gravelly sandy loam, 2 to 7 percent slopes (J).—This soil is similar to Scandia fine sandy loam, 2 to 7 percent slopes, except that the surface layer is a gravelly sandy loam. It occurs on morainic ridges in association with Scandia fine sandy loams and Milaca fine sandy loams. Most areas of this soil are used as woodlots, but a few areas are cultivated. Because of the gravelly surface layer, susceptibility to erosion, and droughtiness, this soil is not suited to intertilled crops. However, some areas can be used for grazing and for hay crops. This soil is in management group 2.

Scandia gravelly sandy loam, 7 to 18 percent slopes (Jp).—This soil occurs on gravelly morainic ridges near the Sherburne County line in the southwestern part of the county. The gravel in the surface soil makes it difficult to use farm machinery on this soil. In many places sand and gravel occur throughout the profile and the substratum. Only a few areas of this soil are cultivated, because it is droughty and erodible. It is best suited to woodland. It is in management group 11.

Scandia gravelly sandy loam, 7 to 18 percent slopes moderately eroded (Jd).—This soil occurs in association with other Scandia gravelly sandy loams, Scandia fine sandy loams, and Milaca fine sandy loams. Most of the surface layer and part of the subsoil have been lost through water erosion. The erosion is the result of poor management. Because of the susceptibility to further erosion, this soil should not be cultivated. It is droughty, low in organic matter and plant nutrients, and too gravelly for ordinary cropping. It should be reforested or used for pasture. This soil is in management group 11.

Scandia gravelly sandy loam, 12 to 25 percent slopes, severely eroded (Js).—The few small areas of this soil occur in the extreme southwestern corner of the county. Most of the surface layer and part of the subsoil have been lost through water erosion. Gullies are numerous, and in places they are more than 5 feet deep.

All of this soil has been cultivated. It is now so severely eroded that it is best used for woodland. It may be used for limited grazing. This soil is in management group 11.

Warman Soils

One undifferentiated group of Warman soils was mapped in Isanti County.

Warman sandy loam and loam (W).—This undifferentiated group of soils was mapped in depressions and along the borders of bogs. It is widely distributed within areas of Chetek and Crown soils in the southwestern section of the county. Drainage is poor to very poor. Boulders and stones are common in some areas. Very few areas are cultivated. The mapping unit is inextensive.

Profile description of Warman loam:

0 to 9 inches, black mucky loam; high in organic matter; well-decomposed muck on the surface; slightly sticky when wet; strongly acid.
9 to 19 inches, grayish-brown clay loam mottled with yellowish red; shows streaks of reddish brown; contains much grit; well-developed gley horizon; massive; sticky when wet; medium acid.
19 to 25 inches +, dark-gray to grayish-brown sandy clay loam, mottled and streaked with yellowish red; many pebbles and stones in upper part; grades downward into reddish pure sands; slightly acid.

The texture of the surface layer ranges from sandy loam to heavy loam; the depth to stratified sand and gravel ranges from 2 to 4 feet.

These soils are too wet for ordinary farming unless they are artificially drained. Normally, artificial drainage is not practical because most of the areas are very small. Some areas are farmed along with the adjoining Crown and Chetek soils. Under favorable conditions yields are better than those on associated soils. These soils are in management group 7.

Zimmerman Soils

The Zimmerman soils are the most extensive in the county. They have developed from water- and wind-deposited fine sands of the glacial outwash plains. These soils are unusually uniform in profile characteristics. Drainage is excessive. The topography is gently sloping to sloping. The deep, droughty, somewhat dunelike Zimmerman fine sands are less extensive and of less agricultural value than the Zimmerman loamy fine sands and fine sands.

Zimmerman loamy fine sand and fine sand, 0 to 2 percent slopes (Z).—The soils in this undifferentiated group developed from very sandy glacial outwash that has been well sorted by stream action. The most extensive areas occur in the southwestern section of the county, along the Anoka County boundary. The Zimmerman fine sands are the predominant soils in the group.

The soils in this group are extremely low in organic matter and essential mineral elements. Drainage is excessive, although on the more extensive flats the water table is frequently high. The water-holding capacity is low, and the soils are usually droughty during dry seasons. Exposed areas are very likely to be damaged by wind erosion, and young plants are often seriously damaged by drifting sands.

These soils warm up early in the spring and are very easy to cultivate. Good tillage practices, suitable rotations, applications of lime, and proper use of barnyard manure and plant residues are needed to control erosion and minimize the effects of drought. The most common rotation consists of 1 year of corn, oats, or rye, followed by 2 years of alfalfa, red clover, or a grass-clover mixture. Weeds are seldom a problem, but good pasture stands are difficult to maintain. Uncultivated areas are in woodlots of scrub oak. This soil is in management group 5.

Zimmerman loamy fine sand and fine sand, 2 to 7 percent slopes (Zu).—The soils of this undifferentiated group occur mainly on the smooth divides of the outwash plains. They are the most extensive soils in the county and the best agricultural soils of the Zimmerman series. The sands contain a high proportion of quartz.

These soils are excessively drained. Runoff is slow because the surface soil is porous. Percolation is rapid. Wind erosion is severe on poorly protected areas. These soils are low in organic matter, nitrogen, and potassium, and are somewhat deficient in available phosphorus.

Profile description of Zimmerman loamy fine sand:

0 to 2 inches, very dark gray loamy fine sand; many decomposed roots and leaves of scrub oak; low in organic matter; weak very fine crumb structure to structureless (single grain); strongly acid.
2 to 5 inches, brown and grayish-brown fine sand; very weakly developed; strongly acid to medium acid.
5 to 60 inches, yellowish-brown fine sand; very uniform; structureless (single grain); medium acid.
60 to 80 inches +, brown fine sand and medium sand; structureless (single grain); coarseness gradually increases with depth; medium acid.

In some places thin veins and narrow bands of fine-textured material occur throughout the soil profile. They are not nearly so pronounced as the banded layers in the Anoka soils.

Most areas of these soils are cultivated. Mixed farming is generally practiced. Dairying is less important than on the Hayden soils. A considerable acreage is in corn and small grains. The soils are particularly well suited to fall-planted rye. Rye is effective in controlling wind erosion. Usually the soil holds enough moisture after the spring thaw so that the rye crop will mature even in dry years.

Alfalfa is somewhat difficult to establish, but if lime is applied and the moisture supply is favorable, a good stand can be produced. Quackgrass is troublesome, especially in older stands of alfalfa. Crops are likely to be damaged by drought in dry years, particularly in areas where the organic-matter content is lower than normal. In the spring young plants are frequently damaged by drifting sands. These soils are in management group 5.

Zimmerman loamy fine sand and fine sand, 7 to 12 percent slopes (Zp).—These soils occur in association with the other Zimmerman soils, generally adjacent to peat bogs and depressions. They are similar to Zimmerman loamy fine sand and fine sand, 2 to 7 percent slopes, but they are more droughty and their surface layers contain much less organic matter. Most areas of these soils are uneroded, but if unprotected they are more susceptible to wind erosion than the

more gently sloping phase. Blowouts are common in areas where protective strips of trees have been removed.

Most of the areas are not cultivated because of the short steep slopes, droughtiness, and the hazard of wind erosion. However, in the more strongly sloping sections of the sand plains, many areas of these soils occur in the same fields as Zimmerman loamy fine sand and fine sand, 2 to 7 percent slopes, and are generally cropped in the same way. These soils are in management group 11.

Zimmerman loamy fine sand and fine sand, 12 to 18 percent slopes (Zr).—These soils occupy short slopes adjacent to bogs or streams. If cleared they are extremely erodible, but most areas are in woods or pasture or are otherwise protected against wind erosion. These soils are droughty and are generally very low in organic matter and nitrogen. They are not suited to cultivation, but should be used for pasture or as woodlots. These soils are in management group 11.

Zimmerman fine sand, 0 to 2 percent slopes (Zf).—This nearly level soil occurs on flat divides or slightly elevated flats between bogs in the sandy outwash plains. Most of the areas are in the extreme southern part of the county near the Anoka County border.

The entire profile consists of nearly uniform well-sorted fine sands that contain very little organic matter. This soil is not so droughty as the more strongly sloping Zimmerman soils. Wind erosion is not serious on protected areas.

Practically all of this soil is under cultivation. Crops are the same as on the Zimmerman loamy fine sands and fine sands, but yields are somewhaf lower. Rye, oats, corn, and hay are probably the best suited crops. This soil is in management group 5.

Zimmerman fine sand, 2 to 7 percent slopes (Zg).—Small, scattered areas of this excessively drained soil occur throughout the sandy outwash plain. This soil is similar to Zimmerman loamy fine sand and fine sand, 2 to 7 percent slopes, but it is coarser textured throughout its profile. The surface soil is a uniform, well-sorted fine sand. The subsoil and substratum grade with depth from fine sand to coarse sand. The surface soil and subsoil are very porous and contain little clay. The sand is predominantly quartz. Some of the fine sand probably has been sorted by wind action. In unprotected areas, which are highly susceptible to wind erosion, blowouts are common. Most areas are protected by trees and are only slightly eroded.

This soil is more droughty than the Zimmerman loamy sands. The moisture supply is insufficient for most crops, except in years of abnormally high rainfall. Corn is generally damaged most by drought. Rye is fairly well suited to this soil because it is drought resistant and it protects the soil against blowing. This soil is in management group 5.

Zimmerman fine sand, 2 to 7 percent slopes, moderately eroded (Zv).—This soil occurs on unprotected parts of the outwash plain. Wind erosion has removed much of the surface layer. Blowouts are common in places that lack sufficient protective cover; they are from a few square feet to an acre or more in size and many are several feet deep. More soil may be lost unless corrective measures are taken.

This soil is very droughty because of its coarse-textured surface layer and subsoil. The water-holding capacity is extremely low because of the low organic-matter content and the lack of fine soil material. The surface layer is strongly acid. The texture is uniform, probably because the fine sands have been sorted by wind or water or by both.

Many fields of this unproductive soil are lying idle; abandoned farmsteads are rather common. This soil is not suited to general farm crops and should be planted to trees. Red pine and jack pine are commonly used to reforest idle areas. Pines planted in north-south strips will help prevent blowing on areas that are not already seriously eroded. This soil is in management group 11.

Zimmerman fine sand, 7 to 12 percent slopes (Zn).—This soil occurs on the sand plains in areas in which coarser textured sands predominate. Many areas occur on dunelike hills southwest of Cambridge on both sides of the Rum River. Much of the soil is in forest that consists mainly of bur oak, red oak, scarlet oak, and scrub oak. In the wooded areas the shifting sands are fairly well stabilized.

If this soil were cleared, it would not be suitable for cultivation because it is extremely droughty and very low in fertility. It is best used for oak or pine forests. This soil is in management group 11.

Zimmerman fine sand, 7 to 12 percent slopes, moderately eroded (Zd).—This soil is similar to Zimmerman fine sand, 2 to 7 percent slopes. Wind erosion is somewhat severe on unprotected areas, and blowouts are rather common (fig. 7). The soil is very droughty and, like the other Zimmerman fine sands, it is extremely low in organic matter, nitrogen, and plant nutrients.

Most of the areas have been cultivated. Because the surface layer is strongly acid, pastures and legume

Figure 7.—**Area of Zimmerman fine sand, 7 to 12 percent slopes, severely eroded, that has been damaged by blowouts. Scrub oaks in background help stabilize shifting sands.**

crops require lime. This soil is low in productivity and is therefore probably best suited to forest. Trees would provide cover for wildlife and protect the soil from further wind erosion. This soil is in management group 11.

Zimmerman fine sand, 7 to 12 percent slopes, severely eroded (Zs).—This soil occurs on unprotected parts of the sand plain, in association with other Zimmerman fine sands. Most of the surface layer has been lost through wind erosion, and there are many blowouts. Entire areas have had to be abandoned because of erosion losses. The cost of reclamation is prohibitive. Many areas have been reforested by the State and Federal governments, mainly to Norway pine, white pine, and jack pine. This soil is in management group 11.

Zimmerman fine sand, 12 to 18 percent slopes (Zh).—This relatively uneroded soil occurs on short slopes adjacent to bogs and streams. It is similar to other phases of Zimmerman fine sand. Most of this soil is wooded or in pasture. It is erodible, very droughty, and very low in organic matter, nitrogen, and other plant nutrients. It is not suited to cultivated crops but is suited to pasture or forests. This soil is in management group 11.

Zimmerman fine sand, 12 to 18 percent slopes, moderately eroded (Zx).—This soil occurs on short slopes, principally adjacent to the Rum River or to peat bogs. It is similar to Zimmerman fine sand, 12 to 18 percent slopes, except that it has been cleared and is moderately eroded (fig. 8). Wind erosion has been severe in unprotected places that have been cultivated. This soil is droughty, very low in organic matter and nitrogen, and strongly acid. It is best suited to limited grazing or to use as woodland. It is in management group 11.

Morphology and Genesis of Soils

Most of the soils of Isanti County have been formed from materials deposited by glaciers. The soils of the glacial uplands, the outwash plain, and the glacial lake plain were derived from materials deposited during or shortly after glacial time. The alluvial soils have been formed from sediments recently deposited by streams, and the organic soils from vegetative remains that have accumulated in wet areas.

Figure 8.—**Zimmerman fine sand, 12 to 18 percent slopes, moderately eroded. This soil has been damaged by wind erosion.**

Factors in Soil Formation

The characteristics of a particular soil depend on (1) the nature of the parent material; (2) climate, both past and present; (3) plant and animal life in and on the soil; (4) relief; and (5) the length of time during which the soil has been developing. During the transformation of the raw parent material into soil, mineral matter decomposes, organic matter accumulates, materials in suspension and solution move downward in the soil profile and some are removed in drainage waters, and new chemical compounds and minerals form. The relative effect of each of the soil-forming factors is reflected in the soil profile.

In Isanti County, differences in parent material account for most of the differences among the soils. Climate, plant and animal life, and relief are fairly uniform throughout the county, and all of the soils have been developing for about the same length of time.

Four kinds of glacial materials supplied the parent material for most of the soils of the county: Calcareous gray glacial till of the Mankato substage; noncalcareous red glacial till of the Cary substage; calcareous glacial lake (lacustrine) deposits; and glacial outwash deposits. A few of the soils were derived from more recent flood-plain alluvium, organic-matter deposits (peat), and beach deposits. The influence of the parent materials is shown by the texture and by the mineral and chemical composition of the soils.

The climate is cool, temperate, and humid throughout the county. Relief is mild; the variation in elevation is only 275 feet. The native vegetation consisted of deciduous forests, except in the northernmost part where the forest was a mixture of coniferous and deciduous trees. The parent materials, except for the older red glacial drift of the Cary substage, have been in place about the same length of time.

Classification of the Soils

Table 3 shows how the soils of Isanti County are classified into the three soil orders—zonal, intrazonal, and azonal—and into suborders, great soil groups, and series.

Zonal soils

Zonal soils are well-developed soils, the significant characteristics of which have been determined by the action of climate and vegetation. Since climate and vegetation are fairly uniform throughout the county, many of the zonal soils are similar in color, depth, and organic-matter content.

The zonal order is represented in Isanti County by three great soil groups, the Gray-Brown Podzolic, the Gray Wooded, and the Prairie soils. The Gray-Brown

TABLE 3.—*Soil series classified by order, suborder, and great soil group*

Suborder and great soil group	Soil series
ZONAL SOILS	
Light-colored podzolized soils of the timbered regions:	
Gray-Brown Podzolic soils	Anoka. Braham. Chetek. Greenbush. Hayden. Milaca. Onamia. Scandia. Zimmerman.
Gray-Brown Podzolic soils, imperfectly drained	Ames. Crown. Lino.
Gray Wooded soils	Dalbo. Kanabec.
Dark-colored soils of the humid grasslands:	
Prairie soils	Hubbard.
INTRAZONAL SOILS	
Hydromorphic soils of marshes, swamps, seep areas, and flats:	
Humic Gley soils	Adolph. Bluffton. Isanti. Warman.
Low-Humic Gley soils	Blomford. Brickton. Freer.
Organic soils	Peat.
AZONAL SOILS	
Regosols	Beach sand. Burnsville-Rodman complex. Emmert. Rough broken land, Zimmerman material.
Alluvial soils	Alluvial land. Rum River.

Podzolic soils predominate in the deciduous forest zone, which includes most of the county. The Gray Wooded soils developed in the coniferous-deciduous forest zone in the extreme northern part of the county. The Prairie soils developed in small open areas, under grass vegetation.

Podzolization is the dominant process in the development of the zonal soils of this county. It causes depletion of bases, development of acidity, and formation of leached A horizons and zones of accumulation in B horizons. The intensity of the podzolization process varies, depending on the effects of the soil microclimate, the vegetation and living organisms in and on the soil, and the nature of the parent material.

There are, however, no true Podzols in Isanti County. True Podzols have a layer of humified acid organic matter on top of the mineral soil; a highly leached, acid, light-gray A_2 horizon; and a dark coffee-brown B_2 horizon.

GRAY-BROWN PODZOLIC SOILS

Gray-Brown Podzolic soils have formed under deciduous forest in a temperate, moist climate. Typically, these soils have a comparatively thin covering of organic matter over a leached grayish-brown horizon. The leached horizon is underlain by a brown horizon that is well developed in structure and texture. Of the soils of Isanti County, the Hayden, Onamia, and Greenbush soils most nearly resemble the typical Gray-Brown Podzolic soils.

Profile description of Hayden silt loam (SE¼NE¼ sec. 8, T. 37 N., R. 24 W.):

- A_1 0 to 3 inches, dark-gray (10YR 4/1, moist)[2] silt loam; some dark-gray well-decomposed organic matter; fine granular structure; slightly acid.
- A_2 3 to 10 inches, pale-brown (10YR 6/3, moist) friable silt loam; weak thin platy structure; medium acid.
- B_{21} 10 to 28 inches, brown (7.5YR 5/4, moist) silty clay loam, slightly mottled with gray and yellow; cleavage faces coated with light-gray silty material; many stones and pebbles; well-developed medium subangular blocky structure; medium acid.
- B_{22} 28 to 42 inches, dark-brown (7.5YR 4/4, moist) silty clay loam streaked with yellow; well-developed medium blocky structure; numerous stones; plastic when wet, hard when dry; strongly acid.
- C 42 inches +, brownish-yellow (10YR 6/6, moist) calcareous till of heavy silt loam; some pebbles; many lime nodules; moderately alkaline.

The well-drained Hayden soils have developed on calcareous glacial till of the Mankato substage. They generally occur on undulating to rolling slopes of the till plains and moraines.

The Milaca and Scandia soils have some characteristics that resemble those of Podzols. Their A_2 horizons are generally grayer than those of typical Gray-Brown Podzolic soils. The B horizon usually shows the color typical of members of the Brown Podzolic great soil group. There is also evidence of textural development in the B horizon. The Milaca soils developed on noncalcareous red till deposited during the Cary substage of the Wisconsin glacial age by the Labradorian Glacier.

Typical profile of Milaca silt loam (SE¼SE¼ sec. 8, T. 37 N., R. 25 W.):

- A_1 0 to 2 inches, dark-gray (10YR 4/1, moist) silt loam; fine granular structure; a few decomposed leaves and roots; slightly acid.
- A_{21} 2 to 9 inches, yellowish-brown (10YR 5/4, moist) friable silt loam; weak thin platy structure; slightly acid.
- A_{22} 9 to 15 inches, brown (10YR 5/3, moist) silt loam; well-developed medium platy structure; a few igneous pebbles; medium acid.
- B 15 to 42 inches, reddish-brown (5YR 4/4, moist) sandy clay loam; coarse blocky to massive structure; individual structural units cemented; many igneous and sandstone pebbles and stones; strongly acid.

[2] Color notations follow the Munsell system for color, explained in the SOIL SURVEY MANUAL, U. S. Dept. Agr. Handbook No. 18, 503 pp., illus. 1951.

