SOIL SURVEY OF

Anoka County, Minnesota

United States Department of Agriculture
Soil Conservation Service
In cooperation with
University of Minnesota
Agricultural Experiment Station

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UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA AGRICULTURAL EXPERIMENT STATION

ANOKA COUNTY is in the east-central part of Minnesota (fig. 1). It has a total land area of 272,000 acres, or 422 square miles. Anoka is the county seat.

Although this is the soil survey of Anoka County, a large acreage, approximately 10,000 acres, in the southern part, namely, the cities of Columbia Heights and Fridley, a small part of Coon Rapids, and the Village of Spring Lake Park, was excluded from this survey. The reworking of the soil during urban construction made it impractical to classify the soils. Onsite investigation is needed to determine soil characteristics in these urban areas.

Since 1950, the suburban communities in the Twin City metropolitan area have expanded rapidly and farming has declined. In 1972, only about 30 percent of the land was farmed; 20 percent was cropped to corn, soybeans, and small grain.

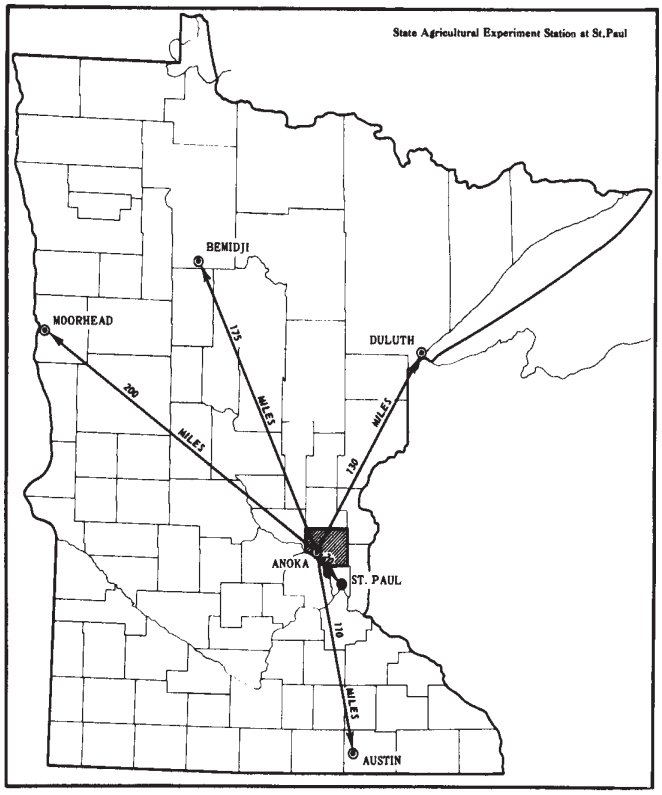

Figure 1.—Location of Anoka County in Minnesota.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Anoka County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not. They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The *soil series* and the *soil phase* are the categories of soil classification most used in a local survey.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Isanti and Lino, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface

layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Anoka loamy fine sand, 0 to 2 percent slopes, is one of several phases within the Anoka series.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some kind that are within an area which is dominantly of one recognized soil phase.

Some mapping units are made up of several soils of different series, or of different phases within one series. One such kind of mapping unit is shown on the soil map of Anoka County as a soil complex.

A soil complex is made up of areas of two or more soils, so intricately mixed or so small in size that it is not practical to show them separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. Generally, the name of a soil complex is the name of the dominant soil. Heyder complex, 4 to 12 percent slopes, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, so severely eroded, or so variable that it has not been classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names such as Cut and fill land.

While a soil survey is in progress, soil scientists take soil samples needed for laboratory measurements and for engineering tests. Laboratory data from the same kinds of soil in other places are also assembled. Data on yields of crops under defined practices are assembled from farm records and from field or plot experiments on the same kinds of soil. Yields under defined management are estimated for all the soils.

Soil scientists observe how soils behave when used as a growing place for native and cultivated plants, and as material for structures, foundations for structures, or covering for structures. They relate this behavior to properties of the soils. For example, they observe that filter fields for onsite disposal of sewage fail on a given kind of soil, and they relate this to the slow permeability of the soil or its high water table. They see that streets, road pavements, and foundations for houses are cracked on a named kind of soil, and they relate this failure to the high shrink-swell potential of the soil material. Thus, they use observation and knowledge of soil properties, together with available research data, to predict limitations or suitability of soils for present and potential uses.

After data have been collected and tested for the key, or benchmark, soils in a survey area, the soil scientists set up trial groups of soils. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others. They then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under current methods of use and management.

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Anoka County. A soil association is a landscape that has a distinctive proportional pattern of soils. It normally consists of one or more major soils and at least one minor soil, and it is named for the major soils. The soils in one association may occur in another, but in a different pattern.

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure. This is because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The six soil associations in Anoka County are described on the following pages.

1. *Hubbard-Nymore association*

Nearly level to gently sloping, excessively drained soils that are sandy throughout

This soil association is mainly a nearly level to gently sloping outwash plain that is dissected by drainageways and pitted by large depressions. Steeper slopes occur next to these larger depressions and drainageways.

This association (fig. 2) makes up about 15 percent of the county. It is about 40 percent Hubbard soils, 35 percent Nymore soils, and 25 percent soils of minor extent.

Hubbard soils have a black and very dark grayish-brown coarse sandy surface layer about 20 inches thick. The subsoil is dark-brown and yellowish-brown coarse sand. The underlying material at a depth of about 44 inches is pale-brown gravelly coarse sand.

Nymore soils typically have a surface layer of very dark gray and black to very dark grayish-brown loamy sand about 2 to 8 inches thick. The subsoil is dark-brown loamy sand. The underlying material at a depth of about 26 inches is yellowish-brown sand.

Of minor extent in this association are Becker, Duelm, Isan, Meehan, and Rifle soils.