C 42 inches +, dark reddish-brown (5YR 3/4, moist) noncalcareous till of sandy clay loam; massive; many lenses and pockets of sand and gravel; boundary between B and C horizons indistinct; slightly acid.

Anoka, Braham, Chetek, and Zimmerman soils have poorly defined horizons and therefore resemble, in some ways, the Regosols, which are azonal soils having few or no clearly expressed profile characteristics. The Zimmerman soils normally have a thin grayish-brown A_1 horizon and a brown or yellowish-brown B horizon, slightly finer textured than the surface soil and darker colored in the lower part. There is no striking development of texture or structure in the B horizon. The C horizon normally is the same in color and texture as when the material was deposited.

The Zimmerman soils have been formed from glacial outwash consisting mainly of water-deposited sands that were laid down during or after the retreat of the last ice sheet (Mankato substage). The soil material contained an unusually high proportion of quartz sand. The soil profile is almost uniform throughout the county, and the horizons vary little if any in texture.

Profile description of Zimmerman loamy fine sand in a wooded area (SE¼SE¼ sec. 10, T. 34 N., R. 24 W.):

A_1 0 to 2 inches, very dark gray (10YR 3/1, moist) loamy fine sand; contains decomposed roots and leaves of scrub oak; low in organic matter; weak very fine crumb structure or structureless (single grain); strongly acid.

A_3 2 to 5 inches, brown (10YR 5/3, moist) and grayish-brown (10YR 5/2, dry) fine sand; very weak development; strongly acid to medium acid.

B 5 to 60 inches, yellowish-brown (10YR 5/4, moist) fine sand; nearly uniform; structureless (single grain); medium acid; thin, very dark brown (10YR 3/3) bands, ⅛ to ¼ inch thick, occur in this layer.

C_1 60 to 80 inches, brown (10YR 5/3, moist) fine sand and medium sand; structureless (single grain); becomes coarser with depth; medium acid.

Several of the Gray-Brown Podzolic soils are imperfectly drained; they are the Ames, Crown, and Lino soils. The level to gently undulating Ames soils are the imperfectly drained associates of the Hayden soils. They have developed from calcareous gray till under the influence of a swamp-forest vegetation. These soils resemble Planosols in that they have a well-developed, fine-textured B_2 horizon, underlain by a coarser textured horizon that overlies the calcareous C horizon. Crown and Lino soils have grayer surface soils and more mottled subsoils than typical Gray-Brown Podzolic soils and are regarded as intergrades to the Low-Humic Gley soils.

GRAY WOODED SOILS

Gray Wooded soils are similar to Gray-Brown Podzolic soils in many characteristics, but they are lighter colored and usually less acid in the A horizon and have a higher base status. They form in a cool, temperate, subhumid to humid climate, under a deciduous, coniferous, or mixed forest. In general, they develop from calcareous parent materials or from materials that have a very high base status.

The Dalbo soils are typical of the Gray Wooded soils of this county. They have formed on silty calcareous lacustrine deposits, mainly on glacial lake plains in the basin of the glacial Lake Grantsburg. They resemble Podzols in some characteristics, but they have a thicker A_2 horizon and are much less acid throughout. Compared to the Gray-Brown Podzolic soils, the Dalbo soils are grayer, have a thicker A_2 horizon, and are less acid. Because Isanti County is in the transitional zone between the Gray-Brown Podzolic soils to the south and east and the Gray Wooded soils to the north, it is to be expected that some soils will have characteristics intermediate between these two great soil groups.

Profile of Dalbo silt loam (NE¼NE¼ sec. 5, T. 37 N., R. 23 W.):

A_0 and A_1 0 to 4 inches, very dark brown (10YR 2/2, moist) friable silt loam; fine granular structure; low in organic matter; neutral.

A_2 4 to 10 inches, light brownish-gray (10YR 6/2, moist) silt loam; well-developed thin platy structure; light-gray coatings on individual platelets; slightly acid.

AB 10 to 17 inches, dark grayish-brown (10YR 4/2, moist) heavy silt loam; fine subangular blocky structure with coatings of light gray on the blocks; strongly acid.

B_2 17 to 32 inches, dark grayish-brown (10YR 4/2, moist) to very dark grayish brown (10YR 3/2, moist) silty clay loam; some yellowish-brown mottles; well-developed coarse subangular blocky structure; light-gray coatings on structural units; no stones or pebbles; strongly acid.

C_1 32 to 44 inches +, light yellowish-brown (10YR 6/4, moist) calcareous slack-water deposit of heavy silt loam; veins of light gray and splotches (rust spots) of yellowish red; highly calcareous smooth lacustrine silts, free of stones and pebbles; many lime concretions; moderately alkaline.

PRAIRIE SOILS

Prairie soils develop under grass in a cool, moderately humid climate. The decomposing grasses build up the organic-matter content of the surface soil, which consequently is dark colored. Vegetation is the dominant factor in the development of Prairie soils.

In Isanti County, this great soil group is represented by only one series, the Hubbard. These soils developed only in small open areas in the forest, called "oak openings," and are very limited in extent. They developed on coarse-textured outwash material. In places they are shallow. The substratum is gravelly in many places. The Hubbard soils have some characteristics of Regosols.

Profile of Hubbard loamy fine sand (NE¼NE¼ sec. 14, T. 34 N., R. 25 W.):

A_1 0 to 10 inches, black (10YR 2/1, moist) to very dark brown (10YR 2/2, moist) loamy fine sand; moderately high in organic matter; very friable; fine granular structure; neutral.

A_3 10 to 25 inches, very dark grayish-brown (10YR 3/2, moist) loamy sand; very loose and friable; slightly acid to neutral.

B_2 25 to 40 inches, dark yellowish-brown (10YR 4/4, moist) fine sand and medium sand; contains a few pebbles; medium acid.

C_1 40 inches +, dark yellowish-brown (10YR 4/4, moist) gravelly medium sand and coarse sand; many small pebbles and grains of coarse sand; becomes coarser with depth; medium acid.

Intrazonal soils

The intrazonal soils are more or less well developed and have been more strongly influenced by local relief or parent material than by climate and vegetation.

Soils of the intrazonal order are well distributed throughout Isanti County. They normally occur in rather small isolated wet areas—swales, depressions, pitted outwash plains, flats, and bogs. Humic Gley, Low-Humic Gley, and Organic soils are intrazonal groups. Humic Gley and Low-Humic Gley soils have gleyed horizons. Gleization is a process that takes place in soils that are excessively wet, or alternately wet and dry. It results in the formation of a sticky, compact, olive-gray horizon in the lower part of the solum. The restricted drainage may be caused by the high clay content or by a high water table. The Bluffton soils are typical of the Humic Gley soils in Isanti County, and the Brickton of the Low-Humic Gley group.

HUMIC GLEY SOILS

Humic Gley soils—an intrazonal group of poorly drained to very poorly drained hydromorphic soils—have a dark-colored mineral horizon high in organic matter. This moderately thick layer is underlain by a mineral gley horizon. Humic Gley soils occur under swamp-forest or herbaceous marsh vegetation in bogs, depressions, or swamps.

Bluffton soils—typical of the Humic Gley group—are the dark-colored associates of the Hayden soils. They occur in poorly drained depressions in the gray calcareous till region.

Profile of Bluffton silty clay loam (SW¼NW¼ sec. 8, T. 37 N., R. 24 W.):

- A_1 0 to 16 inches, black (10YR 2/1, moist) heavy silt loam to silty clay loam; organic-matter content high; fine granular structure; slightly plastic when wet, hard when dry; neutral.
- BG 16 to 30 inches, very dark gray (10YR 3/1, moist) silty clay; splotches of yellowish brown common; slight olive cast when moist; massive; plastic when wet, hard when dry; mildly alkaline.
- C_1 30 to 42 inches, dark grayish-brown (2.5Y 4/2, moist) calcareous clay loam glacial till, mottled with yellowish brown (10YR 5/6, moist); sand grains, pebbles, and stones common; massive; slightly plastic when moist; moderately alkaline.

LOW-HUMIC GLEY SOILS

The Low-Humic Gley soils—an intrazonal group of imperfectly drained to poorly drained soils—have very thin A_1 horizons that are moderately high in organic matter. The surface horizons are underlain by highly mottled gray and brown gleylike mineral horizons that vary little in texture. Swamp-forest vegetation is dominant; a few marsh plants occur in some areas. Most of these soils range from medium acid to very strongly acid.

The Blomford and Freer soils are imperfectly drained to poorly drained. They occur in areas of nearly level or depressional relief, where the water table fluctuates periodically. These soils have developed on coarse-textured acid materials and have a gleyed horizon in the subsoil. The Blomford soil is considered a typical Low-Humic Gley soil.

Profile of cultivated Blomford loamy fine sand (SW¼SW¼ sec. 11, T. 36 N., R. 25 W.):

- A_1 0 to 3 inches, dark grayish-brown (10YR 4/2, moist) friable loamy fine sand; low in organic matter; medium acid.
- A_{2g} 3 to 17 inches, light brownish-gray (2.5Y 6/2, moist) loamy fine sand; mottled in lower part; medium acid.
- B_{1g} 17 to 30 inches, pale-brown (10YR 6/3, moist) fine sandy loam mottled with light gray and brown; medium acid.
- BC 30 to 42 inches, dark yellowish-brown (10YR 4/4, moist) sandy clay loam glacial till that is partially weathered; mottles of reddish brown (5YR 4/4, moist) and red (2.5YR 4/6, moist); slightly acid.
- D 42 inches +, very dark grayish-brown (2.5Y 3/2, moist) calcareous clay loam glacial till; mottled with gray and yellowish brown; contains a few pebbles and small stones; alkaline.

The imperfectly drained Brickton soils have developed on fine-textured, calcareous, slack-water deposits under the influence of swamp-forest vegetation. These soils have a very plastic olive-gray gleyed horizon in the lower subsoil. In color, the very light gray A_2 horizon is similar to that of a Planosol. In some characteristics, the Brickton soils are like Gray Wooded soils.

Profile of Brickton silt loam (SW¼NE¼ sec. 11, T. 37 N., R. 25 N.):

- A_1 0 to 4 inches, very dark gray (10YR 3/1, moist) silt loam; low in organic matter; very smooth and friable; fine granular structure; slightly acid.
- A_2 4 to 10 inches, light brownish-gray (10YR 6/2, moist) silt loam; light gray to white when dry; pronounced thin platy structure; medium acid.
- B_{g1} 10 to 15 inches, very dark grayish-brown (10YR 3/2, moist) silty clay loam; medium subangular blocky structure; plastic when wet, hard when dry; many mottles; strongly acid.
- Bg_2 15 to 30 inches, olive-brown (25Y 4/4, moist) silty clay to clay; coarse blocky structure; highly mottled; drainage slow; very plastic and sticky when wet; no pebbles or stones; strongly acid.
- C_1 30 to 45 inches, light olive-brown (2.5Y 5/4, moist) clay loam; smooth calcareous lacustrine clays; massive; moderately alkaline.

ORGANIC SOILS

Organic soils have a muck or peat surface layer that is underlain by plant remains in various stages of decomposition. These soils are wet most of the year.

Peat soils are the principal organic soils in Isanti County. They consist of raw, partly decomposed organic material. They have developed under swamp or marsh vegetation in depressions, old glacial channels, and swamps, where the water table is high. Tamarack and spruce grow in some of the bogs. These soils are underlain by a mineral layer that begins at depths ranging from a few inches to many feet.

Following is a generalized profile description of Peat, deep, in an open meadow in the sandy outwash plain:

0 to 12 inches, black well-decomposed peat (muck); unrecognizable plant remains; very friable; granular structure; acid.

12 to 36 inches, very dark grayish-brown, partially decomposed, coarse fibrous material consisting of remains of sedges, reeds, and grasses; plant remains easily identified; thin veins of darker colored sedimentary peat; acid.

36 to 96 inches, dark-brown, partially decomposed, fibrous remains of reeds and sedges; thin veins of darker colored material, increasing in thickness with depth; slightly acid to neutral.

96 inches +, olive-yellow, grading to light brownish-gray, stratified marl and lacustrine silts and fine sands; alkaline.

Azonal soils

Azonal soils do not have well-defined horizons, either because the materials have not been in place long enough for horizons to develop or because the parent material or the relief are such as to prevent the normal development of profile characteristics.

The azonal soils of Isanti County are the Regosols and the Alluvial soils. They have little or no profile development. Many azonal soils are unsuited to agriculture because of the coarse material on the surface or of unfavorable relief.

REGOSOLS

Regosols consist of unconsolidated rock (soft mineral deposits) which shows little or no evidence of soil development.

Rough broken land, Zimmerman material, is classified as a Regosol. This land type occurs along the Rum River. It consists of deep deposits of recent colluvial material and has little or no profile development.

The Burnsville-Rodman complex has developed from mixed glacial materials. The horizons are not distinctly differentiated. These soils have some of the characteristics of the Gray-Brown Podzolic soils. The Emmert soils are Regosols that are weakly podzolized. They are somewhat similar to Podzols.

ALLUVIAL SOILS

Alluvial soils are azonal soils that have developed from recent deposits of alluvium. In most areas of Alluvial soils, fresh material is being deposited faster than the soil-forming processes can convert it into soil. As a result, unaltered material accumulates.

The moderately dark colored, imperfectly drained Rum River soil has developed on bottom lands under swamp-forest vegetation. It occupies old abandoned stream channels in the valley of the Rum River. It is only occasionally flooded. Rum River loam has some characteristics of Humic Gley soils.

Following is a profile description of Rum River loam:

A_1 0 to 6 inches, very dark brown (10YR 2/2, moist) friable loam, moderately high in organic matter; medium acid.

B_g 6 to 24 inches, very dark gray (10YR 3/1, moist) silty clay loam mottled with dark yellowish brown (10YR 4/4) and dark gray (10YR 4/1); very plastic when wet, hard when dry; strongly acid.

B_{g2} 24 to 30 inches, very dark gray (10YR 3/1, moist) sandy clay loam mottled with light gray (10YR 7/1, moist); highly mottled and streaked; medium acid.

D 30 to 48 inches, yellowish-brown (10YR 5/4, moist) fine sand mottled with gray and reddish brown; becomes coarser with depth; medium acid.

Alluvial land, well drained, and Alluvial land, poorly drained, occur on bottom lands that are frequently flooded. These soils are extremely variable in drainage and texture. Nearly all the Alluvial land that occurs in the valley of the Rum River has a sandy surface layer.

Use, Management, and Productivity of the Soils of Isanti County

To make the best use of his soils, the farmer must use a suitable system of soil management. In planning his cropping system, he should consider the kinds of soils on the farm and the available labor, equipment, and finances, in relation to what he can expect as a return. His management system should be flexible enough to adjust to changes in economic conditions and changes within the soils.

Principles of Soil Management

The important basic principles of soil management are discussed in this section. These practices are part of the Minnesota Soil Fertility and Conservation Program.

Crop selection and rotation

A good crop rotation is one that (1) helps maintain the supply of organic matter and nitrogen in the soil, (2) increases crop yields, (3) keeps the soil in use most of the time, (4) helps control weeds, insects, and plant diseases, (5) makes it possible to distribute labor efficiently, and (6) permits the substitution of similar crops.

It is important to determine the proportion of soil-conserving crops—legumes and grasses—and soil-depleting crops that can best be grown in a rotation. Soil-depleting crops commonly grown in Isanti County are corn, soybeans grown for grain, and small grains. Continuous production of these crops depletes the plant-nutrient and organic-matter content of the soil, breaks down soil structure, and makes the soil subject to erosion.

Maintaining organic matter

Organic matter is supplied by decomposed roots, stems, leaves, micro-organisms, and insects. Organic matter (1) improves soil structure, (2) provides a reserve supply of plant nutrients, (3) increases biological activity in the soil by providing food for micro-organisms, (4) increases the resistance of the soil to erosion, (5) improves the water-holding capacity, and (6) increases the depth of arable soil.

The organic-matter content can be maintained or

increased by adding barnyard manure, turning under crop residues and green-manure crops, and using a long rotation that includes two or more years of legumes and grasses. Barnyard manure is one of the best sources of organic matter; it also contains nitrogen and other plant nutrients.

Fertilization

Commercial fertilizers are used to replace plant nutrients—mainly nitrogen, phosphate, and potassium —which are constantly being removed from the soil by cropping, erosion, and leaching. If mixed commercial fertilizer is used, plants will mature earlier and yields will be higher.

Sandy soils are generally deficient in nitrogen and potash, and they respond well to fertilization if the moisture supply is adequate. Hay and pasture crops normally respond to fertilizer.

Assistance in deciding the fertilizer requirements of the soils of a particular farm for a particular crop can be obtained from the county agricultural agent or from the Minnesota Agricultural Experiment Station.

Liming

Requirements for lime depend on the natural acidity of the soil, previous management, and the planned cropping program. Soil tests can be made to help determine the need for lime. The county agricultural agent is generally able to make these tests. Soil samples may also be sent to the Soil Testing Laboratory, University Farm, St. Paul, Minn. The county agricultural agent can instruct farmers in the method of taking soil samples.

Most of the cropland of Isanti County is too acid for alfalfa and clover unless lime is applied to neutralize the acidity. Ground limestone is the most economical form of lime to use. Sandy soils require light applications, but silty clay loams and clay soils need heavier applications.

Erosion control

Erosion control and water conservation are necessary on erodible soils to reduce losses of soil and water. Practices that help to control water and wind erosion include contour cultivation, terracing, stripcropping, and sodding of waterways. Sloping land can be protected against water erosion by maintaining organic-matter content and fertility at proper levels, thereby enabling the soil to hold more water and to support vigorous soil-binding crops.

Blowing of sandy soils may be prevented by stripcropping, rough tillage, maintaining a cover of vegetation or surface residues, and providing windbreaks for exposed areas.

Drainage

Providing adequate drainage systems on level and depressed areas that are otherwise well adapted to crops is important in a good soil-management program. In well-drained soils, roots develop normally because movement of air and water is not restricted. Well-drained soils warm up earlier in spring and are less subject to frost heaving than poorly drained soils.

Areas to be drained should be studied by a drainage engineer. The depth and spacing of tile depend on the texture of the subsoil and substratum and the organic-matter content of the soil. The tiles should be placed close together on relatively impervious clay soils. Tile drainage is more effective on friable soils than on fine-textured soils that are somewhat plastic when wet. Because a tile drainage system is costly and often difficult to install, the practicability of making this improvement depends on the benefits expected. Open ditches are commonly used to remove surface water from areas that cannot be tiled or otherwise drained.

Soil Management Groups

For convenience in discussing soil management, the soils of Isanti County are placed in 14 management groups. Each group consists of soils with similar management problems. Suitable crops and suggested rotations and other practices for each management group are shown in table 4.

Management group 1

Group 1 consists of moderately well drained and well drained undulating to gently rolling soils of the uplands. They are the most productive soils in the county. The following soils are in group 1:

Dalbo silt loam, 2 to 7 percent slopes.
Dalbo fine sandy loam, 2 to 12 percent slopes.
Hayden silt loam, 2 to 7 percent slopes.
Hayden silt loam, 2 to 7 percent slopes, moderately eroded.
Hayden fine sandy loam, 2 to 7 percent slopes.
Hayden fine sandy loam, 2 to 7 percent slopes, moderately eroded.
Milaca silt loam, 2 to 7 percent slopes.
Milaca fine sandy loam, 2 to 7 percent slopes.

Management requirements.—These soils are readily permeable, and their subsoils retain moisture well; consequently, the soils are seldom droughty, even during extremely dry years.

The Hayden and Dalbo soils are friable and easily cultivated. In places the Milaca soils tend to puddle and crust, but frequent shallow tillage will keep the surface soil open and porous.

The Milaca soils are slightly acid and may need lime. Some of the Hayden and Dalbo soils do not require lime. Requirements should be determined by a soil test for each area.