The bottom land along the Mississippi and Rum Rivers is occupied by Becker soils. Large drainage-

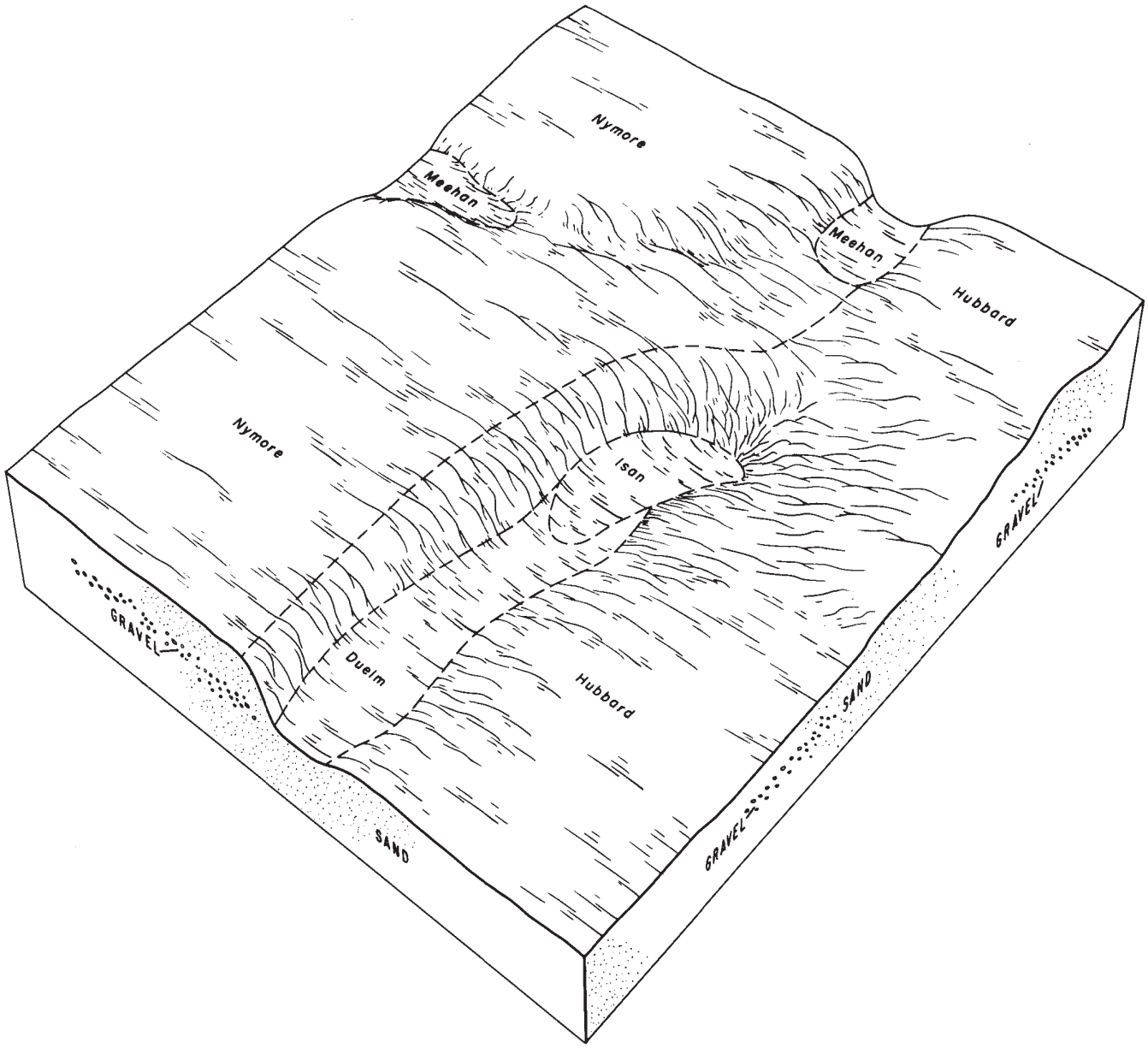

***Figure 2.*—Typical pattern of soils in Hubbard-Nymore association.**

ways and depressions are occupied by Rifle soils. Smaller depressions and drainageways are occupied by Isan soils. Low-lying nearly level areas and narrow rims around larger wet depressions are occupied by Duelm or Meehan soils.

This association is well suited to most urban uses and is moderately well suited to farming and to recreational uses. Fertility and available water capacity are low. The chief management needs are controlling soil blowing, improving fertility, and controlling the level of the water table in low-lying areas.

Much of this association is under urban development. Small areas are cultivated. At a few locations, potatoes are grown under irrigation. Poorly drained areas are used for permanent pasture, recreation, and wildlife.

2. *Zimmerman-Isanti-Lino association*

Nearly level to undulating, excessively drained, somewhat poorly drained, and very poorly drained soils that are dominated by fine sands throughout

This soil association is mainly a broad undulating sand plain. The naturally occurring high water table is at or near the surface in most depressed areas. Steeper slopes occur next to drainageways and large depressions.

This soil association (fig. 3) makes up about 50 per-

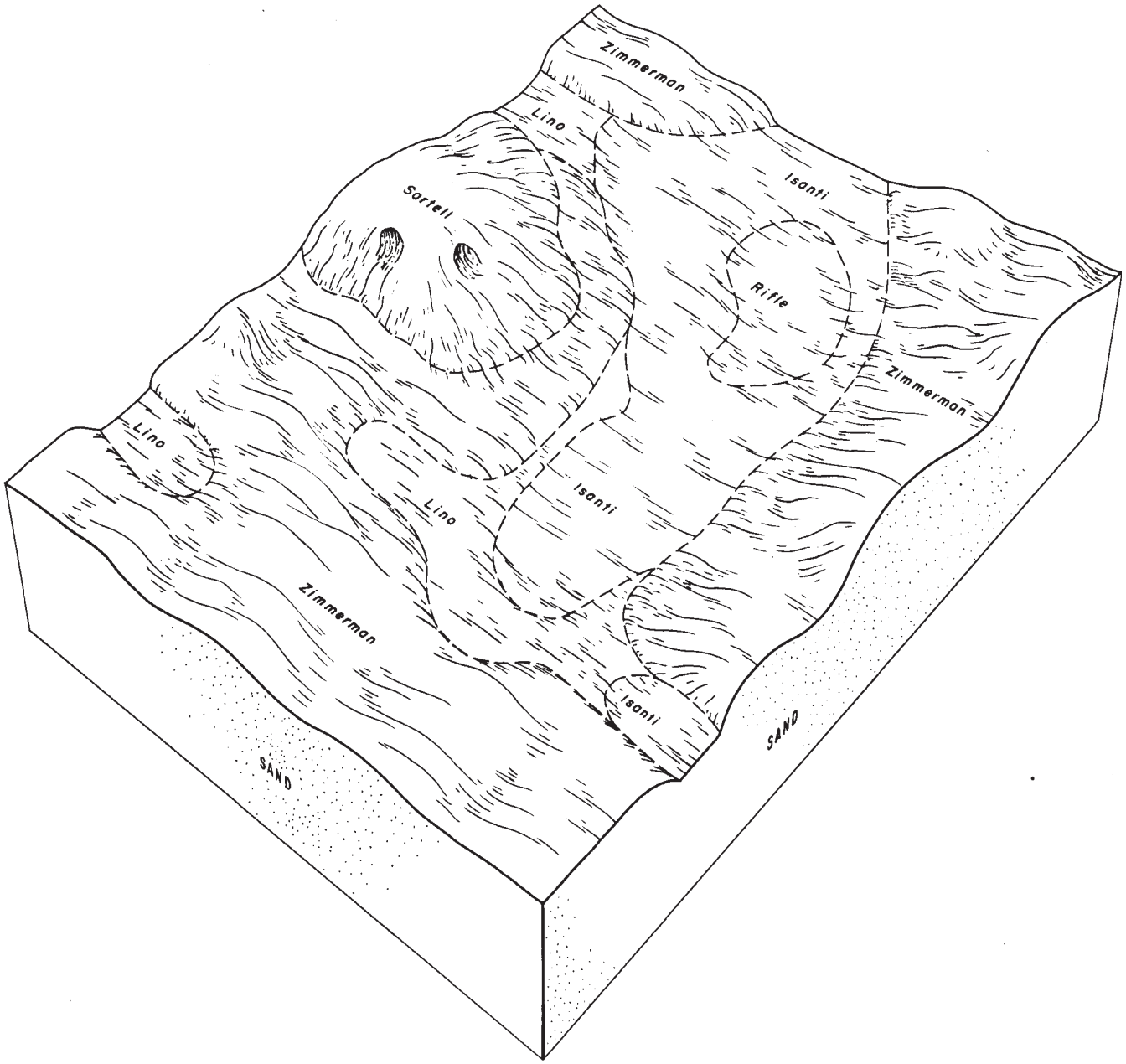

Figure 3.—**Typical pattern of soils in Zimmerman-Isanti-Lino association.**

cent of the county. It is about 45 percent Zimmerman soils, 15 percent Isanti soils, 10 percent Lino soils, and 30 percent soils of minor extent.

The excessively drained Zimmerman soils are in broad undulating areas and on narrow escarpments. The surface layer is very dark gray and dark-brown fine sand about 2 to 10 inches thick. The subsoil is yellowish-brown and light yellowish-brown fine sand. The underlying material at a depth of about 28 inches is very pale brown fine sand.

The very poorly drained Isanti soils are in depressions and on low-lying flats. The surface layer is typically black fine sandy loam about 10 inches thick. The subsoil is gray and dark-gray fine sand. The underlying material at a depth of about 31 inches is light brownish-gray fine sand.

The somewhat poorly drained Lino soils are on small flats, in small depressions, and on small concave rises. The surface layer is black, dark-gray, or dark grayish-brown loamy fine sand about 2 to 8 inches thick. The subsoil is mottled brown and light brownish-gray fine sand. The underlying material at a depth of about 45 inches is pale-brown fine sand.

Of minor extent in this association are Anoka, Markey, Rifle, and Sartell soils.

Undulating to rolling dune-shaped landscapes are

occupied by Sartell soils. Nearly level to sloping sand areas where loamy bands occur in the subsoil are occupied by Anoka soils. Small to large bogs and bog areas adjacent to lakes and small streams are occupied by Markey and Rifle soils.

Much of this association is well suited to urban development. In some areas, however, a high water table severely limits many uses. The association is moderately well suited to farming and provides sites for recreational facilities. Fertility and available water capacity are low. Main concerns of management are controlling soil blowing, improving fertility, and controlling the level of the water table in low-lying areas.

Much of this association is used for urban development, and additional areas are being urbanized every year. Small acreages are used as rural residences. Some areas are farmed. Corn, soybeans, and alfalfa are the crops commonly grown. Many former fields are planted to coniferous trees which are harvested as Christmas trees. Truck crops and cultural sod are grown on the organic soils. Additional areas provide wildlife habitat and sites for recreational facilities.

3. *Heyder-Kingsley-Hayden association*

Gently undulating to steep, well-drained soils formed in loamy glacial till

This soil association is a gently undulating to steep morainic landscape of short irregular slopes, scattered small lakes, and scattered depressions of organic soils.

This association (fig. 4) makes up 10 percent of the county. It is about 40 percent Heyder soils, 20 percent Kingsley soils, 10 percent Hayden soils, and 30 percent soils of minor extent.

Heyder soils are on hill crests and hillsides. The surface layer is typically very dark grayish-brown fine sandy loam about 3 to 8 inches thick. The subsurface layer, which is not evident in some cultivated fields, is grayish-brown fine sandy loam 3 to 15 inches thick. The subsoil is dark yellowish-brown and yellowish-brown sandy loam and fine sandy loam. The underlying material at a depth of about 53 inches is light olive-brown sandy loam.

Kingsley soils, also on hill crests and hillsides, typically have a surface layer of very dark gray fine sandy loam about 3 to 8 inches thick. The subsurface layer, a pale-brown fine sandy loam 5 to 10 inches thick, does not always occur in cultivated fields. The subsoil is dark reddish-brown and reddish-brown sandy clay loam and fine sandy loam. The underlying material at a depth of about 34 inches is firm, dark reddish-brown sandy loam.

Hayden soils on hills and hillsides typically have a surface layer of very dark gray fine sandy loam about 3 to 8 inches thick. The subsurface layer is grayish-brown fine sandy loam 4 to 10 inches thick. The subsoil is dark-brown and dark yellowish-brown loam and sandy clay loam. The underlying material at a depth of about 37 inches is light olive-brown fine sandy loam or loam.

Of minor extent in this association are Blomford, Dalbo, Growton, Kratka, Nowen, and Rifle soils.

Large drainageways and low-lying areas in the larger drainageways are occupied by Rifle soils. Broad, very poorly drained flats are occupied by Kratka soils. Poorly drained small depressions and small drainageways in the uplands are occupied by Blomford or Nowen soils. Broad, nearly level upland areas are occupied by Growton soils. Small flats in the upland are occupied by Dalbo soils.

Much of this association is well suited to urban development. In some areas, however, drainage severely limits many uses. The association is well suited to farming and provides recreational facilities. Fertility and available water capacity are medium to high. Main concerns of management are controlling water erosion and the level of the water table in low-lying areas.

Much of this association is farmed. A few steep areas and undrained wet areas are used for recreation and wildlife. Crops commonly grown are corn, soybeans, and alfalfa. Small acreages are used as rural residences. The urban trend is increasing.

4. *Emmert-Kingsley association*

Gently undulating to steep, excessively drained and well drained soils formed in loamy and sandy glacial drift

This soil association is a gently undulating to steep morainic landscape of short irregular slopes and scattered small marshes and depressions of organic soils.

This association (fig. 5) makes up 3 percent of the county. It is about 45 percent Emmert soils, 30 percent Kingsley soils, and 25 percent soils of minor extent.

Emmert soils are on irregularly shaped knolls and hills. They typically have a surface layer of very dark gray gravelly coarse sandy loam about 2 to 4 inches thick. The subsoil is dark-brown gravelly coarse sand. The underlying material at a depth of about 23 inches is brown to very pale brown coarse sand or gravelly coarse sand.

Kingsley soils are on hill crests and hillsides. They typically have a surface layer of very dark gray fine sandy loam about 3 to 8 inches thick. The subsurface layer, a pale-brown fine sandy loam 5 to 10 inches thick, does not always occur in cultivated fields. The subsoil is dark reddish-brown and reddish-brown sandy clay loam and fine sandy loam. The underlying material at a depth of about 34 inches is firm, dark reddish-brown sandy loam.