TABLE 4.—*Use and management requirements*

Management group and soil	Suitable uses	Suggested rotations[1]	Supplemental practices
Group 1	Corn for grain or silage, small grains, soybeans, legumes, and grasses.	3-year: G–H–C. 4-year: G–H–H–C. 5-year: G–H–H–C–C.	Grassed waterways; contour tillage; contour stripcropping of uniform slopes.
Dalbo silt loam, 2 to 7 percent slopes.			
Dalbo fine sandy loam, 2 to 12 percent slopes.			
Hayden silt loam, 2 to 7 percent slopes.			
Hayden silt loam, 2 to 7 percent slopes, moderately eroded.			
Hayden fine sandy loam, 2 to 7 percent slopes.			
Hayden fine sandy loam, 2 to 7 percent slopes, moderately eroded.			
Milaca silt loam, 2 to 7 percent slopes.			
Milaca fine sandy loam, 2 to 7 percent slopes.			
Group 2	Corn for grain or silage, small grains, soybeans, legumes, and grasses.	4-year: G–H–H–H. 4-year: G–H–H–C. 5-year: G–H–H–H–C. 5-year: G–G–H–H–C. 6-year: G–H–H–H–H–C.	Grassed waterways; contour tillage; contour stripcropping of uniform slopes.
Burnsville-Rodman complex, 2 to 7 percent slopes.			
Dalbo silt loam, 7 to 12 percent slopes.			
Hayden silt loam, 7 to 12 percent slopes.			
Hayden silt loam, 7 to 12 percent slopes, moderately eroded.			
Hayden silt loam, 12 to 18 percent slopes.			
Hayden fine sandy loam, 7 to 12 percent slopes.			
Hayden fine sandy loam, 7 to 12 percent slopes, moderately eroded.			
Hayden fine sandy loam, 12 to 18 percent slopes.			
Milaca silt loam, 7 to 12 percent slopes.			
Milaca fine sandy loam, 7 to 12 percent slopes.			
Milaca fine sandy loam, 7 to 12 percent slopes, moderately eroded.			
Scandia fine sandy loam, 2 to 7 percent slopes.			
Scandia gravelly sandy loam, 2 to 7 percent slopes.			
Group 3	Corn for grain or silage, small grains, soybeans, legumes, and grasses.	3-year: G–H–C. 4-year: G–H–H–C. 5-year: G–H–H–C–C. 6-year: G(SwCl)–C–G–H–H–C.	Artificial drainage.
Ames silt loam.			
Ames fine sandy loam.			
Brickton silt loam.			
Brickton silt loam, clayey subsoil variant.			
Freer silt loam.			
Group 4	Corn for silage, small grains, soybeans, clovers, and grasses.	3-year: G–H–C. 4-year: G–H–H–C. 5-year: G–H–H–C–C.	Artificial drainage.
Adolph silty clay loam.			
Bluffton loam and silty clay loam.			
Group 5	Corn for grain or silage, rye and other small grains, potatoes, legumes, clovers, and grasses.	4-year: G–H–H–C. 5-year: G–H–H–H–C. 5-year: G–G–H–H–H.	Wind stripcropping; field shelterbelts; grassed waterways.
Chetek loamy sand, 2 to 7 percent slopes.			
Chetek loamy sand, 7 to 12 percent slopes.			
Chetek loamy sand, 7 to 12 percent slopes, moderately eroded.			
Hubbard loamy fine sand, 0 to 2 percent slopes.			
Hubbard loamy fine sand, 2 to 7 percent slopes.			
Hubbard loamy fine sand, 7 to 12 percent slopes.			
Zimmerman loamy fine sand and fine sand, 0 to 2 percent slopes.			
Zimmerman loamy fine sand and fine sand, 2 to 7 percent slopes.			
Zimmerman fine sand, 0 to 2 percent slopes.			
Zimmerman fine sand, 2 to 7 percent slopes.			

See footnote at end of table.

TABLE 4.—*Use and management requirements—Continued*

Management group and soil	Suitable uses	Suggested rotations[1]	Supplemental practices
Group 6 Blomford loamy fine sand. Crown loamy sand. Lino loamy fine sand.	Corn for grain or silage, small grains, soybeans, potatoes, clovers, and grasses.	4-year: G–H–H–C. 5-year: G–H–H–H–C.	Wind stripcropping.
Group 7 Isanti loamy fine sand. Warman sandy loam and loam.	Corn for silage, oats, soybeans, clovers, and grasses.	3-year: G–H–C. 4-year: G–H–H–C.	Surface drainage by open ditches.
Group 8 Greenbush silt loam, 0 to 2 percent slopes. Greenbush silt loam, 2 to 7 percent slopes. Kanabec very fine sandy loam, 2 to 7 percent slopes. Kanabec very fine sandy loam, 7 to 12 percent slopes. Onamia fine sandy loam, 2 to 12 percent slopes.	Corn for silage, small grains, soybeans, legumes, and grasses.	3-year: G–H–C. 4-year: G–H–H–C.	Grassed waterways; stripcropping.
Group 9 Anoka loamy fine sand, 0 to 2 percent slopes. Anoka loamy fine sand, 2 to 7 percent slopes. Anoka loamy fine sand, 7 to 12 percent slopes. Braham loamy fine sand, 2 to 7 percent slopes. Braham loamy fine sand, 7 to 12 percent slopes. Braham loamy fine sand, 7 to 12 percent slopes, moderately eroded.	Corn for grain or silage, rye and other small grains, potatoes, soybeans, legumes, and grasses.	3-year: G–H–H. 4-year: G–H–H–C. 5-year: G–H–H–H–C.	Wind stripcropping; grassed waterways.
Group 10 Dalbo silt loam, 12 to 18 percent slopes, moderately eroded. Hayden silt loam, 12 to 18 percent slopes, moderately eroded. Hayden fine sandy loam, 12 to 18 percent slopes, moderately eroded. Milaca silt loam, 12 to 18 percent slopes, moderately eroded. Milaca fine sandy loam, 12 to 18 percent slopes. Milaca fine sandy loam, 12 to 25 percent slopes, severely eroded. Scandia fine sandy loam, 7 to 12 percent slopes, moderately eroded.	Corn for grain or silage, small grains, legumes, and grasses.	4-year: G–H–H–H. 5-year: G–H–H–H–C. Pasture.	Stripcropping; grassed waterways; pasture renovation and improved pasture management.
Group 11 Anoka loamy fine sand, 7 to 18 percent slopes, moderately eroded. Braham loamy fine sand, 12 to 18 percent slopes, moderately eroded. Burnsville-Rodman complex, 7 to 12 percent slopes, moderately eroded. Burnsville-Rodman complex, 12 to 18 percent slopes, moderately eroded. Chetek loamy sand, 12 to 18 percent slopes, moderately eroded. Emmert loamy fine sand, 12 to 25 percent slopes. Emmert loamy fine sand, 12 to 25 percent slopes, moderately eroded. Emmert loamy fine sand, 18 to 25 percent slopes, severely eroded. Scandia fine sandy loam, 7 to 18 percent slopes. Scandia fine sandy loam, 12 to 25 percent slopes, severely eroded. Scandia gravelly sandy loam, 7 to 18 percent slopes. Scandia gravelly sandy loam, 7 to 12 percent slopes, moderately eroded.	Mixed hay, grasses.	Permanent hay or permanent pasture.	Pasture renovation where feasible; regulated grazing; planting to trees; protection from fires.

TABLE 4.—*Use and management requirements—Continued*

Management group and soil	Suitable uses	Suggested rotations[1]	Supplemental practices
Group 11—continued Scandia gravelly sandy loam, 12 to 25 percent slopes, severely eroded. Zimmerman fine sand, 2 to 7 percent slopes, moderately eroded. Zimmerman fine sand, 7 to 12 percent slopes. Zimmerman fine sand, 7 to 12 percent slopes, moderately eroded. Zimmerman fine sand, 7 to 12 percent slopes, severely eroded. Zimmerman fine sand, 12 to 18 percent slopes. Zimmerman fine sand, 12 to 18 percent slopes, moderately eroded. Zimmerman loamy fine sand and fine sand, 7 to 12 percent slopes. Zimmerman loamy fine sand and fine sand, 12 to 18 percent slopes.			
Group 12 Alluvial land, well drained. Alluvial land, poorly drained. Rum River loam.	Corn for grain or silage, soybeans, small grains, mixed hay, and grasses.	3-year: G–H–C. 4-year: G–H–H–C. Permanent pasture.	Surface drainage by open ditches.
Group 13 Peat, deep. Peat, moderately shallow over loam. Peat, moderately shallow over sand.	Soybeans, corn for silage, potatoes, truck crops, mixed hay, and grasses.	4-year: G–H–C–C.	Tile drainage or open ditches; packing of seedbed; protection from fires.
Group 14 Beach sand. Rough broken land, Zimmerman material.	Pasture or wildlife refuge.	Permanent pasture.	Nonarable.

[1] Explanation of letter symbols: C=cultivated crops (corn for grain or silage, soybeans, potatoes); G=grain crops (oats, barley, rye, wheat); H=hay crops (alfalfa, clover, or clover-timothy-bromegrass mixture); SwCl=sweetclover.

A good 3-year rotation for these soils is 1 year of corn, 1 year of oats, and 1 year of red clover or mixed clover, alfalfa, and timothy. The alfalfa and clover are seeded with the grain crop in the spring. Corn, a small grain, and 2 years of hay is a suitable 4-year rotation. The legumes in this rotation will build up the nitrogen supply and help maintain productivity.

Alfalfa and red clover may be grown alone on the better drained areas if the seed is properly inoculated and if the soil contains enough lime.

The organic-matter content of these soils is relatively low. Turning under grass-legume meadows, crop residues, barnyard manure, and green-manure crops will help maintain organic matter.

These soils are deficient in nitrogen and potassium and lack phosphorus in many places. Phosphorus and potassium can be supplied by applying commercial fertilizers. Legume crops and manure, if available, should be used to supply most of the nitrogen needed. Corn yields may be substantially increased if commercial nitrogen is applied, and yields of oats are better if a mixture of nitrogen and phosphate or of nitrogen, phosphate, and potassium is applied.

Erosion control practices are necessary on cultivated areas of Hayden, Milaca, and Dalbo soils, particularly where much of the surface soil has already been lost. Sloping areas should be cultivated on the contour, and waterways should be grassed. Maintaining the organic-matter content and the fertility of the soils also helps control erosion because it keeps the water-holding capacity high and promotes the growth of soil-improving crops.

Management group 2

Group 2 consists of well drained to somewhat excessively drained soils of the uplands on undulating to moderately steep slopes. The soils are similar to the soils in group 1, except that they occur on more rolling topography, are more susceptible to erosion, and have thinner surface and subsoil layers. The following soils are in group 2:

Burnsville-Rodman complex, 2 to 7 percent slopes.
Dalbo silt loam, 7 to 12 percent slopes.
Hayden silt loam, 7 to 12 percent slopes.
Hayden silt loam, 7 to 12 percent slopes, moderately eroded.
Hayden silt loam, 12 to 18 percent slopes.
Hayden fine sandy loam, 7 to 12 percent slopes.
Hayden fine sandy loam, 7 to 12 percent slopes, moderately eroded.
Hayden fine sandy loam, 12 to 18 percent slopes.
Milaca silt loam, 7 to 12 percent slopes.
Milaca fine sandy loam, 7 to 12 percent slopes.
Milaca fine sandy loam, 7 to 12 percent slopes, moderately eroded.
Scandia fine sandy loam, 2 to 7 percent slopes.
Scandia gravelly sandy loam, 2 to 7 percent slopes.

Management requirements.—The management problems of the soils of group 2 are similar to those of group 1, except that erosion is more severe and fertility is generally lower. Good tilth is often difficult to maintain because of water erosion. Rotations should include a high proportion of legumes and grasses, to maintain good tilth and supply nitrogen.

These soils are generally acid and require applications of ground limestone to produce good stands of legumes. If properly fertilized and limed, they produce good yields of the principal crops grown in the county. If erosion control practices are followed, a 4-year rotation consisting of a cultivated crop, a small grain, and 2 years of hay is suitable. Row crops should not be grown unless erosion control practices are followed.

Alfalfa, red clover, and other close-growing crops help to preserve good soil structure and to maintain the supply of the essential plant nutrients. These crops also provide a vegetative cover that helps to prevent erosion.

The organic-matter content of these soils is very low. As a result, tilth is poor in many places, and the soil tends to crust. These conditions can be eliminated by increasing the proportion of legumes and grasses in the rotation or by applying liberal amounts of manure to supply organic matter.

These soils are low in nitrogen and potassium and contain less available phosphorus than the soils of group 1. Large amounts of commercial fertilizers are needed. Corn needs a complete fertilizer, unless plenty of manure is used. If oats are planted following a corn crop that has been heavily fertilized, no additional fertilization is needed.

The erosion hazard is potentially serious. To prevent erosion, row crops should be planted on the contour wherever possible, and waterways should be grassed.

Management group 3

Group 3 consists of imperfectly drained to poorly drained soils of the uplands. They occur on flats and in upper drainageways. Most of them occur in small areas, but the Brickton soils occupy fairly large flats. All these soils are subject to runoff and seepage from the surrounding higher lying land.

Many areas occur in fields that are dominated by the better drained soils of group 1. These fields are farmed as single units. Generally the soil management problems are about the same. The following soils are in group 3:

Ames silt loam.
Ames fine sandy loam.
Brickton silt loam.
Brickton silt loam, clayey subsoil variant.
Freer silt loam.

Management requirements.—The soils of group 3 are generally less productive than the soils of group 1. Artificial drainage must be provided to remove excess surface water. In some places open ditches and bedding may be the only practical means of removing excess water. The fine-textured subsoils are very slowly permeable. Tile drainage is effective only if the tiles are laid close together.

If these soils are properly drained, a 3-year rotation consisting of a row crop, a small grain, and hay may be used. To maintain and increase fertility, and to improve soil structure and permeability, the rotation should include more grasses and legumes and fewer row crops. For legumes, enough lime should be used to maintain a neutral or slightly acid reaction. All crop residues should be returned to the soil, and manure should be applied to build up the organic-matter content. Erosion is not a problem.

Management group 4

These poorly drained to very poorly drained dark-colored soils occupy depressions and flats in the uplands. They also occur along the borders of peat bogs, in association with Milaca, Hayden, and Dalbo soils. Fields are commonly flooded after heavy rains, especially during the spring thaw. Areas that occur within fields of better drained soils are cultivated. Stoniness is a problem on the Adolph soil. The following soils are in group 4:

Adolph silty clay loam.
Bluffton loam and silty clay loam.

Management requirements.—The soils of group 4 must be artificially drained to be used for crops. Closely spaced tile drains will greatly improve drainage, but many small deep depressions are almost impossible to drain. If these soils are cultivated when either too wet or too dry, their structure will deteriorate and tillage will become difficult.

Most areas of the Bluffton soils are neutral to only slightly acid and do not need lime. The Adolph soil generally benefits from applications of lime.

The finer textured soils, if properly drained, are well suited to corn for silage. Because it must be planted late, corn grown for grain seldom matures on these wet soils. Two rotations particularly suited to these soils are as follows: Corn grown for silage, oats, and mixed hay; or 1 year of corn grown for silage, 1 year of soybeans or oats, and 2 years of mixed hay.

These soils are well supplied with organic matter and nitrogen. The available supplies of phosphorus and potassium vary. Corn should generally be fertilized with a phosphate-potassium mixture, but for other crops commercial fertilizers are not generally used.

Management group 5

These well drained to excessively drained deep sandy soils occur on undulating to rolling slopes of the outwash plains. They have developed from water- and wind-deposited sands. Group 5 is the most extensive management group in the county. The following soils are in group 5:

Chetek loamy sand, 2 to 7 percent slopes.
Chetek loamy sand, 7 to 12 percent slopes.
Chetek loamy sand, 7 to 12 percent slopes, moderately eroded.
Hubbard loamy fine sand, 0 to 2 percent slopes.
Hubbard loamy fine sand, 2 to 7 percent slopes.
Hubbard loamy fine sand, 7 to 12 percent slopes.
Zimmerman loamy fine sand and fine sand, 0 to 2 percent slopes.
Zimmerman loamy fine sand and fine sand, 2 to 7 percent slopes.
Zimmerman fine sand, 0 to 2 percent slopes.
Zimmerman fine sand, 2 to 7 percent slopes.

Management requirements.—Most of these deep sandy soils are very loose and porous. Because natural drainage is excessive, they are generally droughty. However, tilth conditions are always favorable and the soils normally can be cultivated soon after rains.

These soils are slightly acid to strongly acid and therefore need lime. Liming is important in establishing soil-improving crops such as alfalfa and clover.

Both the organic-matter content and the nitrogen content of these soils are very low. Adding organic matter will improve the water-holding capacity and increase the supply of nitrogen. Nitrogen-fixing legumes, alfalfa and clover, are good sources of nitrogen. All crop residues should be returned to the soil, manure should be applied frequently, and legume crops should be plowed under at regular intervals.

Every rotation should include a soil-improving crop. A rotation suited to these soils, after lime is applied, consists of corn, oats, and 2 years of alfalfa. Before corn is planted, a legume crop should be plowed under or manure should be applied, or both. Alfalfa and clover are normally seeded with the small grain in the spring. A mixture of alfalfa and bromegrass will provide a good cover and give a good yield of hay. Fall-planted rye helps control wind erosion. Rye ordinarily requires less moisture and plant nutrients than oats or soybeans. Soybeans, grown as a cash crop, are increasing in importance. However, yields are generally very low unless rainfall is well distributed during the growing season. A 5-year rotation that includes 3 years of hay would be suitable for these soils, but quackgrass is likely to invade the hay stand after 2 years.

Some of the nearly level areas are well suited to potatoes, cucumbers, dry edible beans, and other truck crops. If the soils are well fertilized and diseases and insects are properly controlled, these crops will provide additional income and may be used in the rotation in place of corn.

The general fertility level of these soils is low. Because of the low organic-matter content, little nitrogen is available for plant growth unless commercial nitrogen is applied. Corn needs a complete commercial fertilizer. A side dressing of nitrogen will increase corn yields. Commercial fertilizer may be used to advantage to supplement applications of farm manure or may be applied immediately following a green-manure crop.

Erosion by wind or water is a serious hazard on unprotected areas of these soils. Deep gullies and blowouts will form unless erosion is controlled. Strip-cropping and the use of shelterbelts on unprotected areas will help conserve these soils. Rotations should include at least 2 or 3 years of hay. Manure should be used liberally, and legume crops plowed under, to improve fertility, increase water-holding capacity, and minimize erosion losses.

Management group 6

Group 6 consists of imperfectly drained and moderately well drained soils that occur on flats and in slight depressions on the outwash plains.

Most areas of these soils are small, narrow, elongated depressions that occur within larger areas of the better drained sandy soils of group 5. They are managed in the same way as the soils surrounding them. Larger areas, however, may have slightly different management requirements. Group 6 includes the following soils:

Blomford loamy fine sand.
Crown loamy sand.
Lino loamy fine sand.

Management requirements.—The management requirements of these soils are similar to those of the soils of group 5.

The soils of group 6 are not generally droughty because they are moderately high in organic matter and are situated in slight depressions and on flats. The water-holding capacity is higher than that of the associated excessively drained sandy soils. Soils of group 6 do not, as a rule, need artificial drainage, but some of the larger low-lying flats require ditches to remove surface water, especially in the spring.

These soils need lime if legumes are grown. It is fairly easy to maintain the organic-matter content if grasses and legumes are occasionally plowed under, all crop residues are returned to the soil, and manure is applied frequently.

Drought and erosion are less serious hazards than in group 5. Wind erosion is seldom a problem, although some soil drifting occurs. Suitable rotations and protection for exposed areas will help control wind erosion. The water-holding capacity can be increased by building up the supply of organic matter.

A 4- or 5-year rotation should include 2 or 3 years of hay. Continuous cropping to corn, soybeans, or other soil-depleting crops will deplete the supply of organic matter and decrease the water-holding capacity.