Of minor extent in this association are Chetek, Marsh, Mora, Ronneby, and Rifle soils.

Chetek soils are on the short irregular sides and the tops of hills. Mora soils are on low-lying knolls and in small drainageways. Ronneby soils are on small flats and in small depressions. Marsh and Rifle soils commonly are in large depressions.

Much of this association is moderately well suited to urban uses and is moderately well suited to poorly suited to farming and to recreational uses. The small areas that are poorly drained are severely limited. Fertility and available water capacity range from very low to high. The chief management needs are controlling water erosion and controlling the level of the water table in low-lying areas.

A large part of this association is an ordnance proving ground. Only a small part is farmed because the soils are steep and droughty. Commonly grown crops

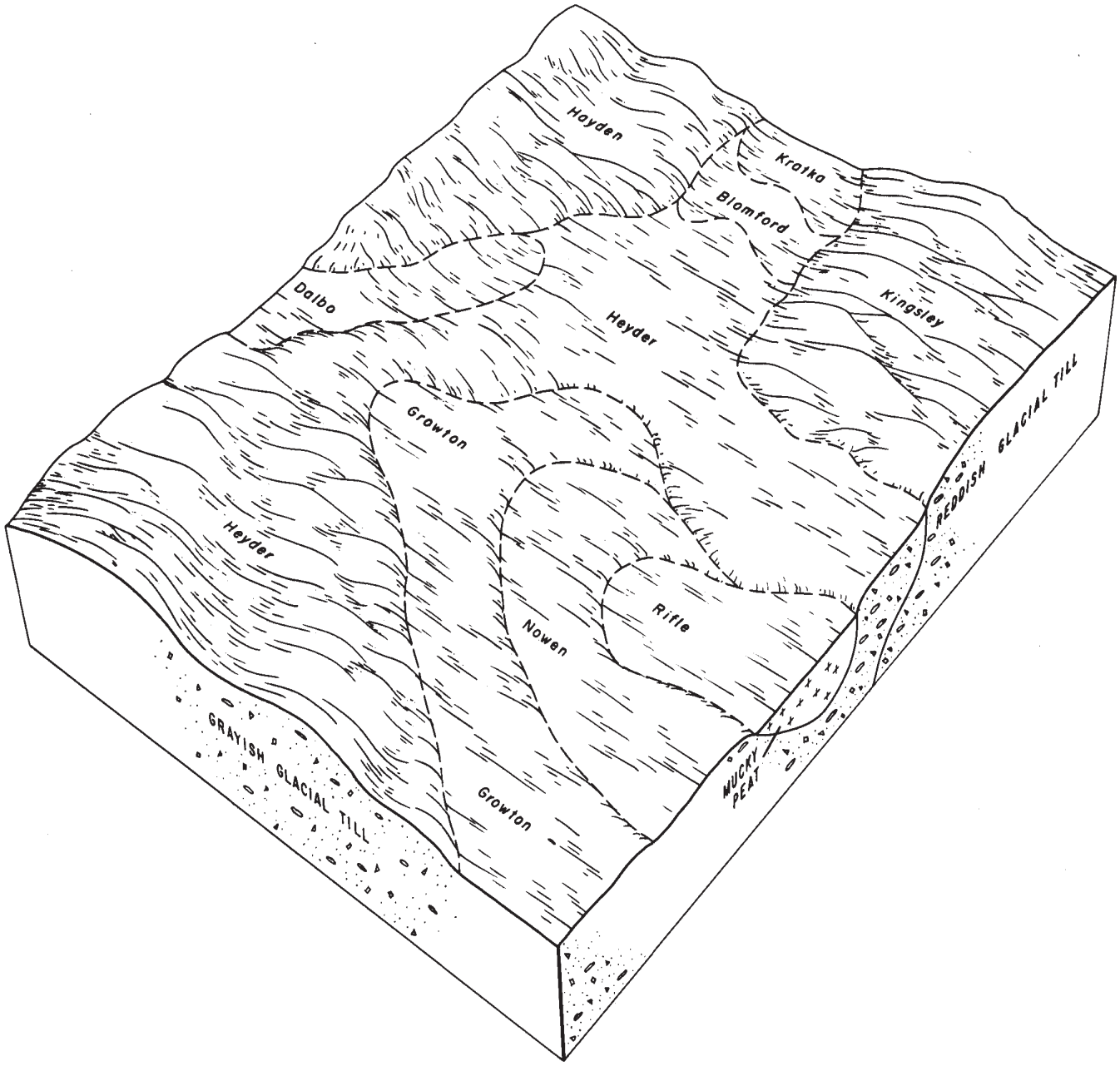

Figure 4.—**Typical pattern of soils in Heyder-Kingsley-Hayden association.**

are alfalfa, corn silage, and oats. Few areas are used for recreation and wildlife. Small acreages are rural residences. The urban trend is increasing.

5. Nessel-Dundas-Webster association

Nearly level to gently sloping, moderately well drained and poorly drained soils formed in loamy glacial till

This neary level to gently sloping soil association is a series of undulating ground moraines. Steeper slopes are adjacent to large bogs and drainageways. All slopes are short.

This soil association (fig. 6) makes up about 5 percent of the county. It is about 35 percent Nessel soils, 15 percent Dundas soils, 15 percent Webster soils, and 35 percent soils of minor extent.

Nessel soils are nearly level to gently sloping and moderately well drained. They typically have a surface layer of very dark grayish-brown fine sandy loam about 2 to 9 inches thick. The subsurface layer is grayish-brown fine sandy loam 7 to 14 inches thick. The subsoil is mottled yellowish-brown, brown, and light olive-brown fine sandy loam and sandy clay loam. The underlying material at a depth of about 40 inches is light olive-brown, calcareous fine sandy loam.

Dundas soils are nearly level and poorly drained.