Management group 7

Group 7 consists of poorly drained dark-colored soils that occur in depressions on the outwash plains. They have developed under a cover of marshgrasses, sedges, and water-tolerant trees. The water table is normally high; after heavy rains surface runoff from the surrounding higher land is likely to drown out the crops. These soils occur in association with Zimmerman, Chetek, Hubbard, and Anoka soils. Only a few areas are cultivated. The following soils are in group 7:

Isanti loamy fine sand.
Warman sandy loam and loam.

Management requirements.—Only a few areas of these soils are cultivated. The soils are nearly waterlogged unless they are artificially drained. Open ditches are better than tile drains, because the substrata are sandy.

These soils are fairly high in organic matter and nitrogen. By turning under crop residues and greenmanure crops and applying barnyard manure, the supplies of organic matter and nitrogen can be maintained. Lime is needed in most areas.

In their natural state, these soils will produce only wild hay. If they are artificially drained, they will produce fair yields of corn silage, soybeans, small grains, and mixed hay. A suitable rotation consists of corn, soybeans or a small grain, and 1 or 2 years of hay. Soybeans do better on these soils than on the sandy excessively drained soils of management group 5.

Management group 8

Group 8 consists of moderately well drained to well drained, medium-textured soils of the outwash plains and lake plains. They occur only in the extreme northern part of the county along the Kanabec County line. The total acreage is very small. They have coarse, rapidly permeable, sandy and gravelly substrata, and therefore have poor water-holding capacity. The following soils are in group 8:

Greenbush silt loam, 0 to 2 percent slopes.
Greenbush silt loam, 2 to 7 percent slopes.
Kanabec very fine sandy loam, 2 to 7 percent slopes.
Kanabec very fine sandy loam, 7 to 12 percent slopes.
Onamia fine sandy loam, 2 to 12 percent slopes.

Management requirements.—The management problems for this group are similar to those for management group 1, except that soils of group 8 tend to be droughty. All the soils in group 8 have acid surface layers and require lime in varying amounts; heavy applications of lime are needed if alfalfa is grown.

The supplies of organic matter and nitrogen are low. They can be built up by applying large amounts of barnyard manure, turning under legumes before planting corn, and following suitable crop rotations. The supply of available plant nutrients is normally small, and the necessary elements must be supplied by applications of manure and commercial fertilizers. Rotations suitable for the soils of group 1 are also suitable for these soils. A 4-year rotation of corn, oats, and 2 years of hay is excellent. On dairy farms, pasture can be included in the rotation.

Because of the more gentle slopes, erosion is a less serious hazard than on the soils of group 1, but erosion control practices similar to those required by soils of group 1 should be applied.

Management group 9

These well drained to somewhat excessively drained, nearly level to rolling soils occur on the outwash plains. The following soils are in group 9:

Anoka loamy fine sand, 0 to 2 percent slopes.
Anoka loamy fine sand, 2 to 7 percent slopes.
Anoka loamy fine sand, 7 to 12 percent slopes.
Braham loamy fine sand, 2 to 7 percent slopes.
Braham loamy fine sand, 7 to 12 percent slopes.
Braham loamy fine sand, 7 to 12 percent slopes, moderately eroded.

Management requirements.—Management requirements are about the same as for the soils of management group 5, but are normally less difficult to meet. The soils are droughty but less so than the sandy soils of management group 5; generally they hold enough moisture for crops if rainfall is adequate and well distributed through the season.

Soils of group 9 are very low in organic matter and nitrogen. All crop residues should be returned to the soil, manure should be applied frequently, and legumes should be plowed under at regular intervals. Fertilizer requirements are about the same as for the soils of group 5.

These soils are easy to cultivate and respond very well to fertilization. They are well suited to cucumbers, beans, and other truck crops. The rotations suitable for the soils of group 5 are also suitable for these soils. Potatoes may be substituted for corn in the rotation.

Wind erosion is a hazard. Exposed areas can be protected by field shelterbelts. Jack pine and red pine make good windbreaks and are well suited to these soils. In places, stripcropping will prevent wind and water erosion.

Management group 10

Group 10 consists of well drained to somewhat excessively drained soils. They occur on short, irregular, undulating to steep slopes of the glacial uplands. The following soils are in group 10:

Dalbo silt loam, 12 to 18 percent slopes, moderately eroded.
Hayden silt loam, 12 to 18 percent slopes, moderately eroded.
Hayden fine sandy loam, 12 to 18 percent slopes, moderately eroded.
Milaca silt loam, 12 to 18 percent slopes, moderately eroded.
Milaca fine sandy loam, 12 to 18 percent slopes.
Milaca fine sandy loam, 12 to 25 percent slopes, severely eroded.
Scandia fine sandy loam, 7 to 12 percent slopes, moderately eroded.

Management requirements.—The soils of group 10 are subject to severe erosion when cultivated. They are used mostly for pasture. Some areas are cultivated occasionally, and other areas are in forest.

All of these soils are low in potassium, phosphorus, nitrogen, and organic matter, but they respond well to good management, especially the areas used for pasture. Run-down pastures can be renovated by applying lime and phosphate before plowing in the fall, then fertilizing and reseeding with a good pasture mixture in the spring. A pasture mixture commonly used consists of whiteclover, Kentucky bluegrass, and alsike clover. Grazing should be restricted during the first year, and overgrazing should be avoided after the pasture stand is established. Weeds should be controlled by clipping or spraying.

Areas that have been cultivated continuously to

row crops are severely eroded. In many places most of the surface soil has been washed away. These areas should either be taken out of cultivation or be protected by effective erosion-control methods. Cultivation should be on the contour where possible. Legumes and small grains should be grown on eroded areas instead of corn and other row crops.

Management group 11

Group 11 consists of excessively drained droughty soils of the glacial uplands and outwash plains. They occur on undulating to steep slopes throughout the county. Many areas of these soils are in the southwestern corner of the county. Other areas occur throughout the till and outwash plains, on steep escarpments adjacent to peat bogs and low-lying depressions. The following soils are in group 11.

Anoka loamy fine sand, 7 to 18 percent slopes, moderately eroded.
Braham loamy fine sand, 12 to 18 percent slopes, moderately eroded.
Burnsville-Rodman complex, 7 to 12 percent slopes, moderately eroded.
Burnsville-Rodman complex, 12 to 18 percent slopes, moderately eroded.
Chetek loamy sand, 12 to 18 percent slopes, moderately eroded.
Emmert loamy fine sand, 12 to 25 percent slopes.
Emmert loamy fine sand, 12 to 25 percent slopes, moderately eroded.
Emmert loamy fine sand, 18 to 25 percent slopes, severely eroded.
Scandia fine sandy loam, 7 to 18 percent slopes.
Scandia fine sandy loam, 12 to 25 percent slopes, severely eroded.
Scandia gravelly sandy loam, 7 to 18 percent slopes.
Scandia gravelly sandy loam, 7 to 12 percent slopes, moderately eroded.
Scandia gravelly sandy loam, 12 to 25 percent slopes, severely eroded.
Zimmerman fine sand, 2 to 7 percent slopes, moderately eroded.
Zimmerman fine sand, 7 to 12 percent slopes.
Zimmerman fine sand, 7 to 12 percent slopes, moderately eroded.
Zimmerman fine sand, 7 to 12 percent slopes, severely eroded.
Zimmerman fine sand, 12 to 18 percent slopes.
Zimmerman fine sand, 12 to 18 percent slopes, moderately eroded.
Zimmerman loamy fine sand and fine sand, 7 to 12 percent slopes.
Zimmerman loamy fine sand and fine sand, 12 to 18 percent slopes.

Management requirements.—Each of these soils is unsuited to cultivation, because of steep slopes, erodibility, droughtiness, stoniness, or low fertility, or a combination of two or more of these characteristics. The soils can be used for hay crops, for pasture, or for forest. Effective erosion control is the principal management problem. The hazard of wind or water erosion is serious, unless a good sod cover is maintained.

Pastures could be improved by the same practices as can be used on the soils of group 10, but it is not worthwhile to renovate some of the pastures on the soils of group 11. Because of the danger of further erosion, grazing should be restricted. Many areas that are poorly suited to pasture should be reforested (fig. 9). Forested areas should be protected from fire.

***Figure 9.*—Zimmerman loamy fine sand and fine sand, 7 to 12 percent slopes, is adapted to white pine.**

Management group 12

The soils and land types of group 12 occur on the bottom lands of the Rum River, Stanchfield Creek, and some of the smaller streams. The following soils are in the group:

Alluvial land, well drained.
Alluvial land, poorly drained.
Rum River loam.

Alluvial land is dissected by old river channels, oxbows, and stream terraces, and includes backwater areas that are waterlogged the year round. It is frequently flooded. Rum River loam has a high water table at times, but is only occasionally flooded.

Management requirements.—Rum River loam is a fertile bottom-land soil that produces high yields of corn, soybeans, and hay crops. Most of it is adequately drained, and crops are seldom damaged by overflow. In areas where corn has been grown continuously for a number of years, the organic-matter content of the soil has been depleted and the structure has deteriorated. A 4-year rotation of corn, a small grain or soybeans, and 2 years of mixed hay will help to restore organic matter and improve the soil structure.

Alluvial land, well drained, is cropped to corn, soybeans, small grains, and mixed hay, although the areas are frequently flooded. Ditches to carry off excess water have been made by dredging old channels. This land is especially valuable for pasture during the summer, when pastures on the sandy plains are likely to dry up.

Alluvial land, poorly drained, is not normally used for crops. It is used for limited grazing or is left in woods. The areas are flooded so frequently that artificial drainage is generally not practical.

Management group 13

Group 13 consists of peat soils, the principal organic soils in Isanti County. Peat soils occur in bogs in all sections of the county. They are associated with the sandy outwash soils and the finer textured soils of

the upland till and lake plains. A few areas have been artificially drained and cultivated, but crops on these areas are likely to be damaged by frosts late in spring and early in fall. The following soils are in group 13:

Peat, deep.
Peat, moderately shallow over loam.
Peat, moderately shallow over sand.

Management requirements.—Improved drainage is essential for profitable management of peat soils. Either tile drains or open ditches can be used, depending on local conditions, particularly the thickness of the peat. The large areas of Peat, deep, should be drained by open ditches. Tile drains are effective where the peat is moderately shallow and is underlain by loam or silty clay loam.

Peat soils are very high in organic matter and fairly high in nitrogen. They normally require applications of phosphate and potassium. Peat soils should never be burned over, because this practice destroys organic matter and flattens the relief to the extent that drainage is further impaired.

Peat, moderately shallow over sand, has other management problems. Peat decreases rapidly in thickness after intensive farming, because the organic matter oxidizes. Even under ordinary farm operations, peat settles. If the layer of peat is shallow to begin with, after a few years of cultivation nothing is left but the underlying sand. Maintenance of drainage systems is also a problem, because the underlying loose sand tends to flow when it is wet.

Corn grown for silage is generally the most suitable crop for peat soils. Because frosts occur late in spring and early in fall, early maturing varieties of corn should be grown. Corn may be used in a rotation with soybeans and mixed timothy and alsike clover for hay or pasture.

Peat soils are well suited to truck farming. If properly drained and fertilized, they produce high yields of potatoes, cabbage, onions, carrots, and beets. Soybeans and corn also do well.

Control of wind erosion is necessary, especially on well-decomposed peat soils. In preparing the seedbed, the soil should be packed thoroughly before planting.

Management group 14

Group 14 consists of miscellaneous nonarable land types that are unsuited to ordinary farming. They are either too steep or too droughty for cultivated crops but may be used for limited grazing. The following land types are in group 14:

Beach sand.
Rough broken land, Zimmerman material.

Estimated Yields

Estimated average acre yields are given for the principal crops of the county in table 5. Yields are listed under two levels of management. The yields in columns A are those to be expected under prevailing management practices—crop rotations, some erosion control practices, the growth of legumes, and the application of commercial fertilizer, lime, and barnyard manure; these yields are based on information furnished by farmers and the county agent and from crop reports by the Agricultural Conservation Program (ACP). The yields in columns B are those that can be expected under a more intensive application of good prevailing practices; they are based, in part, on the results of fertility studies conducted by the University of Minnesota Agricultural Experiment Station.

Capability Groups of Soils

The capability classification is a means of showing the comparative suitability of different soils for agricultural use. The classification of a particular soil depends on the variety of uses to which it is suited, its susceptibility to erosion or other damage if it is cultivated, and the kind of management it needs to protect it from erosion and maintain its productivity.

Eight general capability classes are recognized. In classes I, II, and III are soils that are suitable for annual or periodic cultivation. Class I soils are those that have the widest range of use. They are level, productive, well drained, and easy to work. They do not erode readily, even if cultivated continuously, and they will remain productive if managed with normal care. Class II soils do not have quite so wide a range of suitability as class I soils. Some class II soils are gently sloping and consequently need moderate care to prevent erosion; others may be slightly droughty or slightly too wet, or somewhat limited in depth. Class III soils can be cropped regularly but have a narrower range of use and need still more careful management.

In class IV are soils that should be cultivated only occasionally or only under very careful management.

In classes V, VI, and VII are soils that should not be cultivated but that can be used for pasture, for range, or for forest. Class V soils are level but are droughty, wet, or low in fertility, or otherwise unsuitable for cultivation. Class VI soils are not suitable for crops because they are steep or droughty or otherwise limited. Some soils in class VI can, without damage, be cultivated enough so that trees can be set out or pasture plants seeded. Class VII soils have even more limitations than those in class VI.

In class VIII are soils that have practically no agricultural use. These areas produce little useful vegetation, but they may constitute attractive scenery; they may form parts of watersheds or they may provide shelter for wildlife. Some areas have been developed into recreational facilities. Mountains, deserts, and active sand dunes are examples of class VIII land.

The soils in any one capability class are limited to the same degree but may be limited for different reasons. To show what characteristic of each soil limits its uses, any one of the classes II through VII may be divided into from one to four subclasses, each iden-

TABLE 5.—*Estimated average acre yields of the principal crops on each soil under two levels of management*

[Yields in columns A are those obtained under prevailing management practices. Yields in columns B are those to be expected under a more intensive application of good prevailing practices. Absence of yield figure indicates the crop is not commonly grown on the soil]

Map symbol	Soil	Corn for grain		Corn for silage		Oats		Rye		Soybeans		Potatoes		Alfalfa		Mixed hay		Rotation pasture	
		A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
		Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Cow-acre-days* [1]	*Cow-acre-days* [1]
Ad	Adolph silty clay loam [2]			9	11					13	16	125	140			1.5	2.0	110	130
A	Alluvial land, well drained	25	30	6	7	25	28	10	15	12	14	125	130			1.0	1.1	100	120
Aw	Alluvial land, poorly drained																		
Y	Ames silt loam	40	50	9	11	45	50			12	15	150	175			1.7	2.0	160	210
Ys	Ames fine sandy loam	40	50	8	10	43	48			12	15	155	180			1.7	2.0	160	210
G	Anoka loamy fine sand, 0 to 2 percent slopes	35	45	8	10	35	40	17	22	10	12	125	165	1.7	2.7	1.2	1.5	110	130
Gu	Anoka loamy fine sand, 2 to 7 percent slopes	35	45	7	9	35	40	17	22	9	11	120	160	1.7	2.7	1.2	1.5	100	125
Gp	Anoka loamy fine sand, 7 to 12 percent slopes	28	38	5	7	30	35	14	19			100	120	1.3	2.3	1.0	1.3	90	115
Gy	Anoka loamy fine sand, 7 to 18 percent slopes, moderately eroded.													1.0	1.3	.7	.9	70	90
U	Beach sand																		
N	Blomford loamy fine sand	34	42	7	9	35	40	18	23	11	15	130	150			1.5	1.8	115	130
Bc	Bluffton loam and silty clay loam [2]	40	45	10	12	40	45			14	18					1.8	2.1	160	210
Nu	Braham loamy fine sand, 2 to 7 percent slopes	35	45	7	9	35	40	17	22	8	10	110	130	1.7	2.7	1.2	1.5	100	120
Np	Braham loamy fine sand, 7 to 12 percent slopes	30	40	5	7	30	35	13	18	6	8	105	120	1.4	2.4	1.0	1.3	90	115
Nd	Braham loamy fine sand, 7 to 12 percent slopes, moderately eroded.													1.0	1.2	.8	1.1	80	105
Nx	Braham loamy fine sand, 12 to 18 percent slopes, moderately eroded.															.7	.9	70	90
Bk	Brickton silt loam	38	50	10	12	43	48			14	18	155	175			1.7	2.0	170	220
Bv	Brickton silt loam, clayey subsoil variant	38	50	11	13	40	45			15	18	150	165			1.7	2.0	170	220
V	Burnsville-Rodman complex, 2 to 7 percent slopes.	25	30	5	6	30	35	15	20	7	10			1.3	1.5	1.0	1.2	85	105
Vd	Burnsville-Rodman complex, 7 to 12 percent slopes, moderately eroded.													.8	1.0	.8	1.0	70	90
Vx	Burnsville-Rodman complex, 12 to 18 percent slopes, moderately eroded.													.6	.8	.6	.8	60	80
C	Chetek loamy sand, 2 to 7 percent slopes	20	30	6	8	30	40	12	15	8	11	125	140	1.8	2.2	1.4	1.6	115	145
Cp	Chetek loamy sand, 7 to 12 percent slopes	15	20	4	6	20	25	10	13	6	8	95	115	1.4	2.0	1.1	1.4	100	125
Cd	Chetek loamy sand, 7 to 12 percent slopes, moderately eroded.	12	17	3	5	16	20	8	11	5	7	90	105	1.1	1.6	1.0	1.3	90	115
Cx	Chetek loamy sand, 12 to 18 percent slopes, moderately eroded.															.7	1.0	80	100
Cw	Crown loamy sand	30	35	7	9	30	35	18	22	10	12	120	160	1.0	2.0	1.2	1.4	90	120
D	Dalbo silt loam, 2 to 7 percent slopes	48	58	9	11	55	65			14	18	175	200	3.0	3.5	1.7	2.0	160	210
Dp	Dalbo silt loam, 7 to 12 percent slopes	43	53	7	9	48	58			10	14	150	175	2.5	3.0	1.5	1.8	155	205
Dx	Dalbo silt loam, 12 to 18 percent slopes, moderately eroded.													2.0	2.5	1.2	1.5	145	160
Df	Dalbo fine sandy loam, 2 to 12 percent slopes	45	55	8	10	55	65	17	20	12	16	175	200	2.5	3.0	1.7	2.0	160	210
E	Emmert loamy fine sand, 12 to 25 percent slopes.					20	25	7	10					.6	.8	.5	.7	80	100
Eh	Emmert loamy fine sand, 12 to 25 percent slopes, moderately eroded.													.5	.7	.4	.6	70	90
Es	Emmert loamy fine sand, 18 to 25 percent slopes, severely eroded.																		
F	Freer silt loam	38	48	8	10	43	58			10	14	170	185	1.5	2.0	1.5	1.7	145	185
X	Greenbush silt loam, 0 to 2 percent slopes	38	48	8	10	42	56			10	14	170	185			1.5	1.7	140	180
Xu	Greenbush silt loam, 2 to 7 percent slopes	35	45	7	9	42	56	17	20	9	13	160	175	1.5	2.5	1.5	1.7	130	170
B	Hayden silt loam, 2 to 7 percent slopes	45	55	8	10	50	60			12	16	175	200	2.5	3.0	1.7	2.0	150	200
Bu	Hayden silt loam, 2 to 7 percent slopes, moderately eroded.	40	50	7	9	45	55			11	15	165	180	2.3	2.8	1.5	1.8	145	195