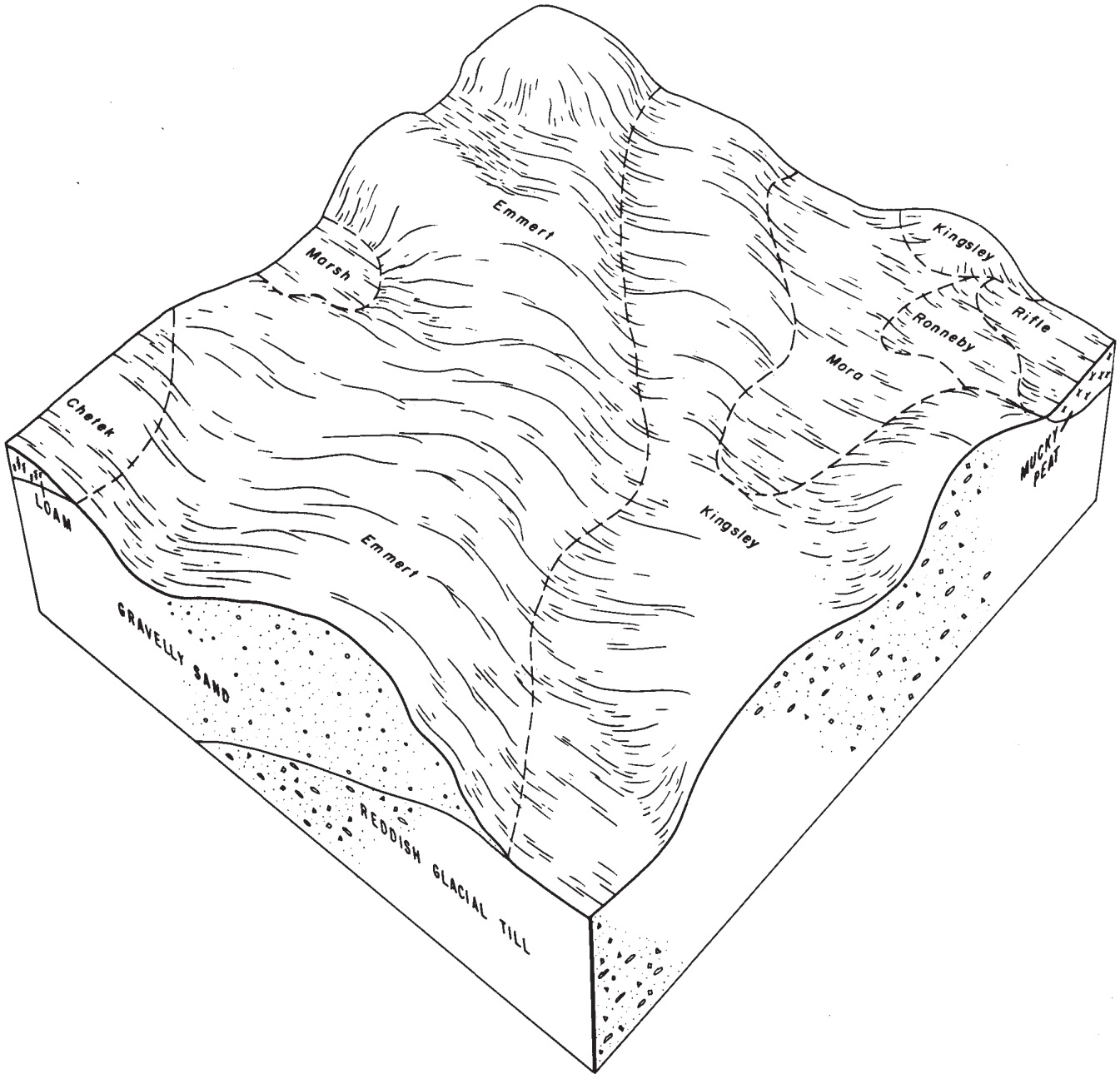

Figure 5.—**Typical pattern of soils in Emmert-Kingsley association.**

They typically have a surface layer of black loam about 4 to 10 inches thick. The subsurface layer is mottled gray fine sandy loam 5 to 12 inches thick. The subsoil is mottled dark-gray to light olive-gray sandy clay loam. The underlying material at a depth of about 39 inches is mottled gray, calcareous fine sandy loam.

Webster soils are nearly level to slightly depressional and are poorly drained. The surface layer is black loam about 12 to 16 inches thick. The subsoil is mottled gray and light olive-gray sandy clay loam. The underlying material at a depth of about 23 inches is mottled gray and light olive-gray, calcareous fine sandy loam.

Of minor extent in this association are Blomford, Braham, Cathro, Glencoe, Kratka, and Rifle soils.

Large depressions and low-lying areas are occupied by Rifle soils. Smaller depressions are occupied by Cathro soils. Some small depressions and rims around some of the larger depressions are occupied by Glencoe or Kratka soils. The nearly level sand-capped areas are Blomford soils. The gently sloping to sloping sand capped areas are Braham soils.

Much of this association is moderately to poorly suited to most urban uses. It is well suited to farming and provides sites for recreational facilities. Fertility is high, and the available water capacity is very high.

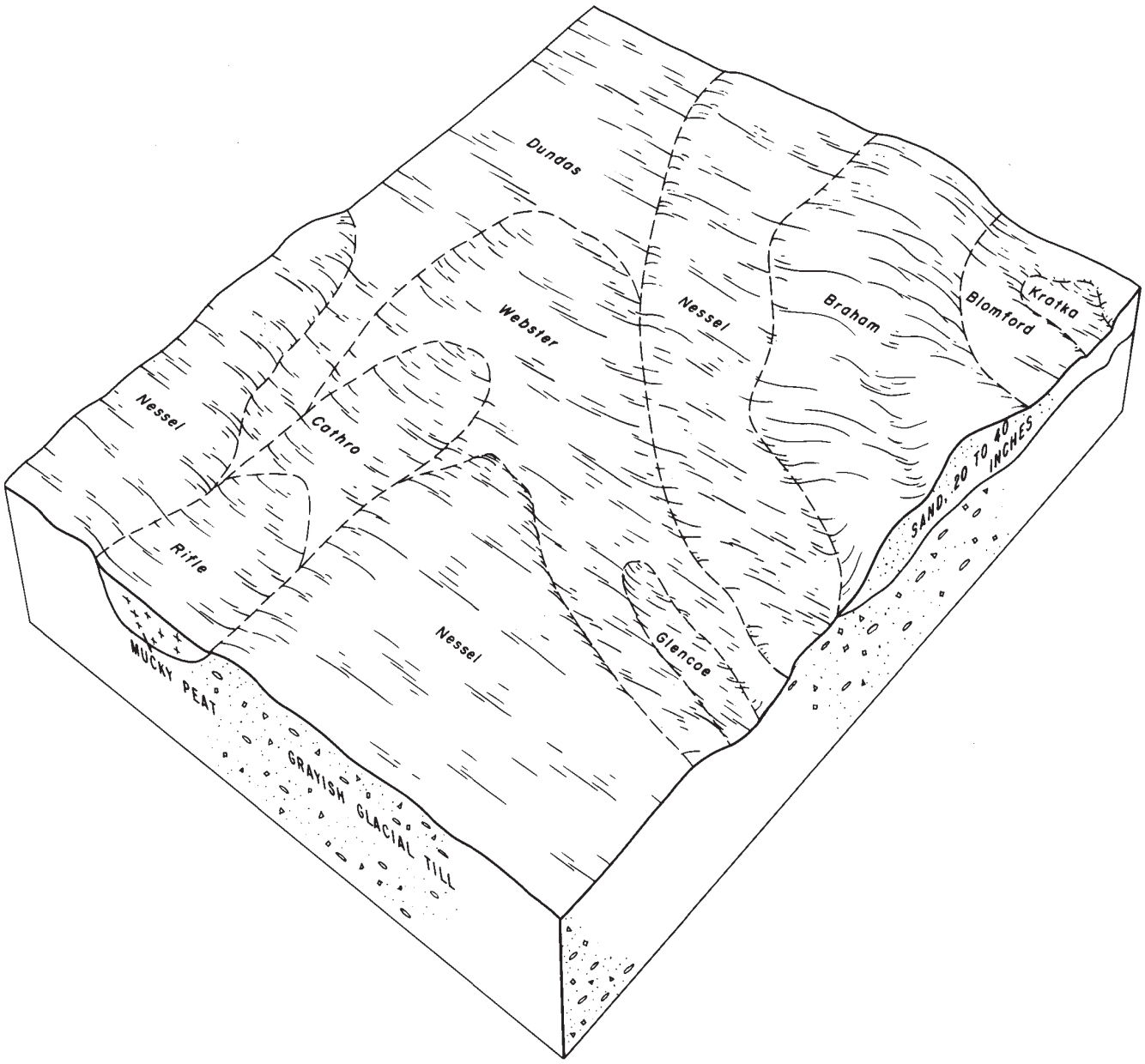

Figure 6.—**Typical pattern of soils in Nessel-Dundas-Webster association.**

The chief management needs are controlling the level of the water table in low-lying areas, controlling erosion in the more sloping areas, and maintaining fertility.

About half the association is farmed. Commonly grown crops are corn, soybeans, and alfalfa. Some undrained wet areas are used for recreation and wildlife. The increasing urban trend is expected to continue.

6. *Rifle-Isanti association*

Nearly level, very poorly drained soils formed in organic material and fine sand

This soil association is a series of large level bogs dominated by organic soils and small sandy islandlike features that rise several feet above the general level of the surrounding bogs. The natural water table is high.

This association (fig. 7) makes up about 17 percent of the county. It is about 60 percent Rifle soils, 20 percent Isanti soils, and 20 percent soils of minor extent.

Rifle soils occur in large bogs and are very poorly drained. They have a surface layer of very dark brown mucky peat about 8 inches thick. The next layer and the underlying material are dark yellowish-brown and very dark grayish-brown mucky peat.

Isanti soils occur as slight rises and narrow rims around islandlike features and are very poorly drained. They have a surface layer typically of black loamy fine

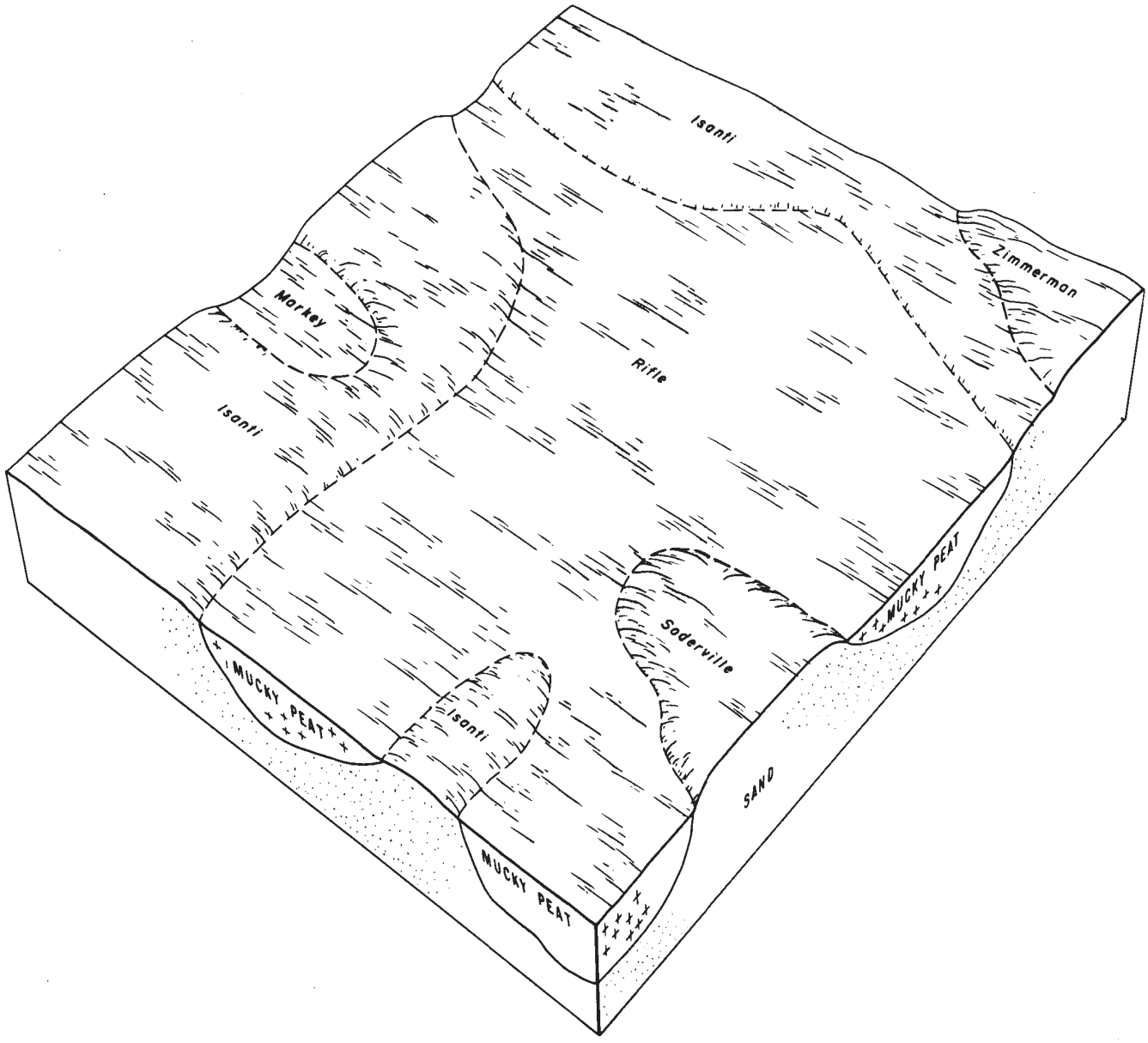

Figure 7.—**Typical pattern of soils in Rifle-Isanti association.**

sand or fine sandy loam about 10 inches thick. The subsoil is gray and dark-gray fine sand. The underlying material to a depth of about 31 inches is light brownish-gray fine sand.

Of minor extent in this association are Markey, Soderville, and Zimmerman soils.

Organic soil areas, moderately deep to sandy materials, are occupied by Markey soils. Intermediate lying sandy areas are occupied by Soderville soils. Higher, excessively drained sandy areas are occupied by Zimmerman soils.