Map symbol	Soil	Corn for grain		Corn for silage		Oats		Rye		Soybeans		Potatoes		Alfalfa		Mixed hay		Rotation pasture	
		A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
		Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Cow-acre-days* [1]	*Cow-acre-days* [1]
Bp	Hayden silt loam, 7 to 12 percent slopes	38	48	6	8	42	52	----	----	9	13	160	175	2.3	2.8	1.5	1.8	145	195
Bd	Hayden silt loam, 7 to 12 percent slopes, moderately eroded.	35	45	5	7	40	50	----	----	7	11	150	165	2.1	2.6	1.3	1.6	140	190
Br	Hayden silt loam, 12 to 18 percent slopes	----	----	----	----	30	35	----	----	----	----	----	----	2.0	2.5	1.2	1.5	140	190
Bx	Hayden silt loam, 12 to 18 percent slopes, moderately eroded.	----	----	----	----	----	----	----	----	----	----	----	----	1.5	2.0	1.0	1.3	130	180
T	Hayden fine sandy loam, 2 to 7 percent slopes	45	55	7	9	50	60	18	25	10	14	175	200	2.5	3.0	1.7	2.0	150	200
Tu	Hayden fine sandy loam, 2 to 7 percent slopes, moderately eroded.	40	50	6	8	43	53	16	21	9	13	165	180	2.3	2.8	1.5	1.8	145	195
Tp	Hayden fine sandy loam, 7 to 12 percent slopes	38	48	5	7	40	50	14	19	7	11	160	175	2.1	2.6	1.3	1.6	140	190
Td	Hayden fine sandy loam, 7 to 12 percent slopes, moderately eroded.	33	42	----	----	35	45	11	16	----	----	----	----	2.0	2.5	1.2	1.5	135	185
Tr	Hayden fine sandy loam, 12 to 18 percent slopes	----	----	----	----	25	35	7	12	----	----	----	----	1.8	2 3	1.0	1.3	135	185
Tx	Hayden fine sandy loam, 12 to 18 percent slopes, moderately eroded.	----	----	----	----	----	----	----	----	----	----	----	----	1.5	2.0	.8	1.1	130	180
H	Hubbard loamy fine sand, 0 to 2 percent slopes	28	38	7	9	30	35	16	21	8	10	110	150	1.5	2.0	1.1	1.3	90	110
Hu	Hubbard loamy fine sand, 2 to 7 percent slopes	26	36	6	8	27	32	15	20	7	9	105	145	1.4	1.9	1.1	1.3	90	110
Hp	Hubbard loamy fine sand, 7 to 12 percent slopes	21	26	5	7	24	29	13	18	5	7	100	130	1.1	1.6	1.0	1.2	85	105
Is	Isanti loamy fine sand [2]	----	----	8	10	35	40	----	----	10	13	120	160	----	----	1.3	1.5	100	125
K	Kanabec very fine sandy loam, 2 to 7 percent slopes.	38	48	7	9	42	56	17	20	9	13	160	175	1.5	2.5	1.3	1.7	140	180
Kp	Kanabec very fine sandy loam, 7 to 12 percent slopes.	35	45	6	8	38	52	16	19	7	11	150	165	1.3	2.3	1.2	1.5	135	175
L	Lino loamy fine sand	30	35	7	9	35	40	18	22	9	12	120	160	1.5	2.5	1.2	1.4	90	120
M	Milaca silt loam, 2 to 7 percent slopes	40	50	7	9	40	50	----	----	10	14	175	200	2.0	2.5	1.5	1.7	140	180
Mp	Milaca silt loam, 7 to 12 percent slopes	35	45	6	8	35	45	----	----	8	12	165	190	1.8	2.3	1.3	1.5	135	175
Mx	Milaca silt loam, 12 to 18 percent slopes, moderately eroded.	30	40	----	----	30	40	----	----	----	----	----	----	1.5	2.0	1.0	1.2	130	170
Mf	Milaca fine sandy loam, 2 to 7 percent slopes	30	40	5	7	35	45	15	20	8	12	150	175	1.5	2.0	1.3	1.5	130	170
Mn	Milaca fine sandy loam, 7 to 12 percent slopes	25	35	4	6	30	40	12	17	6	10	125	150	1.2	1.7	1.1	1.3	125	165
Md	Milaca fine sandy loam, 7 to 12 percent slopes, moderately eroded.	22	32	----	----	25	35	9	14	----	----	100	125	1.0	1.5	1.0	1.2	120	160
Mr	Milaca fine sandy loam, 12 to 18 percent slopes	----	----	----	----	23	33	8	13	----	----	----	----	1.0	1.5	1.0	1.2	120	160
Ms	Milaca fine sandy loam, 12 to 25 percent slopes, severely eroded.	----	----	----	----	----	----	----	----	----	----	----	----	.8	1.0	.7	.9	110	150
ON	Onamia fine sandy loam, 2 to 12 percent slopes	35	45	7	9	35	45	17	20	9	13	160	175	1.5	2.5	1.3	1.7	140	180
P	Peat, deep [2]	----	----	8	10	40	45	----	----	12	15	175	200	----	----	1.8	2.1	150	200
Pc	Peat, moderately shallow over loam [2]	40	45	8	10	40	45	----	----	12	15	185	210	----	----	1.8	2.1	150	180
Ps	Peat, moderately shallow over sand [2]	30	35	7	9	33	38	----	----	10	12	165	190	----	----	1.5	1.8	140	170
ZL	Rough broken land, Zimmerman material	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
R	Rum River loam	40	45	9	11	45	50	----	----	15	18	150	170	----	----	1.5	2.0	110	130
S	Scandia fine sandy loam, 2 to 7 percent slopes	20	30	4	6	30	40	12	15	6	9	125	140	1.2	1.7	1.3	1.5	130	160
Sp	Scandia fine sandy loam, 7 to 18 percent slopes	----	----	----	----	20	25	8	10	----	----	----	----	.9	1.2	1.0	1.2	120	150
Sd	Scandia fine sandy loam, 7 to 12 percent slopes, moderately eroded.	----	----	----	----	18	23	7	9	----	----	----	----	.9	1.2	1.0	1.2	120	150
Ss	Scandia fine sandy loam, 12 to 25 percent slopes, severely eroded.	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
J	Scandia gravelly sandy loam, 2 to 7 percent slopes.	20	30	4	6	25	35	11	14	5	8	115	130	1.4	1.9	1.2	1.3	120	150
Jp	Scandia gravelly sandy loam, 7 to 18 percent slopes.	----	----	----	----	20	30	8	10	----	----	----	----	1.0	1.3	1.0	1.2	115	140
Jd	Scandia gravelly sandy loam, 7 to 12 percent slopes, moderately eroded.	----	----	----	----	18	28	7	9	----	----	----	----	.9	1.1	.8	1.0	115	140

See footnotes at end of table.

TABLE 5.—*Etimated average acre yields of the principal crops on each soil under two levels of management—Continued*

Map symbol	Soil	Corn for grain		Corn for silage		Oats		Rye		Soybeans		Potatoes		Alfalfa		Mixed hay		Rotation pasture	
		A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
		Bu.	*Bu.*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Cow-acre-days* [1]	*Cow-acre-days* [1]
Js	Scandia gravelly sandy loam, 12 to 25 percent slopes, severely eroded.	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
W	Warman sandy loam and loam [2]	----	----	8	10	35	40	----	----	10	13	120	150	----	----	1.3	1.5	100	125
Z	Zimmerman loamy fine sand and fine sand, 0 to 2 percent slopes.	25	30	6	7	30	35	15	20	8	10	110	150	1.5	2.5	1.0	1.2	85	105
Zu	Zimmerman loamy fine sand and fine sand, 2 to 7 percent slopes.	25	30	5	6	30	35	15	20	7	9	100	140	1.5	2.5	1.0	1.2	80	100
Zp	Zimmerman loamy fine sand and fine sand, 7 to 12 percent slopes.	20	25	4	5	25	30	12	17	5	7	90	130	1.3	2.3	.9	1.1	75	95
Zr	Zimmerman loamy fine sand and fine sand, 12 to 18 percent slopes.	----	----	----	----	20	25	10	15	----	----	----	----	1.1	2.1	.8	1.0	70	90
Zf	Zimmerman fine sand, 0 to 2 percent slopes	20	25	5	6	25	30	12	17	6	8	100	130	1.5	2.5	1.0	1.2	85	105
Zg	Zimmerman fine sand, 2 to 7 percent slopes	17	22	4	5	22	27	10	12	5	7	90	120	1.3	2.3	.9	1.0	80	100
Zv	Zimmerman fine sand, 2 to 7 percent slopes moderately eroded.	----	----	----	----	----	----	8	10	4	6	75	100	1.0	2.0	.8	.9	75	90
Zn	Zimmerman fine sand, 7 to 12 percent slopes	15	20	----	----	18	23	8	10	----	----	75	100	1.0	2.0	.8	.9	75	90
Zd	Zimmerman fine sand, 7 to 12 percent slopes, moderately eroded.	----	----	----	----	15	20	7	9	----	----	----	----	.8	1.6	.7	.8	70	85
Zs	Zimmerman fine sand, 7 to 12 percent slopes, severely eroded.	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Zh	Zimmerman fine sand, 12 to 18 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Zx	Zimmerman fine sand, 12 to 18 percent slopes, moderately eroded.	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----

[1] The term "cow-acre-days" is used to express the carrying capacity or grazing value of pasture. It equals the number of days of grazing 1 acre will provide 1 animal unit in a year without injury to the sod; 1 animal unit is a mature cow, steer, or horse, or 5 mature sheep.

[2] Estimates are for areas that are well enough drained to be suitable for crops.

tified by a letter following the capability class number. The letter "e" indicates that the risk of erosion is what limits the uses of the soil; the letter "w" is used if the soil is limited by excess water; the letter "s" shows that the soil is shallow, droughty, or unusually low in fertility; and the letter "c" is used to indicate that the climate is so hazardous that it limits the uses of the soil.

Classes and Subclasses in Isanti County

The soils of Isanti County have been placed in capability classes II, III, IV, VI, and VII. None of the soils of the county are in classes I, V, or VIII. The class and subclass for each soil in the county are shown on the supplement at the back of this report. Definitions of each class and subclass follow:

Class II.—Soils suitable for regular cultivation; only moderate risk of erosion or other damage.
- IIe: Gently sloping silty and loamy soils.
- IIw: Silty and loamy soils that have imperfect to slow drainage.

Class III.—Soils suitable for cultivation in a regular cropping system; moderately severe risks of erosion or other damage.
- IIIe: Silty and loamy gently sloping, sloping, and eroded sloping soils.
- IIIs: Nearly level and gently sloping sandy soils.
- IIIw: Nearly level, imperfectly drained to poorly drained soils and alluvial land subject to frequent overflow.

Class IV.—Soils unsuitable for regular cultivation; if cultivated, they require extremely careful management.
- IVe: Gently sloping gravelly soils, moderately steep loamy soils, and moderately steep eroded soils.
- IVs: Nearly level to sloping, sandy droughty soils.
- IVw: Somewhat poorly drained and very poorly drained soils.

Class VI.—Soils not suitable for regular cultivation because they are too steep, too wet, or too droughty.
- VIe: Sloping and moderately steep, sandy, gravelly, loamy, or silty soils, some of which are eroded.
- VIs: Sloping and moderately steep droughty soils, most of which are eroded.
- VIw: Very poorly drained organic soils that are moderately shallow over sand.

Class VII.—Soils of seriously limited suitability for pasture or woodland.
- VIIe: Loamy or gravelly, moderately steep and steep soils that are moderately eroded or severely eroded.
- VIIs: Rough broken land and other soils, some of which are eroded, that have very unfavorable texture.
- VIIw: Poorly drained alluvial land cut by stream channels or oxbows and subject to frequent overflow.

Agriculture

The earliest crops grown in Isanti County were cereals. The first crop was raised in North Branch Township in 1857. In the late 1880's, successful experiments in potato growing were conducted. Potatoes became the most important crop in the county when farming replaced lumbering as the major industry. Potatoes were shipped to southern states for seed. Several cooperative factories were established to produce starch from potatoes.

In recent years, potato production has declined and dairy farming has become the dominant agricultural activity. In 1952, there were nine creameries in the county. Income from dairy products may be supplemented by the sale of small grains, or of poultry, swine, or other livestock.

Crops

The principal crops are hay, corn, oats, rye, and soybeans. Acreages of the principal crops in stated years are given in table 6.

About 27 percent of the corn is harvested for silage and fodder. Corn planted for grain is generally an early maturing hybrid. Oats generally follow corn in the rotation and serve as a companion crop to alfalfa and clover seeded in the spring. Yields of oats are very good on the glacial till soils. Rye is the principal crop on the light-colored sandy soils. It is grown mostly as a cash crop. Fall-planted rye helps prevent

TABLE 6.—*Acreages of principal crops in stated years*

Crop	1929	1939	1949	1954
	Acres	*Acres*	*Acres*	*Acres*
Corn	12,342	19,370	25,915	24,553
Small grains threshed or combined:				
Small grains grown and threshed mixed	(1)	[2] 594	1,202	337
Winter wheat	81	2,664	490	788
Spring wheat	2,874	982	926	316
Oats	23,058	14,113	23,743	18,474
Barley	4,377	2,115	483	69
Rye	13,124	21,425	11,069	8,095
Soybeans	15	1,275	7,034	17,152
Potatoes	14,671	8,341	[3] 1,015	[4] 506
Hay, total	[5] 42,573	[5] 35,400	[6] 29,894	[7] 27,780
Alfalfa	7,550	10,869	[8] 10,540	[8] 17,251
Clover and timothy, separately or mixed	10,145	5,051	5,994	5,020
Small grains cut for hay	147	449	748	300
Wild hay	22,138	13,608	9,775	3,874
Other hay crops	2,593	5,423	2,837	1,335

[1] Not reported.
[2] Excludes wheat and flax.
[3] Excludes acreage for farms with less than 15 bushels harvested.
[4] Excludes acreage for farms with less than 20 bushels harvested.
[5] Excludes sorghum hay.
[6] Excludes soybean and sorghum hay.
[7] Excludes soybean hay.
[8] Cut for hay or dehydrating.

TABLE 7.—*Number of livestock on farms in stated years*

Livestock	1930	1940	1950	1954
Horses and mules	6,037	[1] 4,712	1,755	685
Cattle	27,018	[1] 22,448	24,711	26,470
Swine	5,716	[2] 5,088	6,883	8,688
Sheep	2,118	[3] 1,979	1,542	2,441
Chickens	[1] 145,651	[2] 130,270	[2] 146,061	[2] 155,843
Turkeys	[4] 3,767	[4] 5,727	[4] 56,541	107,265

[1] Over 3 months old. [2] Over 4 months old. [3] Over 6 months old. [4] Raised in year preceding census.

wind erosion on sandy soils. Most of the soybean crop is sold.

Production of potatoes, the principal crop in the county before 1910, has steadily declined. Shortages of labor and damage to potatoes by plant diseases were largely responsible for the decrease in acreage. In the past 30 years the wheat acreage has decreased.

Livestock and Livestock Products

The number of livestock on farms in stated years is shown in table 7. The decrease in the number of horses and mules is due in part to the increased use of tractors and trucks. The number of turkeys raised each year is increasing. Only 3,767 turkeys were raised in 1930, but 107,265 were raised in 1950.

Types of Farms

The 1,492 farms of Isanti County were classified in the 1954 Federal census as follows:

Type of farm	*Number*
Dairy	782
Livestock, other than dairy and poultry	110
Field-crop, other than vegetable and fruit-and-nut	135
Poultry	80
General	135
Miscellaneous and unclassified	250
Total	1,492

Of the general farms, 50 were primarily livestock, 75 crop and livestock, and 10 primarily crop. The average farm in the county was 157.9 acres in 1954.

Farm Tenure

According to the 1954 census, 958 farms in the county were operated by full owners, 425 by part owners, 84 by tenants, and 3 by farm managers. In 1954, there were 29 cash tenants, 25 share tenants and sharecroppers, and 14 share-cash tenants.

Farm Equipment

According to the 1954 census, there were 1,767 tractors on 1,827 farms, and 1,709 automobiles on 1,342 farms. There were 287 grain combines on 282 farms and 257 corn pickers on 257 farms. Much of the corn is harvested by mechanical pickers. Most of the small grains and soybeans are harvested with combines. In 1954, 727 farms had milking machines. Telephones were reported on 1,112 farms, and electricity on 1,377 farms. In 1954, 2,622 tons of commercial fertilizers were used.

Engineering Application[3]

This soil survey report for Isanti County, Minnesota, contains information that can be used by engineers to:

(1) Make soil and land-use studies that will aid in the selection and development of industrial, business, residential, and recreational sites.

(2) Make estimates of runoff and erosion characteristics, for use in designing drainage structures and planning dams and other structures for water and soil conservation.

(3) Make reconnaissance surveys of soil and ground conditions that will aid in selecting highway and airport locations and in planning detailed soil surveys for the intended locations.

(4) Locate sand and gravel for use in structures.

(5) Correlate pavement performance with types of soil and thus develop information that will be useful in designing and maintaining the pavements.

(6) Determine the suitability of soil units for cross-county movements of vehicles and construction equipment.

(7) Supplement information obtained from other published maps and reports and aerial photographs, for the purpose of making soil maps and reports that can be readily used by engineers.

The mapping and the descriptive report are somewhat generalized, however, and should be used only in planning more detailed field surveys to determine the in-place condition of the soil at the site of the proposed engineering construction.

Soil Science Terminology

Some of the terms used by the agricultural soil scientist may be unfamiliar to the engineer, and some words—for example, soil, clay, silt, sand, aggregate, and granular—may have special meanings in soil science. These terms are defined as follows:

Aggregate: A cluster of primary soil particles held together by internal forces to form a clod or fragment.

Clay: A soil separate or size group of mineral particles less than 0.002 mm. (0.000079 in.) in diameter. Clay as a textural class includes soil material containing 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Granular structure: Individual grains grouped into spherical aggregates with indistinct sides. Highly porous granules are commonly called crumbs.

[3] This section was prepared by the Division of Physical Research, Bureau of Public Roads. Test data in table 8 were obtained in the Soils Laboratory, Bureau of Public Roads.

Sand: A soil separate ranging in diameter from 2.0 mm. (0.079 in.) to 0.05 mm. (0.002 in.). As a textural class sand consists of soil material that contains 85 percent or more sand; the percentage of silt plus 1½ times the percentage of clay does not exceed 15.

Silt: A soil separate having diameters ranging from 0.05 mm. (0.002 in.) to 0.002 mm. (0.000079 in.). As a textural class silt includes soil material that contains 80 percent or more silt and less than 12 percent clay.

Soil: The natural medium for the growth of land plants on the surface of the earth; composed of organic and mineral materials.

Topsoil: Presumably fertile soil material used to topdress roadbanks, gardens, and lawns.

Soil Test Data and Engineering Soil Classifications

To be able to make the best use of the soil maps and the soil survey reports, the engineer should know the physical properties of the soil materials and the in-place condition of the soil. After testing soil materials and observing the behavior of soils when used in engineering structures and foundations, the engineer can develop design recommendations for the soil units delineated on the maps.

Soil test data

Soil samples from seven extensive soil series were tested in accordance with standard procedures[4] to help evaluate the soils for engineering purposes. The test data are given in table 8. Although the soils were sampled in two different localities, the test data probably do not show the maximum range in physical test characteristics of materials that will be encountered in engineering construction.

The engineering soil classifications in table 8 are based on data obtained by mechanical analyses and by tests to determine liquid limits and plastic limits. Mechanical analyses were made by combined sieve and hydrometer methods. Percentage of clay obtained by the hydrometer method should not be used in naming soil textural classes.

The liquid limit and plastic limit tests measure the effect of water on the consistence of the soil material. As the moisture content of a clayey soil increases from a very dry state, the material changes from a solid to a semisolid or plastic state. As the moisture content is further increased, the material changes from the plastic to a liquid state. The plastic limit is the moisture content at which the soil material passes from a solid to a plastic state. The liquid limit is the moisture content at which the material passes from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and plastic limit. It indicates the range of moisture content within which a soil material is in a plastic condition.

Table 8 also gives compaction (moisture-density) data for the tested soils. If a soil material is compacted at successively higher moisture contents, assuming that the compactive effort remains constant, the density of the compacted material will increase until the "optimum moisture content" is reached. After that, the density decreases with increase in moisture content. The highest dry density obtained in the compaction test is termed "maximum dry density." Moisture-density data are important in earthwork, for as a rule optimum stability is obtained if the soil is compacted to about the maximum dry density, when it is at approximately the optimum moisture content.