Most of this association is poorly suited to urban, farm, and recreational uses. Natural fertility is moderate to low. Available water capacity is low to very high. The chief management needs are controlling the level of the water table and improving and maintaining fertility.

A large part of this association is a game refuge. Small parts are farmed and urbanized. If drained, the organic soils are suited to specialty crops. The largest acreage is in cultured sod. Smaller acreages are in carrots, potatoes, and radishes.

Urban development is limited to the better drained areas. Special precautions are needed against conditions created by the high water table.

Descriptions of the Soils

This section describes the soil series and mapping

units in Anoka County. Each soil series is described in detail, and then, briefly, each mapping unit in that series. Unless it is specifically mentioned otherwise, it is to be assumed that what is stated about the soil series holds true for the mapping units in that series. Thus, to get full information about any one mapping unit, it is necessary to read both the description of the mapping unit and the description of the soil series to which it belongs.

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of soils. Color terms are for moist soil unless otherwise stated. The profile described in the series is representative for the mapping units in that series. If the profile of a given mapping unit differs from the one described for the series, these differences are stated in describing the mapping unit, or they are differences that are apparent in the name of the mapping unit.

As mentioned in the section "How This Survey Was Made," not all mapping units are members of a soil series. Loamy wet land, for example, does not belong to a soil series, but nevertheless, is listed in alphabetic order along with the soil series.

The names, descriptions, and delineations of soil in this published soil survey do not always agree or join fully with soil maps of adjoining counties published at an earlier date. Differences are brought about by better knowledge about soils or modification and refinements in soil series concepts. In addition, the correlation of a recognized soil is based upon the acreage of that soil and the dissimilarity to adjacent soils within the survey area. Frequently, it is more feasible to include soils, small in extent, with similar soils, where management and response is much the same.

Preceding the name of each mapping unit is a symbol. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the community development group, the capability unit, and the woodland group to which the mapping unit has been assigned. The page for the description of each capability unit, woodland group, or other interpretative group can be found by referring to the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary at the end of this survey, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*6*).[1]

Alluvial Land

Af—Alluvial land, mixed, frequently flooded. This land is nearly level and very poorly drained to somewhat poorly drained. It formed in mixed alluvial material that varies in texture and color. It occurs along the streams and rivers and commonly is dissected by old channels and oxbows. Thus, it appears corrugated.

The texture of the surface layer is sandy or loamy or mucky peat. Commonly, the surface is mantled with recently deposited fine sands. The underlying material is variable and can be in strata of sands, loams, or organic soil material.

Permeability varies, and available water capacity is moderate to high. Natural fertility is medium. Flooding is frequent in spring, occurring for periods of 2 days to 2 weeks. The floodwater commonly is 1 to 4 feet deep. The hazard of flooding and the poor drainage make this land very poorly suited to most uses. Community development group 8; capability unit VIw–1; woodland group 5w1.

Anoka Series

The Anoka series consists of nearly level to sloping, somewhat excessively drained soils formed in outwash sands. These are nearly level to undulating soils on broad outwash plains. The native vegetation was mainly mixed oak forest.

In a representative profile the surface layer is dark grayish-brown loamy fine sand about 8 inches thick. The subsurface layer is dark-brown and brown, loose loamy fine sand and fine sand about 21 inches thick. The subsoil is brown and dark-brown, friable, weakly cemented very fine sandy loam about 31 inches thick. The underlying material is dark-brown, yellowish-brown, and pale-brown fine sand.

Permeability is moderately rapid, and the available water capacity is moderate. The organic-matter content is low. The supply of available nitrogen is low, phosphorus medium, and potassium low.

Most areas of Anoka soils are used for crops, to which they are moderately well suited. The major limitations are the moderate available water capacity and the resulting hazards of droughtiness and soil blowing.

Representative profile of Anoka loamy fine sand, 2 to 6 percent slopes, in a pasture 1,140 feet north and 30 feet west of the southeast corner of sec. 34, T. 33 N., R. 24 W.

Ap—0 to 8 inches, dark grayish-brown (10YR 4/2) loamy fine sand; weak, medium, granular structure; very friable; strongly acid; abrupt, smooth boundary.

A21—8 to 18 inches, dark-brown (10YR 4/3) loamy fine sand; massive in place, parting to single grained; loose; medium acid; clear, wavy boundary.

A22—18 to 29 inches, brown (10YR 5/3) fine sand; massive in place, parting to single grained; loose; medium acid; abrupt, smooth boundary.

B21t—29 to 45 inches, brown (7.5YR 5/4) very fine sandy loam; a few masses of light brownish-gray (10YR 6/2) bleached sand grains; weak, thick, platy structure parting to weak, fine, subangular blocky; friable; few, patchy, strong-brown (7.5YR 5/8) clay films on faces of peds; strongly acid; clear, smooth boundary.

B22t—45 to 60 inches, dark-brown (7.5YR 4/4) very fine sandy loam; a few masses of light brownish-gray (10YR 6/2) bleached sand grains; weak, thick, platy structure; friable; hard when dry; medium acid; abrupt, smooth boundary.

C1—60 to 70 inches, dark-brown (7.5YR 4/4) and yellowish-brown (10YR 5/4) fine sand; massive breaking to weak, thick, platy pieces; friable; hard when dry; medium acid; abrupt, smooth boundary.

C2—70 to 80 inches, pale-brown (10YR 6/3) fine sand; single grained; loose; slightly acid.

[1] Italic numbers in parentheses refer to Literature Cited, p. 90.