Engineering classifications systems

Most highway engineers classify soil materials in accordance with the system approved by the American Association of State Highway Officials.[5] In this system, soil materials are classified in seven principal groups. The groups range from A–1, consisting of gravelly soils of high bearing capacity, to A–7, consisting of clay soils having low strength when wet. Within each group, the relative engineering value of the soil material is indicated by a group index number. Group indexes range from 0 for the best materials to 20 for the poorest. The group index number is shown in parentheses, following the soil group symbol, in the next to last column of table 8. The principal characteristics according to which soils are classified in this system are shown in table 9.

Some engineers prefer to use the Unified soil classification system.[6] In this system soil materials are identified as coarse grained (8 classes), fine grained (6 classes), or highly organic. The principal characteristics of the 15 classes of soil are given in table 10. The classification of the tested soils, according to the Unified system, is given in the last column of table 8.

Soil Engineering Data and Recommendations

Some of the engineering information can be obtained from the soil map. It will often be necessary, however, to refer to other parts of the report, particularly to these sections: General Nature of the Area, Soil Survey Methods and Definitions, Soil Series and Their Relations, and Descriptions of the Soils.

The highway soil engineering data and recommendations given in table 11 are based on the soil test data in table 8, information in the rest of the report, and experience with the same kinds of soils in other counties.

The red glacial drift materials, which were derived from igneous rocks and sandstones at the western margin of Lake Superior, are more durable when used in engineering structures than the gray glacial drift materials, which were derived from limestone and calcareous shale formations northwest of the county.

[4] AMERICAN ASSOCIATION OF STATE HIGHWAY OFFICIALS. STANDARD SPECIFICATIONS FOR HIGHWAY MATERIALS AND METHODS OF SAMPLING AND TESTING. Ed. 7, 1955.

[5] See footnote 4.

[6] WATERWAYS EXPERIMENT STATION, CORPS OF ENGINEERS, U. S. ARMY. THE UNIFIED SOIL CLASSIFICATION SYSTEM. Tech. Memo. 3–357, 3 v. 1953.

TABLE 8.—*Engineering test data*[1] *for soil samples*

Soil name and location	Parent material	Bureau of Public Roads report No.	Depth	Horizon	Moisture–density		Mechanical analysis [2]			
					Maximum dry density per cubic foot	Optimum moisture	Percentage passing sieve [3]			
							2-in.	1½-in.	1-in.	¾-in.
			Inches		*Pounds*	*Percent*				
Anoka loamy fine sand:										
		90086	0– 8	A_p	110	13				
SW¼NW¼ sec. 30, T. 35 N., R. 23 W.	Glacial outwash	90087	32–54	B_2tir	118	12				
		90088	54+	C	107	14				
		90089	0– 4	A_p	105	14				
NE¼NE¼ sec. 10, T. 36 N., R. 25 W.	Glacial outwash	90090	20–45	B_2tir	112	13				
		90091	56–70+	C_2	104	16				
Bluffton silty clay loam:										
		90056	0–16	A_1	84	30				
SW¼NE¼ sec. 8, T. 37 N., R. 24 W.	Mankato till	90057	16–30	G	106	17				
		90058	30–42	C_1	120	13			100	96
		90059	0– 8	A_1	77	33				
Center of sec. 6, T. 35 N., R. 24 W.	Calcareous lacustrine clays (Mankato).	90060	8–34	G	68	40				
		90061	34–45+	C_1	110	17				
Brickton silt loam:										
		90080	4–10	A_2	105	17				
SW¼NE¼ sec. 11, T. 37 N., R. 25 W.	Calcareous lacustrine silts and clays.	90081	15–30	B_{22}	96	22				
		90082	30–45+	C_1	100	22				
		90083	3– 9	A_2	103	19				
SW¼NW¼ sec. 20, T. 37 N., R. 25 W.	Calcareous lacustrine silts and clays.	90084	17–35	B_{22}	106	20				
		90085	35–50+	C_1	113	16				
Dalbo silt loam:										
		90074	4–10	A_2	105	19				100
NE¼NE¼ sec. 5, T. 37 N., R. 23 W.	Calcareous lacustrine silts and clays.	90075	17–32	B_2	107	17	100	92	92	90
		90076	32–44+	C_1	107	19				
		90077	5– 9	A_2	101	19				
NW¼SE¼ sec. 13, T. 37 N., R. 25 W.	Calcareous lacustrine silts and clays.	90078	9–18	B_{21}	106	19				
		90079	25+	C	108	18				
Hayden fine sandy loam:										
		90062	4–10	A_2	117	12			100	99
NE¼SE¼ sec. 11, T. 36 N., R. 24 W.	Mankato till	90063	17–38	B_2	114	15				100
		90064	38–55+	C_1	121	12				
		90065	3– 8	A_2	110	13				
NE¼NW¼ sec. 19, T. 37 N., R. 24 W.	Mankato till	90066	8–28	B_{21}	111	16				
		90067	42–50+	C_1	112	15				
Milaca silt loam:										
		90068	2– 9	A_{21}	112	13				
SE¼SE¼ sec. 8, T. 37 N., R. 25 W.	Cary till	90069	15–42	B	130	9				100
		90070	42–60+	C_1	134	8	100	88	87	86
Milaca fine sandy loam:										
		90071	3–11	A_2	125	9				100
NE¼SE¼ sec. 20, T. 34 N., R. 25 W.	Cary till	90072	20–47	B_2	125	11				
		90073	47–75+	C_1	128	10				
Zimmerman loamy fine sand:										
		90092	0– 5	A	110	12				
SE¼SE¼ sec. 10, T. 34 N., R. 24 W.	Glacial outwash	90093	5–60	B	110	13				
		90094	60–80	C_1	110	13				
		90095	0– 8	A_1	104	15				
SE¼SE¼ sec. 32, T. 36 N., R. 25 W.	Glacial outwash	90096	8–48	B_1	104	15				
		90097	60+	C_1	105	14				

[1] Tests performed by Bureau of Public Roads in accordance with standard procedures of the American Association of State Highway Officials (A.A.S.H.O.). See footnote 4, p. 47.

[2] Mechanical analyses according to A.A.S.H.O. Designation: T 88. Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the A.A.S.H.O. procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 mm. in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 mm. in diameter is excluded

taken from 14 soil profiles, Isanti County, Minn.

Mechanical analysis [2]—Continued										Liquid limit	Plasticity index	Classification	
Percentage passing sieve [3]—Continued						Percentage smaller than [3]							
⅜-in.	No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 60 (0.25 mm)	No. 200 (0.074 mm)	0.05 mm	0.02 mm	0.005 mm	0.002 mm			A.A.S.H.O. [4]	Unified [5]
		100	99	95	39	29	14	9	7	NP [6]	NP [6]	A–4(1)	SM
		100	96	79	28	20	11	10	9	NP [6]	NP [6]	A–2–4(0)	SM
		100	95	65	12	9	4	3	3	NP [6]	NP [6]	A–2–4(0)	SP-SM
		100	98	93	29	18	7	4	3	NP [6]	NP [6]	A–2–4(0)	SM
		100	99	96	32	22	13	12	12	NP [6]	NP [6]	A–2–4(0)	SM
		100	99	96	32	20	5	4	4	NP [6]	NP [6]	A–2–4(0)	SM
		100	99	98	95	85	59	30	21	58	20	A–7–5(16)	MH or OH
		100	99	98	95	87	63	31	26	40	19	A–6(12)	CL
93	92	90	81	74	55	46	28	19	15	30	14	A–6(6)	CL
		100	98	97	93	89	72	40	29	64	16	A–7–5(14)	MH or OH
		100	98	96	92	88	73	43	33	76	17	A–7–5(15)	MH
		100	99	98	87	78	54	37	30	44	24	A–7–6(14)	CL
		100	98	96	93	86	62	21	11	24	4	A–4(8)	ML-CL
		100	99	97	95	94	89	57	46	61	35	A–7–6(20)	CH
					100	99	91	46	33	43	21	A–7–6(13)	CL
				100	99	90	60	25	17	32	9	A–4(8)	ML-CL
				100	98	92	75	42	29	43	23	A–7–6(14)	CL
				100	94	80	48	22	16	30	11	A–6(8)	CL
99	98	97	91	80	58	53	39	23	17	22	9	A–4(5)	CL
87	85	83	74	61	36	31	20	13	11	22	9	A–4(0)	SC
				100	99	98	87	31	18	33	11	A–6(8)	ML-CL
		100	99	98	95	86	60	19	13	33	7	A–4(8)	ML
		100	99	98	95	90	70	32	28	37	15	A–6(10)	CL
				100	99	85	47	15	11	26	4	A–4(8)	ML-CL
99	98	96	86	76	51	42	24	11	8	20	3	A–4(3)	ML
99	98	96	87	81	61	54	38	25	20	37	19	A–6(9)	CL
100	99	98	93	89	74	63	36	17	12	24	7	A–4(8)	ML-CL
		100	97	94	87	72	36	12	9	NP [6]	NP [6]	A–4(8)	ML
		100	98	96	92	78	45	30	17	28	9	A–4(8)	CL
		100	99	98	94	85	59	16	10	27	6	A–4(8)	ML-CL
		100	95	89	79	66	30	11	7	20	3	A–4(8)	ML
95	92	89	78	62	34	27	15	10	8	16	3	A–2–4(0)	SM
84	81	76	62	49	25	20	12	8	5	14	3	A–2–4(0)	SM
96	94	91	78	62	36	32	19	8	5	15	2	A–4(0)	SM
		100	99	96	92	88	67	18	10	27	5	A–4(8)	ML-CL
		100	99	97	94	91	76	34	27	35	15	A–6(10)	CL
		100	91	49	11	10	7	5	4	NP [6]	NP [6]	A–2–4(0)	SP-SM
		100	93	49	12	12	10	5	4	NP [6]	NP [6]	A–2–4(0)	SP-SM
		100	91	50	11	10	7	4	4	NP [6]	NP [6]	A–2–4(0)	SP-SM
			100	97	19	13	5	4	3	NP [6]	NP [6]	A–2–4(0)	SM
			100	97	18	12	5	4	3	NP [6]	NP [6]	A–2–4(0)	SM
		100	99	95	20	15	7	5	3	NP [6]	NP [6]	A–2–4(0)	SM

from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soils.

[3] Based on total material. Laboratory test data corrected for amount discarded in field sampling.

[4] Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing (Pt. 1): The Classification of Soils and Soil-Aggregate Mixtures for Highway Purposes, A.A.S.H.O. Designation: M 145–49.

[5] Based on the Unified Soil Classification System. Tech. Memo. 3–357, v. 1, Waterways Experiment Station, Corps of Engineers, March 1953.

[6] NP—Nonplastic.

TABLE 9.—*Classification of soils by American Associaton of State Highway Officials*[1]

General classification	Granular materials (35 percent or less passing No. 200 sieve)							Silt-clay materials (More than 35 percent passing No. 200 sieve)				
	A–1		A–3	A–2				A–4	A–5	A–6	A–7	
Group classification	A–1–a	A–1–b		A–2–4	A–2–5	A–2–6	A–2–7				A–7–5	A–7–6
Sieve analysis: Percent passing—												
No. 10	50 maximum.											
No. 40	30 maximum.	50 maximum.	51 minimum.									
No. 200	15 maximum.	25 maximum.	10 maximum.	35 maximum.	35 maximum.	35 maximum.	35 maximum.	36 minimum.	36 minimum.	36 minimum.	36 minimum.	36 minimum.
Characteristics of fraction passing No. 40 sieve:												
Liquid limit			NP [2]	40 maximum.	41 minimum.	40 maximum.	41 minimum.	40 maximum.	41 minimum.	40 maximum.	41 minimum.	41 minimum.
Plasticity index	6 maximum.	6 maximum.	NP [2]	10 maximum.	10 maximum.	11 minimum.	11 minimum.	10 maximum.	10 maximum.	11 minimum.	11 minimum.[3]	11 minimum.[3]
Group index	0	0	0	0	0	4 maximum.	4 maximum.	8 maximum.	12 maximum.	16 maximum.	20 maximum.	20 maximum.
Usual types of significant constituent materials.	Stone fragments, gravel, and sand.	Stone fragments, gravel, and sand.	Fine sand.	Silty gravel and sand.	Silty gravel and sand.	Clayey gravel and sand.	Clayey gravel and sand.	Nonplastic to moderately plastic silty soils.	Highly elastic silts.	Medium plastic clays.	Highly plastic clays.	Highly plastic clays.
General rating as subgrade.	Excellent to good					Fair to poor						

[1] Based on Standard Specifications for Highway Materials and Methods of Sampling and Testing (pt. 1; ed. 7): The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes, A.A.S.H.O. Designation: M 145–49.

[2] NP—Nonplastic.

[3] Plasticity index of A–7–5 subgroup is equal to or less than LL minus 30. Plasticity index of A–7–6 subgroup is greater than LL minus 30.

TABLE 10.—*Characteristics of soil groups in Unified soil classification system*[1]

Major divisions	Group symbol	Soil description	Value as foundation material [2]	Value as base course directly under bituminous pavement	Value for embankments	Compaction: Characteristics and recommended equipment	Approximate range in A.A.S.H.O. maximum dry density [3]	Field (in-place) CBR	Subgrade modulus k	Drainage characteristics	Comparable groups in A.A.S.H.O. classification
							Lb./cu. ft.		*Lb./sq.in./in*		
Coarse-grained soils (*less than 50 percent passing No. 200 sieve*):											
Gravels and gravelly soils (*more than half of coarse fraction retained on No. 4 sieve.*)	GW	Well-graded gravels and gravel-sand mixtures; little or no fines.	Excellent	Good	Very stable; use in pervious shells of dikes and dams.	Good; use crawler-type tractor, pneumatic-tire roller, or steel-wheel roller.	125–135	60–80	300+	Excellent	A–1
	GP	Poorly graded gravels and gravel-sand mixtures; little or no fines.	Good to excellent.	Poor to fair	Reasonably stable; use in pervious shells of dikes and dams.	Same	115–125	25–60	300+	Excellent	A–1
	GM	Silty gravels and gravel-sand-silt mixtures.	Good	Poor to good	Reasonably stable; not particularly suited to shells, but may be used for impervious cores or blankets.	Good, but needs close control of moisture; use pneumatic-tire or sheepsfoot roller.	120–135	20–80	200–300+	Fair to practically impervious.	A–1 or A–2
	GC	Clayey gravels and gravel-sand-clay mixtures.	Good	Poor	Fairly stable; may be good for impervious core.	Fair, use pneumatic-tire or sheepsfoot roller.	115–130	20–40	200–300	Poor to practically impervious.	A–2
Sands and sandy soils (*more than half of coarse fraction passing No. 4 sieve*).	SW	Well-graded sands and gravelly sands; little or no fines.	Good	Poor	Very stable; may be used in pervious sections; slope protection required.	Good; use crawler-type tractor or pneumatic-tire roller.	110–130	20–40	200–300	Excellent	A–1
	SP	Poorly graded sands and gravelly sands; little or no fines.	Fair to good.	Poor to not suitable.	Reasonably stable; may may be used in dike section having flat slopes.	Same	100–120	10–25	200–300	Excellent	A–1 or A–3
	SM	Silty sands and sand-silt mixtures.	Fair to good.	Same	Fairly stable; not particularly suited to shells, but may be used for impervious cores or dikes.	Good, but needs close control of moisture; use pneumatic-tire or sheepsfoot roller.	110–125	10–40	200–300	Fair to practically impervious.	A–1, A–2, or A–4
	SC	Clayey sands and sand-clay mixtures.	Fair to good.	Not suitable	Fairly stable; use as impervious core for flood-control structures.	Fair; use pneumatic-tire roller or sheepsfoot roller.	105–125	10–20	200–300	Poor to practically impervious.	A–2, A–4, or A–6

TABLE 10.—*Characteristics of soil groups in Unified soil classification system*[1]*—Continued*

Major divisions	Group symbol	Soil description	Value as foundation material [2]	Value as base course directly under bituminous pavement	Value for embankments	Compaction: Characteristics and recommended equipment	Approximate range in A.A.S.H.O. maximum dry density [3]	Field (in-place) CBR	Subgrade modulus k	Drainage characteristics	Comparable groups in A.A.S.H.O. classification
							Lb./cu. ft.		*Lb./sq.in./in*		
Fine-grained soils (*more than 50 percent passing No. 200 sieve*):											
Silts and clays (*liquid limit of 50 or less*).	ML	Inorganic silts and very fine sands, rock flour, silty or clayey fine sands, and clayey silts of slight plasticity.	Fair to poor.	Not suitable.	Poor stability; may be used for embankments if properly controlled.	Good to poor; close control of moisture is essential; use pneumatic-tire or sheepsfoot roller.	95–120	5–15	100–200	Fair to poor.	A–4, A–5, or A–6
	CL	Inorganic clays of low to medium plasticity, gravelly clays, sandy clays, silty clays, and lean clays.	Fair to poor.	Not suitable.	Stable; use in impervious cores and blankets.	Fair to good; use pneumatic-tire or sheepsfoot roller.	95–120	5–15	100–200	Practically impervious.	A–4, A–6, or A–7
	OL	Organic silts and organic clays having low plasticity.	Poor.	Not suitable.	Not suitable for embankments.	Fair to poor; use sheepsfoot roller.[4]	80–100	4–8	100–200	Poor.	A–4, A–5, A–6, or A–7
Silts and clays (*liquid limit greater than 50*).	MH	Inorganic silts, micaceous or diatomaceous fine sandy or silty soils, and elastic silts.	Poor.	Not suitable.	Poor stability; use in core of hydraulic fill dam; not desirable in rolled fill construction.	Poor to very poor; use sheepsfoot roller.[4]	70– 95	4–8	100–200	Fair to poor.	A–5 or A–7
	CH	Inorganic clays having high plasticity and fat clays.	Poor to very poor.	Not suitable.	Fair stability on flat slopes; use in thin cores, blankets, and dike sections of dams.	Fair to poor; use sheepsfoot roller.[4]	75–105	3–5	50–100	Practically impervious.	A–7
	OH	Organic clays having medium to high plasticity and organic silts.	Same.	Not suitable.	Not suitable for embankments.	Poor to very poor; use sheepsfoot roller.[4]	65–100	3–5	50–100	Practically impervious.	A–5 or A–7
Highly organic soils	Pt	Peat and other highly organic soils.	Not suitable	Not suitable.	Not used in embankments, dams, or subgrades for pavements					Fair to poor.	None.

[1] Based on information in The Unified Soil Classification System, Technical Memorandum No. 3–357, Volumes 1, 2, and 3, Waterways Experiment Station, Corps of Engineers, 1953. Ratings and ranges in test values are for guidance only. Design should be based on field survey and test of samples from construction site.

[2] Ratings are for subgrade and subbases for flexible pavement.

[3] Determined in accordance with test designation: T 99–49, A.A.S.H.O.

[4] Pneumatic-tire rollers may be advisable, particularly when moisture content is higher than optimum.

Therefore, the color of the soil parent material is given in the brief soil descriptions in table 11.

The range of texture (grain size) of some of the materials is considerable; therefore, the engineering soil classification given in table 11 may not apply to all parts of a mapped soil unit.

Frost action is one of the primary soil-engineering problems in the county. Although it might be desirable to suspend earthwork operations during the winter months to prevent the use of frozen soil materials for constructing embankments, it is not always economically feasible to do so. Earthwork in gravelly or sandy materials that do not contain more than a small percentage of silt or clay is normally permitted during the winter months, provided the required standards of construction with respect to compaction of soils and the exclusion of frozen material are maintained.

Susceptibility of the soil material to frost action has also been considered in rating the soils as sources of "sand-gravel" material. To be nonsusceptible to frost action, not more than about 10 percent of the soil material should pass the No. 200 sieve. Because of the scarcity of sand-gravel materials, however, a slightly higher percentage of fine material may be permitted in the subbase and base courses for pavements.

The ratings given for suitability of the soils as sources of topsoil, for use on embankment and cut slopes and in ditches of highways, apply to Isanti County. Many of the soils are rated "poor" as a source of topsoil because the material is too sandy to be high in fertility.

The construction of roads in undulating to rolling glacial uplands may require considerable earthwork. Some of the glacial till deposits contain lenses or pockets of fine sand and silt that are susceptible to differential frost heave. In places where these materials occur, a sufficiently thick layer of material that is not susceptible to heaving should be used in the highway subgrade to prevent detrimental heaving of the pavement. Where there are clay lenses or pockets in coarse-grained deposits, differential frost heave may be prevented either by mixing the clay with the coarse-grained material so that heaving will be uniform or by using a sufficiently thick layer of very permeable coarse sand or sandy gravel in the upper part of the subgrade to prevent heaving.

The requirements for underdrains in roadway-cut sections should be determined by field exploration. The highly organic surface layer of the Adolph and Bluffton soils, and small areas of muck that occur within glacial till mapping units, should be excavated when they occur within the roadway section. The organic soil material should either be wasted or placed on the embankment slopes. In depressed areas where the water table is near the ground surface, highway embankments should be constructed of well-drained sandy or gravelly material and to a sufficient height so that the pavement surface will be at least 4 feet above the water table.

The glacial-outwash soils, such as the Anoka, Blomford, Braham, Isanti, and Lino soils, are composed of fine sand or loamy sand and have water tables at depths of less than 5 feet; they are therefore very susceptible to the development of ice lenses. The formation of ice lenses causes differential heave of the pavement. The following methods have been used to prevent detrimental heave of pavements: (1) Construction of deep side ditches to lower the water table beneath the roadway, (2) building a continuous embankment section composed of very permeable coarse sand or sandy-gravel materials, and (3) removal of frost-susceptible material to a depth of about 5 feet below the proposed elevation of the pavement and refilling with coarse sand or gravel that is not susceptible to frost action.

In some depressions in the glacial outwash areas, the water table may be near the ground surface; here, a highly organic or muck layer has developed, even though the underlying materials may be stratified sand and gravel. The highly organic material should be removed from the roadway section and placed where it will not be detrimental to road structures. An embankment should be built across the depressed areas so that the pavement surface is at least 4 feet above the water table.

Glaciolacustrine soils such as the Brickton and Dalbo, which are composed of stratified silty or clayey materials, make poor road foundations when the water table is at only a slight depth below the pavement. In addition, if the soil contains layers of silt and fine sand, ice lenses may develop, causing differential frost heave. The road gradeline should be at least 2 feet above the natural ground surface in the Brickton soils and at least 3 feet above the water table in the Dalbo soils. Where the water table is within 5 feet of the gradeline, a foundation course of very permeable material, which is thick enough to prevent detrimental frost heave, should be used. The unit that is mapped as Beach sand occurs adjacent to the glaciolacustrine deposits in some areas and may be suitable material for the foundation course.

Roads should be constructed on embankments in parts of the bottom lands that are subject to flooding. Suitable materials for use in the embankments may be taken from the adjacent bottom land.

Peat has low strength and occurs in areas where the water table is normally high; therefore, it is not suitable for use in foundations of roads or other engineering structures. Roads normally should be alined to avoid deep peat. The peat within roadway-cut sections should be wasted, and that in embankment sites or below the gradeline in cut sections should be removed and replaced by a suitable soil material. Small areas of peat are not shown on the soil map; in some depressed areas the peat may underlie several feet of glacial or glaciofluvial material. Consequently, a thorough field investigation should be made in depressed areas.

At many construction sites, major variations in the soil may occur within the depth of the proposed excavation, and several soil units may occur within a short distance. The soil maps and profile descriptions, as well as the engineering data and recommendations given in this section, should be used in planning detailed surveys of soils at construction sites. By using the information in the soil survey reports, the soils engineer can concentrate on the most suitable soil units. Then, a minimum number of soil samples will be required for laboratory testing, and an adequate soil investigation can be made at minimum cost.

TABLE 11.—*Highway soil engineering data and recommendations*

GLACIAL UPLANDS

Soil series	Brief description of soil profile and ground condition	Dominant slope	Estimated soil classification		Depth to seasonally high water table [1]	Suitability as source of—		Remarks
			A.A.S.H.O.	Unified		Topsoil [2]	Sand-gravel	
		Percent			*Feet*			
Adolph	½ to 1 foot of very poorly drained highly organic silty clay loam on 2 to 3 feet of clay loam to silty clay developed from sandy clay loam red till; occasional lenses of coarse sand or fine gravel below 3 feet.	0- 2	A–6 or A–7	MH or OH over CL, MH, or CH.	½ to 1	Fair	Not suitable	
Ames	1 to 1½ feet of imperfectly drained silt loam on 1 to 1½ feet of silty clay loam developed from clay loam gray till.	0- 2	A–4 or A–6	ML or CL	1 to 2	Poor	Not suitable	
Bluffton	1 to 1½ feet of very poorly to poorly drained highly organic silty clay loam on 1½ to 2½ feet of silty clay developed from clay loam gray till.	0- 2	A–6 or A–7	MH or OH over CL, MH, or CH.	½ to 1	Good	Not suitable	Overlain in places by a thin layer of peat or muck.
Burnsville-Rodman	1 to 4 feet of well drained to excessively drained loamy sand or sandy loam over somewhat stratified gray sand and gravel.	2–18	A–2 or A–4 over A–1, A–2, or A–3.	SM, SC, or ML over GW, GP, SW, or SP.	Deep	Not suitable	Fair to good	Quality of sand and gravel must be determined by laboratory tests.
Emmert	½ to 2½ feet of excessively drained loamy fine sand over a mixture of red sand, gravel, and coarser particles; some deposits stratified.	12–25	A–2 over A–1 or A–2.	SM over GW, GP, SW, or SP.	Deep	Not suitable	Good	Processing to remove cobblestones and stones may be required at source of sand and gravel.
Freer	1 to 1½ feet of imperfectly drained silt loam on 1 to 1½ feet of silty clay loam developed from sandy clay loam red till; some lenses of coarse sand.	0- 2	A–4 or A–6	ML or CL	1 to 2	Poor	Not suitable	
Hayden	½ to 1 foot of moderately well drained to well drained fine sandy loam or silt loam on 2 to 3 feet of clay loam developed from loam, silt loam, or clay loam gray till.	2–18	A–4 or A–6	ML or CL	6 to 10	Fair	Not suitable	
Milaca	½ to 1½ feet of well drained to excessively drained silt loam or sandy loam on 2 to 3 feet of clay loam or sandy clay loam developed from sandy loam or sandy clay loam red till containing some lenses of sand and gravel; in places there are many stones throughout the profile.	2–18	A–2, A–4, or A–6.	SM, ML, or CL.	8 to 12	Fair	Not suitable	In places a relatively impervious layer may retard internal drainage.
Scandia	2½ to 3½ feet of somewhat excessively drained to excessively drained sandy loam or gravelly sandy loam over loose sand and gravel; in places the materials are stratified. Soil has developed from red drift on a mixture of red and gray drift.	2–18	A–2 or A–4 over A–1, A–2, or A–3.	SM or SC over SW or SP.	Deep	Poor	Fair to good	Predominantly sand.

GLACIAL OUTWASH

Anoka	2 to 5 feet of well-drained loamy fine sand or sand underlain by gray fine sand; bands of fine sandy loam, ranging from very thin to 2 feet in thickness, at depths below 1 foot.	2–12	A–2 with bands of A–4 over A–2 or A–3.	SM over SP or SM.	3 to 5	Poor	Not suitable	In places internal drainage is retarded by bands of sandy loam.
Blomford	1½ to 4 feet of imperfectly drained loamy fine sand or sandy loam over loam to silty clay loam gray till or lacustrine silty clay loam.	0- 2	A–2 or A–4 over A–4 or A–6.	SM over ML or CL.	2 to 4	Poor	Not suitable	
Braham	1½ to 4 feet of well drained to excessively drained loamy fine sand or fine sand over loam to clay loam gray till or lacustrine silty clay loam.	2–12	A–2 or A–3 over A–4, A–6, or A–7.	SM or SP over ML or CL.	3 to 5	Poor	Not suitable	
Chetek	1 to 2 feet of well drained to excessively drained loamy sand or sandy loam over stratified red sand and gravel; gray till at depths of 3 to 4 feet in many places.	2–12	A–2 or A–4 over A–1, A–2, or A–3.	SM or SC over GW, GP, SW, or SP.	Deep	Poor	Fair to good	Suitability as source of sand and gravel may be limited because of shallow depth to gray till.
Crown	2 to 4 feet of imperfectly drained to moderately well drained loamy sand over stratified red sand and gravel.	0- 2	A–2 over A–1, A–2, or A–3.	SM over GW, GP, SW, or SP.	2 to 4	Poor	Limited	Suitability as source of sand and gravel is limited by high water table.

TABLE 11.—*Highway soil engineering data and recommendations—Continued*

Soil series	Brief description of soil profile and ground condition	Dominant slope	Estimated soil classification		Depth to seasonally high water table [1]	Suitability as source of—		Remarks
			A.A.S.H.O.	Unified		Topsoil [2]	Sand-gravel	
		Percent			*Feet*			
Hubbard	1 to 2½ feet of well-drained loamy fine sand over gray sand.	0– 7	A–2 over A–2 or A–3.	SM over SP or SM.	Deep	Fair	Poor	Upper 8 inches contains considerable organic matter. Below 3 feet gravel content increases with depth.
Isanti	0 to 1 foot of poorly drained mucky loamy fine sand over 2 to 3 feet of loamy fine sand or fine sandy loam developed from gray fine sand.	0– 2	A–2 or A–3 over A–3.	SM over SP	½ to 1	Fair to good	Not suitable	Organic-matter content of the surface layer varies.
Lino	1 to 2 feet of imperfectly drained to moderately well drained loamy sand or fine sand over gray sand.	0– 2	A–2 over A–2 or A–3.	SM over SP or SM.	2 to 4	Poor to fair	Not suitable	
Onamia	1½ to 4 feet of well-drained sandy loam over stratified red sand and gravel.	2–12	A–2 or A–4 over A–1, A–2, or A–3.	SM or SC over GW, GP, SW, or SP.	Deep	Fair	Fair to good	
Warman	6 to 10 inches of poorly drained mucky loam or mucky sandy loam on 2 to 3 feet of sandy clay loam or clay loam over stratified red sand and gravel.	0– 2	A–4 or A–6 over A–1, A–2, or A–3.	OL on CL over GW, GP, SW, or SP.	½ to 1	Fair	Limited	Suitability as source of sand and gravel is limited by high water table.
Zimmerman	Somewhat excessively drained to excessively drained loamy fine sand or fine sand; gray sand becomes coarser at increasing depths.	2–12	A–2 or A–3	SM or SP	Deep	Poor	Not suitable	Water table may occur at depth of 6 to 10 feet in nearly flat areas.
GLACIOLACUSTRINE DEPOSITS								
Brickton	1 to 1½ feet of poorly drained to imperfectly drained silt loam to silty clay loam on 1 to 1½ feet of silty clay developed from lacustrine silts and clays.	0– 2	A–4, A–6, or A–7.	ML, CL, or CH.	1 to 2	Poor	Not suitable	
Dalbo	1 to 1½ feet of moderately well drained to well drained silt loam to fine sandy loam on 1 to 2 feet of silty clay loam developed from lacustrine silts and clays; strata of fine sand in some places.	2–12	A–4, A–6, or A–7.	SC, ML, CL, or CH.	6 to 10	Fair	Not suitable	
Greenbush	1½ to 3 feet of moderately well drained to well drained silt loam or silty clay loam over stratified red sand and gravel.	0– 7	A–4 or A–6 over A–1, A–2, or A–3.	ML or CL over GW, GP, SW, or SP.	Deep	Fair	Fair to good	Fine-textured material overlying sand and gravel may be saturated during spring months.
Kanabac	1 to 1½ feet of moderately well drained to well drained fine sandy loam on 1 to 1½ feet of sandy loam to clay loam over stratified red sand and gravel.	2– 7	A–4 or A–6 over A–1 A–2, or A–3.	ML or CL over GW, GP, SW, or SP.	Deep	Fair	Fair to good	Same.
BOTTOM LANDS								
Alluvial land, well-drained.	Moderately well drained to well drained stratified mixed coarse to fine sand; some layers of finer textured material.	0– 2	A–2 or A–3	SM or SP	3 to 6	Limited	Not suitable	Occasionally flooded.
Alluvial land, poorly drained.	Poorly drained stratified mixed loamy fine sand to silty clay loam; overlain in places by thin layer of muck.	0– 2	A–2, A–4, or A–6.	SM, SC, ML, or CL.	0 to 1	Limited	Not suitable	Frequently flooded.
Rum River	3 to 4 feet of poorly drained to imperfectly drained loam, silty clay loam, or sandy clay loam over stratified sandy alluvium.	0– 2	A–4 or A–6 over A–2 or A–3.	ML or CL over SM or SP.	1 to 3	Fair	Not suitable	Occasionally flooded.

[1] Deep means that water table is probably at a depth greater than 10 feet.

[2] Rating is for the surface or A-horizon material for use on embankment and cut slopes, and in using ditches to promote the growth of vegetation.

Map symbol	Soils	Slope range	Topography	Parent material or substratum	Drainage	Surface soil		Subsoil		Principal present uses	Management group	Land capability class and subclass
						Color	Consistence	Color	Consistence			
		Percent										
Ad	Adolph silty clay loam	0–2	Nearly level or depressional.	Noncalcareous glacial till.	Very poor	Black	Variable	Dark gray	Plastic when wet.	Corn (silage), hay, and pasture.	4	IVw.
A	Alluvial land, well drained	0–2	Nearly level	Alluvial materials (variable).	Moderately good to good.	Variable	Variable	Variable	Variable	Hay and pasture	12	IIIw.
Aw	Alluvial land, poorly drained	0–2	Nearly level	Alluvial materials (variable).	Poor (subject to overflow).	Variable	Variable	Variable	Variable	Pasture	12	VIIw.
Y	Ames silt loam	0–2	Nearly level	Calcareous glacial till	Imperfect	Dark gray	Friable	Mottled dark grayish brown to olive brown.	Very plastic when wet.	Corn, small grains, hay, and pasture.	3	IIw.
Ys	Ames fine sandy loam	0–2	Nearly level	Calcareous glacial till	Imperfect	Dark gray	Friable	Same	Same	Same	3	IIw.
G	Anoka loamy fine sand, 0 to 2 percent slopes.	0–2	Nearly level	Deep outwash sands	Good	Very dark grayish brown.	Loose	Yellowish brown.	Friable	Corn, small grains, alfalfa, and rye.	9	IIIs.
Gu	Anoka loamy fine sand, 2 to 7 percent slopes.	2–7	Gently sloping.	Deep outwash sands	Good to somewhat excessive.	Brown to grayish brown.	Loose	Same	Friable	Same	9	IIIs.
Gp	Anoka loamy fine sand, 7 to 12 percent slopes.	7–12	Sloping	Deep outwash sands	Somewhat excessive.	Same	Loose	Same	Friable	Same	9	IVs.
Gy	Anoka loamy fine sand, 7 to 18 percent slopes, moderately eroded.	7–18	Sloping to strongly sloping.	Deep outwash sands	Excessive	Brown	Friable	Same	Friable	Alfalfa, hay, and pasture	11	VIs.
U	Beach sand	0–7	Nearly level to gently sloping.	Sand, gravel, and cobblestones.	Excessive	Light yellowish brown.	Loose	Same	Friable	Limited grazing	14	VIIs.
N	Blomford loamy fine sand	0–2	Same	Outwash and lake-laid sands underlain by till.	Imperfect	Dark grayish brown.	Friable	Dark yellowish brown to olive brown.	Slightly plastic when wet.	Soybeans, corn, small grains, hay, and pasture.	6	IIIw.
Bc	Bluffton loam and silty clay loam.	0–2	Nearly level and depressional.	Calcareous glacial till	Poor to very poor.	Black to very dark gray.	Slightly plastic when wet.	Very dark gray mottled with yellowish brown.	Plastic when wet.	Corn (silage), hay, and pasture.	4	IIIw.
Nu	Braham loamy fine sand, 2 to 7 percent slopes.	2–7	Gently sloping.	Outwash sands underlain by till or lacustrine deposits.	Good	Brown to grayish brown.	Loose	Yellowish brown.	Friable	Corn, small grains, hay, and pasture.	9	IIIs.
Np	Braham loamy fine sand, 7 to 12 percent slopes.	7–12	Sloping	Same	Good to somewhat excessive.	Same	Loose	Same	Friable	Same	9	IVs.
Nd	Braham loamy fine sand, 7 to 12 percent slopes, moderately eroded.	7–12	Sloping	Same	Somewhat excessive.	Yellowish brown.	Loose	Same	Friable	Same	9	VIs.
Nx	Braham loamy fine sand, 12 to 18 percent slopes, moderately eroded.	12–18	Moderately steep.	Same	Excessive	Same	Loose	Same	Friable	Same	11	VIs.
Bk	Brickton silt loam	0–2	Nearly level to gently undulating.	Calcareous lacustrine silts and clays.	Imperfect	Very dark gray.	Friable	Dark grayish brown to olive brown.	Very plastic when wet.	Corn (silage), small grains, pasture clovers, and tame grasses.	3	IIw.
Bv	Brickton silt loam, clayey subsoil variant.	0–2	Nearly level	Calcareous lacustrine clays.	Imperfect to poor.	Same	Slightly plastic when wet.	Olive brown	Same	Corn (silage), hay, and pasture.	3	IIIw.
V	Burnsville-Rodman complex, 2 to 7 percent slopes.	2–7	Undulating	Mixed calcareous till, sand, and gravel.	Good to somewhat excessive.	Light yellowish brown.	Friable	Dark yellowish brown.	Variable	Corn, small grains, alfalfa, and pasture.	2	IVs.

Supplement to the soil map—Isanti County, Minn.—Continued

Map symbol	Soils	Slope range	Topography	Parent material or substratum	Drainage	Surface soil		Subsoil		Principal present uses	Management group	Land capability class and subclass
						Color	Consistence	Color	Consistence			
		Percent										
Vd	Burnsville-Rodman complex, 7 to 12 percent slopes, moderately eroded.	7–12	Rolling	Same	Excessive	Same	Friable	Same	Variable	Hay and pasture	11	VIs.
Vx	Burnsville-Rodman complex, 12 to 18 percent slopes, moderately eroded.	12–18	Rolling to hilly.	Same	Excessive	Yellowish brown.	Variable	Same	Variable	Hay and pasture	11	VIIs.
C	Chetek loamy sand, 2 to 7 percent slopes.	2– 7	Undulating	Stratified noncalcareous sand and gravel.	Somewhat excessive.	Dark yellowish brown.	Loose	Yellowish brown.	Friable; somewhat firm in lower part.	Corn, small grains, alfalfa, and pasture.	5	IVs.
Cp	Chetek loamy sand, 7 to 12 percent slopes.	7–12	Gently rolling and rolling.	Same	Excessive	Same	Loose	Reddish brown.	Same	Same	5	VIs.
Cd	Chetek loamy sand, 7 to 12 percent slopes, moderately eroded.	7–12	Undulating and rolling.	Same	Excessive	Dark brown.	Variable	Reddish brown.	Somewhat firm.	Same	5	VIs.
Cx	Chetek loamy sand, 12 to 18 percent slopes, moderately eroded.	12–18	Moderately steep.	Same	Excessive	Dark brown.	Variable	Reddish brown.	Somewhat firm.	Hay and pasture	11	VIIs.
Cw	Crown loamy sand	0– 2	Level to gently undulating.	Same	Imperfect to moderately good.	Very dark gray.	Friable	Dark grayish brown.	Friable	Corn, small grains, alfalfa, and pasture.	6	IIIs.
D	Dalbo silt loam, 2 to 7 percent slopes.	2– 7	Undulating	Calcareous lacustrine silts and clays.	Moderately good to good.	Grayish brown to light brownish gray.	Friable	Very dark grayish brown.	Plastic when wet.	Corn, small grains, alfalfa, clovers, and tame grasses.	1	IIe.
Dp	Dalbo silt loam, 7 to 12 percent slopes.	7–12	Rolling	Same	Good	Light brownish gray.	Friable	Dark brown	Same	Same	2	IIIe.
Dx	Dalbo silt loam, 12 to 18 percent slopes, moderately eroded.	12–18	Hilly	Same	Good	Brownish gray.	Slightly plastic when wet.	Dark brown	Plastic when wet.	Small grains, alfalfa, hay, and pasture.	10	IVe.
Df	Dalbo fine sandy loam, 2 to 12 percent slopes.	2–12	Undulating and rolling.	Same	Good	Light brownish gray.	Friable	Dark brown	Slightly plastic when wet.	Corn, small grains, alfalfa, clovers, and tame grasses.	1	IIIe.
E	Emmert loamy fine sand, 12 to 25 percent slopes.	12–25	Hilly and steep.	Mixed noncalcareous till, sand, and gravel.	Excessive	Light brown or pale brown.	Friable	Dark brown	Variable	Small grains, hay, and pasture.	11	VIIs.
Eh	Emmert loamy fine sand, 12 to 25 percent slopes, moderately eroded.	12–25	Same	Same	Excessive	Brown	Slightly plastic when wet.	Dark brown	Variable	Hay and pasture	11	VIIs.
Es	Emmert loamy fine sand, 18 to 25 percent slopes, severely eroded.	18–25	Same	Same	Excessive	Brown	Same	Dark brown	Variable	Limited grazing	11	VIIs.
F	Freer silt loam	0– 2	Nearly level	Noncalcareous glacial till.	Imperfect	Very dark gray.	Friable	Mottled dark brown to strong brown.	Plastic when wet.	Corn, small grains, hay, and pasture.	3	IIw.
X	Greenbush silt loam, 0 to 2 percent slopes.	0– 2	Nearly level	Silty material underlain by acid sand and gravel.	Moderately good.	Light brownish gray.	Friable	Dark yellowish brown to reddish brown.	Slightly plastic when wet.	Corn, small grains, hay, alfalfa, clovers, and pasture.	8	IIe.
Xu	Greenbush silt loam, 2 to 7 percent slopes.	2– 7	Undulating	Same	Moderately good to good.	Same	Friable	Reddish brown	Same	Same	8	IIe.

Supplement to the soil map—Isanti County, Minn.—Continued

Map symbol	Soils	Slope range	Topography	Parent material or substratum	Drainage	Surface soil		Subsoil		Principal present uses	Management group	Land capability class and subclass
						Color	Consistence	Color	Consistence			
		Percent										
B	Hayden silt loam, 2 to 7 percent slopes.	2–7	Nearly level to undulating.	Calcareous glacial till.	Same	Very dark gray.	Friable	Yellowish brown.	Same	Corn, small grains, alfalfa, tame grasses, and clovers.	1	IIe.
Bu	Hayden silt loam, 2 to 7 percent slopes, moderately eroded.	2–7	Undulating	Same	Same	Same	Slightly plastic when wet.	Same	Plastic when wet.	Same	1	IIe.
Bp	Hayden silt loam, 7 to 12 percent slopes.	7–12	Gently rolling and rolling.	Same	Good	Same	Friable	Same	Slightly plastic when wet.	Same	2	IIIe.
Bd	Hayden silt loam, 7 to 12 percent slopes, moderately eroded.	7–12	Same	Same	Good	Yellowish brown.	Slightly plastic when wet.	Same	Plastic when wet.	Same	2	IIIe.
Br	Hayden silt loam, 12 to 18 percent slopes.	12–18	Rolling and hilly.	Same	Good	Same	Same	Same	Same	Same	2	VIe.
Bx	Hayden silt loam, 12 to 18 percent slopes, moderately eroded.	12–18	Hilly and steep.	Same	Somewhat excessive.	Same	Same	Same	Same	Pasture	10	IVe.
T	Hayden fine sandy loam, 2 to 7 percent slopes.	2–7	Nearly level to undulating.	Same	Good	Dark gray	Friable	Same	Slightly plastic when wet.	Corn, small grains, alfalfa, clovers, and tame grasses.	1	IIe.
Tu	Hayden fine sandy loam, 2 to 7 percent slopes, moderately eroded.	2–7	Undulating	Same	Good	Light yellowish brown.	Friable	Same	Same	Same	1	IIe.
Tp	Hayden fine sandy loam, 7 to 12 percent slopes.	7–12	Gently rolling and rolling.	Same	Good	Same	Friable	Same	Same	Same	2	IIIe.
Td	Hayden fine sandy loam, 7 to 12 percent slopes, moderately eroded.	7–12	Same	Same	Good to somewhat excessive.	Yellowish brown.	Slightly plastic when wet.	Same	Plastic when wet.	Same	2	IIIe.
Tr	Hayden fine sandy loam, 12 to 18 percent slopes.	12–18	Rolling and hilly.	Same	Somewhat excessive.	Same	Same	Same	Same	Pasture	2	VIe.
Tx	Hayden fine sandy loam, 12 to 18 percent slopes, moderately eroded.	12–18	Same	Same	Good to somewhat excessive.	Light yellowish brown.	Same	Same	Same	Corn, small grains, alfalfa, clovers, and tame grasses.	10	VIIe.
H	Hubbard loamy fine sand, 0 to 2 percent slopes.	0–2	Nearly level	Calcareous sandy outwash.	Somewhat excessive.	Black to very dark brown.	Very friable.	Dark yellowish brown.	Friable	Corn, small grains, alfalfa, hay, and rye.	5	IVs.
Hu	Hubbard loamy fine sand, 2 to 7 percent slopes.	2–7	Gently sloping.	Same	Excessive	Same	Very friable.	Same	Friable	Same	5	IVs.
Hp	Hubbard loamy fine sand, 7 to 12 percent slopes.	7–12	Sloping	Same	Excessive	Same	Very friable.	Same	Friable	Same	5	VIIs.
Is	Isanti loamy fine sand	0–2	Nearly level or depressional.	Deep outwash sands	Poor	Very dark gray to black.	Friable	Mottled grayish brown.	Friable	Corn (silage), small grains, hay, and pasture.	7	IVw.
K	Kanabec very fine sandy loam, 2 to 7 percent slopes.	2–7	Undulating	Silty material overlying sand and gravel.	Moderately good.	Very dark gray to brown and pale brown.	Friable	Yellowish brown to strong brown.	Slightly plastic.	Corn, small grains, alfalfa, and hay.	8	IIe.
Kp	Kanabec very fine sandy loam, 7 to 12 percent slopes.	7–12	Gently rolling and rolling.	Same	Good	Same	Friable	Same	Same	Same	8	IIIe.

Supplement to the soil map—Isanti County, Minn.—Continued

Map symbol	Soils	Slope range	Topography	Parent material or substratum	Drainage	Surface soil		Subsoil		Principal present uses	Management group	Land capability class and subclass
						Color	Consistence	Color	Consistence			
		Percent										
L	Lino loamy fine sand	0–2	Nearly level to gently undulating.	Deep outwash sands	Imperfect to moderately good.	Very dark gray.	Loose	Mottled dark grayish brown.	Loose	Corn, soybeans, small grains, hay, and pasture.	6	IIIs.
M	Milaca silt loam, 2 to 7 percent slopes.	2–7	Undulating	Noncalcareous glacial till.	Good	Dark gray	Friable	Reddish brown.	Slightly plastic when wet.	Corn, small grains, alfalfa, hay, and potatoes.	1	IIe.
Mp	Milaca silt loam, 7 to 12 percent slopes.	7–12	Gently rolling.	Same	Good	Dark gray	Friable	Reddish brown.	Same	Same	2½	IIIe.
Mx	Milaca silt loam, 12 to 18 percent slopes, moderately eroded.	12–18	Rolling	Same	Good to somewhat excessive.	Brown	Slightly plastic when wet.	Reddish brown.	Same	Hay and pasture	10	IVe.
Mf	Milaca fine sandy loam, 2 to 7 percent slopes.	2–7	Undulating	Noncalcareous glacial till.	Good	Dark gray	Friable	Reddish brown.	Same	Corn, small grains, alfalfa, hay, and potatoes.	1	IIIe.
Mn	Milaca fine sandy loam, 7 to 12 percent slopes.	7–12	Gently rolling and rolling.	Same	Good	Dark gray	Friable	Reddish brown.	Same	Same	2	IIIe.
Md	Milaca fine sandy loam, 7 to 12 percent slopes, moderately eroded.	7–12	Undulating and rolling.	Same	Good to somewhat excessive.	Light brown.	Slightly plastic when wet.	Reddish brown.	Same	Same	2	IIIe.
Mr	Milaca fine sandy loam, 12 to 18 percent slopes.	12–18	Hilly	Same	Somewhat excessive.	Light brown.	Friable	Reddish brown.	Same	Small grains, hay, and pasture.	10	IVe.
Ms	Milaca fine sandy loam, 12 to 25 percent slopes, severely eroded.	12–25	Hilly and steep.	Same	Excessive	Light reddish brown.	Slightly plastic when wet.	Reddish brown.	Same	Pasture	10	VIIe.
ON	Onamia fine sandy loam, 2 to 12 percent slopes.	2–12	Undulating and rolling.	Stratified noncalcareous sand and gravel.	Good	Dark gray	Friable	Reddish brown.	Same	Corn, small grains, alfalfa, and hay.	8	IIIe.
P	Peat, deep	0–2	Nearly level	Undecomposed organic matter.	Very poor	Black to dark brown.	Friable	Black to dark grayish brown.	Slightly plastic.	Potatoes, truck crops, hay, and pasture.	13	IIIw.
Pc	Peat, moderately shallow over loam.	0–2	Nearly level	Undecomposed organic matter over loams.	Very poor	Dark brown to black.	Friable (fibrous).	Dark brown	Variable	Corn, potatoes, hay, truck crops, and pasture	13	IIIw.
Ps	Peat, moderately shallow over sand.	0–2	Nearly level	Undecomposed organic matter over sands.	Very poor	Same	Friable (fibrous).	Dark brown	Variable	Same	13	VIw.
ZL	Rough broken land, Zimmerman material.	19+	Strongly sloping to steep.	Sandy colluvial material.	Excessive	Grayish brown.	Loose	Yellowish brown.	Loose	Limited grazing and forest.	14	VIIs.
R	Rum River loam	0–2	Nearly level	Silty alluvium underlain by sands.	Imperfect to poor.	Black to very dark brown.	Slightly plastic when wet.	Very dark gray.	Plastic when wet.	Corn, small grains, soybeans, potatoes, hay, and pasture.	12	IIw.
S	Scandia fine sandy loam, 2 to 7 percent slopes.	2–7	Undulating	Mixed noncalcareous till, sand, and gravel.	Somewhat excessive.	Dark gray	Friable	Reddish brown.	Friable	Corn, small grains, hay, and pasture.	2	IIIe.
Sp	Scandia fine sandy loam, 7 to 18 percent slopes.	7–18	Rolling and hilly.	Same	Excessive	Light brown.	Friable	Reddish brown.	Friable	Small grains, hay, and pasture.	11	VIe.
Sd	Scandia fine sandy loam, 7 to 12 percent slopes, moderately eroded.	7–12	Rolling	Same	Excessive	Yellowish brown.	Slightly plastic when wet.	Reddish brown.	Slightly plastic when wet.	Hay and pasture	10	VIe.
Ss	Scandia fine sandy loam, 12 to 25 percent slopes, severely eroded.	12–25	Hilly and steep.	Same	Excessive	Yellowish brown.	Same	Reddish brown.	Same	Pasture and forest	11	VIIe.
J	Scandia gravelly sandy loam, 2 to 7 percent slopes.	2–7	Undulating	Mixed noncalcareous till, sand, gravel, and cobblestones.	Somewhat excessive.	Dark grayish brown.	Friable	Reddish brown.	Friable	Corn, small grains, hay, and pasture.	2	IVe.

Supplement to the soil map—Isanti County, Minn.—Continued

Map symbol	Soils	Slope range	Topography	Parent material or substratum	Drainage	Surface soil		Subsoil		Principal present uses	Management group	Land capability class and subclass
						Color	Consistence	Color	Consistence			
		Percent										
Jp	Scandia gravelly sandy loam, 7 to 18 percent slopes.	7–18	Rolling and hilly.	Same	Excessive	Same	Friable	Reddish brown.	Friable	Small grains, hay, and pasture.	11	VIe.
Jd	Scandia gravelly sandy loam, 7 to 12 percent slopes, moderately eroded.	7–12	Rolling	Same	Excessive	Yellowish brown.	Slightly plastic when wet.	Reddish brown.	Friable	Same	11	VIe.
Js	Scandia gravelly sandy loam, 12 to 25 percent slopes, severely eroded.	12–25	Hilly and steep.	Same	Excessive	Dark yellowish brown.	Same	Reddish brown.	Friable	Pasture and forest	11	VIIe.
W	Warman sandy loam and loam.	0– 2	Nearly level	Stratified noncalcareous sand and gravel.	Poor	Very dark brown to black.	Same	Dark gray	Plastic when wet.	Corn for silage, small grains, hay, and pasture.	7	IVw.
Z	Zimmerman loamy fine sand and fine sand, 0 to 2 percent slopes.	0– 2	Nearly level	Deep outwash sands	Somewhat excessive.	Brown to grayish brown.	Loose	Yellowish brown.	Loose	Corn, rye, small grains, potatoes, and hay.	5	IVs.
Zu	Zimmerman loamy fine sand and fine sand, 2 to 7 percent slopes.	2– 7	Gently sloping.	Deep outwash sands	Excessive	Same	Loose	Same	Loose	Same	5	IVs.
Zp	Zimmerman loamy fine sand and fine sand, 7 to 12 percent slopes.	7–12	Sloping	Deep outwash sands	Excessive	Same	Loose	Same	Loose	Same	11	VIIs.
Zr	Zimmerman loamy fine sand and fine sand, 12 to 18 percent slopes.	12–18	Moderately steep.	Deep outwash sands	Excessive	Same	Loose	Same	Loose	Small grains and hay	11	VIIs.
Zf	Zimmerman fine sand, 0 to 2 percent slopes.	0– 2	Nearly level	Deep outwash fine sands.	Somewhat excessive.	Grayish brown.	Loose	Same	Loose	Corn, rye, small grains, hay, and potatoes.	5	IVs.
Zg	Zimmerman fine sand, 2 to 7 percent slopes.	2– 7	Gently sloping.	Deep outwash fine sands.	Excessive	Same	Loose	Same	Loose	Same	5	IVs.
Zv	Zimmerman fine sand, 2 to 7 percent slopes, moderately eroded.	2– 7	Gently sloping.	Deep outwash fine sands.	Excessive	Same	Loose	Same	Loose	Pasture and forest	11	VIIs.
Zn	Zimmerman fine sand, 7 to 12 percent slopes.	7–12	Sloping	Deep outwash fine sands.	Excessive	Same	Loose	Same	Loose	Pasture and forest	11	VIIs.
Zd	Zimmerman fine sand, 7 to 12 percent slopes, moderately eroded.	7–12	Sloping	Deep outwash fine sands.	Excessive	Light yellowish brown.	Loose	Same	Loose	Pasture and forest	11	VIIs.
Zs	Zimmerman fine sand, 7 to 12 percent slopes, severely eroded.	7–12	Sloping	Deep outwash fine sands.	Excessive	Same	Loose	Same	Loose	Pasture and forest	11	VIIs.
Zh	Zimmerman fine sand, 12 to 18 percent slopes.	12–18	Moderately steep.	Deep outwash sands	Excessive	Same	Loose	Same	Loose	Pasture and forest	11	VIIs.
Zx	Zimmerman fine sand, 12 to 18 percent slopes, moderately eroded.	12–18	Same	Deep outwash sands	Excessive	Same	Loose	Same	Loose	Pasture and forest	11	VIIs.

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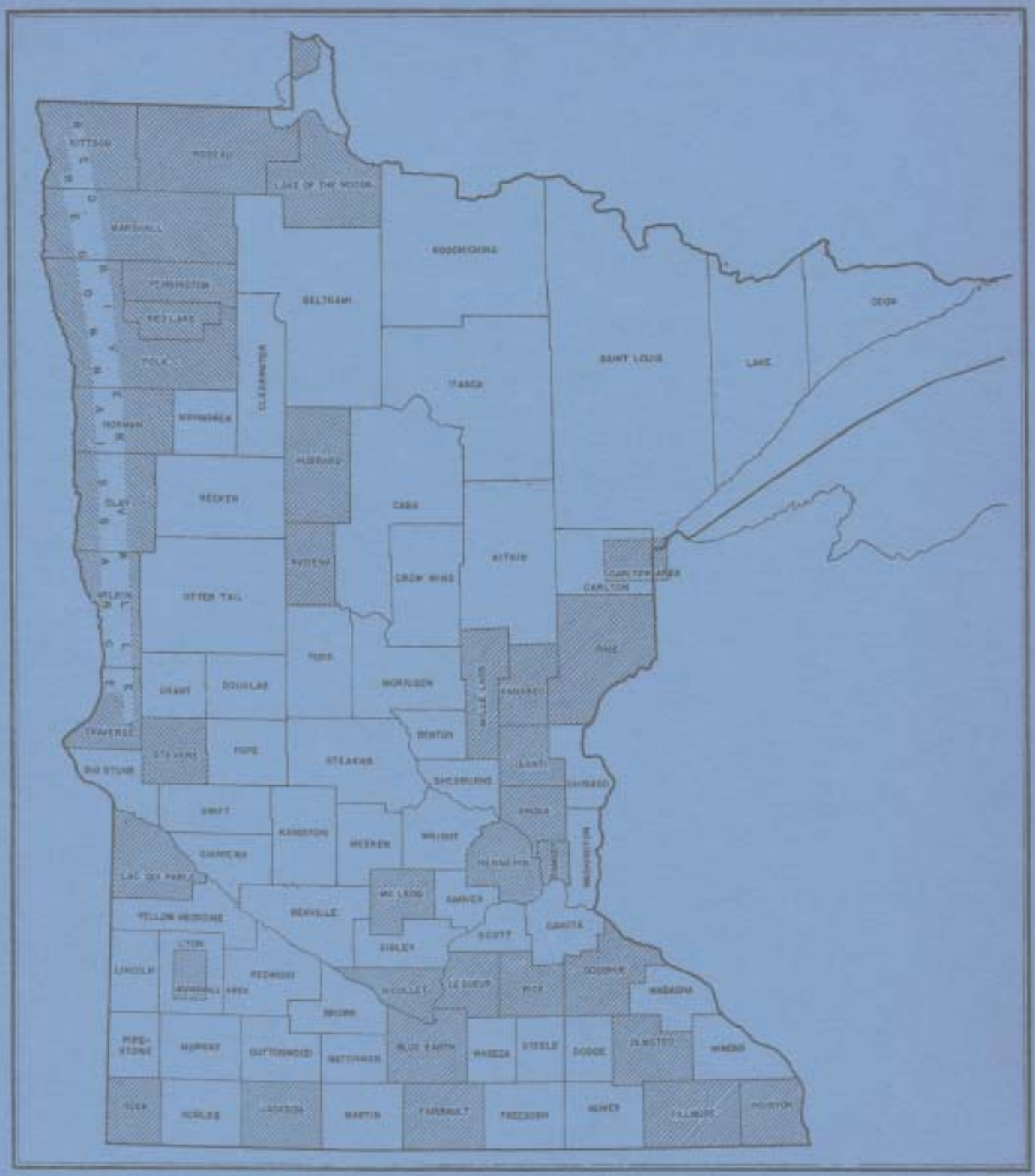

Areas surveyed in Minnesota shown by shading. Detailed and semidetailed surveys shown by northeast-southwest hatching; reconnaissance surveys shown by northwest-southeast hatching.

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