TABLE 1.—*Approximate acreage and proportionate extent of the soils*

Soil	Acres	Percent	Soil	Acres	Percent
Alluvial land, mixed, frequently flooded	1,145	0.4	Isanti fine sandy loam	30,610	11.6
Anoka loamy fine sand, 0 to 2 percent slopes	480	.2	Kingsley fine sandy loam, 2 to 6 percent slopes	1,865	.7
Anoka loamy fine sand, 2 to 6 percent slopes	1,255	.5	Kingsley fine sandy loam, 6 to 12 percent slopes, eroded	3,800	1.5
Anoka loamy fine sand, 6 to 12 percent slopes	505	.2	Kingsley fine sandy loam, 12 to 18 percent slopes	1,470	.7
Becker very fine sandy loam	695	.3	Kingsley fine sandy loam, 18 to 30 percent slopes	575	.2
Blomford loamy fine sand	1,610	.6	Kratka loamy fine sand	1,280	.5
Braham loamy fine sand, 2 to 6 percent slopes	1,740	.7	Lake beaches	450	.2
Braham loamy fine sand, 6 to 18 percent slopes	400	.2	Langola loamy sand, 0 to 6 percent slopes	435	.2
Brickton silt loam	450	.2	Lino loamy fine sand, 0 to 4 percent slopes	13,230	5.1
Cathro muck	1,245	.5	Loamy wet land	2,195	.8
Chetek sandy loam, 2 to 6 percent slopes	330	.1	Lupton muck	305	.1
Chetek sandy loam, 6 to 12 percent slopes	225	.1	Markey muck	5,320	2.0
Cut and fill land	1,205	.5	Marsh	5,620	2.2
Dalbo silt loam, 1 to 5 percent slopes	605	.2	Meehan sand	1,090	.4
Dickman sandy loam, 0 to 2 percent slopes	535	.2	Millerville mucky peat	1,050	.4
Dickman sandy loam, 2 to 6 percent slopes	250	.1	Mora fine sandy loam, 1 to 4 percent slopes	1,000	.4
Duelm loamy coarse sand	1,075	.4	Nessell fine sandy loam, 1 to 4 percent slopes	4,680	1.8
Dundas loam	2,000	.8	Nowen sandy loam	1,345	.5
Emmert gravelly coarse sandy loam, 6 to 12 percent slopes	885	.3	Nymore loamy coarse sand, 12 to 25 percent slopes	540	.2
Emmert gravelly coarse sandy loam, 12 to 25 percent slopes	1,245	.5	Nymore loamy sand, 0 to 2 percent slopes	3,840	1.5
Emmert complex, 4 to 12 percent slopes	280	.1	Nymore loamy sand, 2 to 6 percent slopes	10,410	4.0
Emmert complex, 12 to 25 percent slopes	1,250	.5	Nymore loamy sand, 6 to 12 percent slopes	2,260	.8
Glencoe loam	250	.1	Rifle mucky peat	29,505	11.3
Growton fine sandy loam, 1 to 4 percent slopes	1,770	.7	Rifle muck, woody	720	.2
Hayden fine sandy loam, 2 to 6 percent slopes	1,060	.4	Rifle soils, ponded	2,100	.8
Hayden fine sandy loam, 6 to 12 percent slopes, eroded	1,655	.6	Rondeau muck	230	.1
Hayden fine sandy loam, 12 to 24 percent slopes	755	.3	Ronneby fine sandy loam	510	.2
Heyder fine sandy loam, 2 to 6 percent slopes	3,580	1.4	Sartell fine sand, 2 to 6 percent slopes	1,835	.7
Heyder fine sandy loam, 6 to 12 percent slopes, eroded	3,740	1.4	Sartell fine sand, 6 to 12 percent slopes	2,645	1.0
Heyder fine sandy loam, 12 to 18 percent slopes	1,745	.7	Sartell fine sand, 6 to 12 percent slopes, eroded	890	.3
Heyder fine sandy loam, 18 to 30 percent slopes	635	.2	Sartell fine sand, 12 to 24 percent slopes, eroded	970	.3
Heyder complex, 4 to 12 percent slopes	655	.3	Seelyeville muck	1,290	.5
Heyder complex, 12 to 25 percent slopes	745	.3	Soderville fine sand, 0 to 4 percent slopes	1,900	.7
Hubbard coarse sand, 0 to 2 percent slopes	5,240	2.0	Webster loam	2,260	.8
Hubbard coarse sand, 2 to 6 percent slopes	9,970	3.8	Zimmerman fine sand, 0 to 2 percent slopes	3,970	1.5
Hubbard coarse sand, 6 to 12 percent slopes	1,265	.5	Zimmerman fine sand, 2 to 6 percent slopes	46,250	17.6
Isan sandy loam	505	.2	Zimmerman fine sand, 6 to 12 percent slopes	9,540	3.6
			Zimmerman fine sand, 12 to 24 percent slopes	2,210	.8
			Gravel pits	35	(1)
			Water	8,870	3.3
			Total	262,080	100.0

[1] Less than 0.05 percent.

The thickness of the solum commonly is 50 to 80 inches. The Ap horizon is dark grayish brown, very dark grayish brown, or dark brown and is 6 to 9 inches thick. It typically is loamy fine sand, but in places is loamy very fine sand and fine sand. The A2 horizon is dark-brown, brown, or yellowish-brown loamy fine sand, loamy very fine sand, fine sand, or very fine sand in the upper part and fine sand or very fine sand in the lower part. It is 18 to 26 inches thick.

The B21t horizon is brown, dark-brown, or dark yellowish brown fine sandy loam, very fine sandy loam, or loamy very fine sand. The Bt horizon occurs as a single horizon or as a multiple horizon 6 inches or more thick. It commonly begins at depths of 20 to 40 inches. Patchy strong-brown coatings and bleached sand coatings occur in the lower part of the A22 horizon or in the B21t horizon. The clay content is 3 percent or more than that in the horizons above or below.

The C horizon is dark brown, yellowish brown, pale brown, or brown.

Reaction is strongly acid to medium acid in the A and B horizons and medium acid to neutral in the C horizon.

Anoka soils are associated with Zimmerman soils from which they differ in having a Bt horizon more than 6 inches thick.

AnA—Anoka loamy fine sand, 0 to 2 percent slopes. This nearly level soil is in broad outwash areas 5 to 30 acres in size. Included in some mapped areas are slight depressions where the surface layer is thicker and darker colored than this Anoka soil and areas of soils that contain thin strata of medium and coarse sands. Also included are small areas of Soderville and Zimmerman soils.

The chief limitations to the use and management of this soil for farming are the moderate available water

capacity and the resulting hazards of soil blowing and droughtiness.

Most areas are cropped. The soil is moderately well suited to corn, soybeans, and alfalfa and is well suited to pasture and woodland and to urban development. Community development group 1; capability unit IIIs–2; woodland group 3s1.

AnB—Anoka loamy fine sand, 2 to 6 percent slopes. This gently undulating soil occupies broad outwash areas 10 to 40 acres in size. It has the profile described as representative of the series. Included in mapping are small areas where soil blowing has removed most of the original surface layer and the present surface layer is lighter colored. Also included are small areas of Zimmerman soils.

The chief limitations to the use and management of this soil for farming are the moderate available water capacity and the resulting hazards of soil blowing and droughtiness.

Most areas are cropped. Some are used for urban development. The soil is moderately well suited to corn, soybeans, and alfalfa and is well suited to pasture and woodland. Community development group 1; capability unit IIIs–2; woodland group 3s1.

AnC—Anoka loamy fine sand, 6 to 12 percent slopes. This sloping soil is on the sand plains. Areas are 3 to 20 acres in size. Slopes are short and irregular.

Included with this soil in mapping are areas where soil blowing and water erosion have removed most of the original surface layer and the present surface layer is lighter colored. Also included are small areas of Zimmerman soils.

The hazards of erosion and soil blowing, the moderate available water capacity, and the resulting hazard of droughtiness are limitations for both farm and urban use.

Most areas are used for crops, to which the soil is poorly suited. Other areas are used for pasture, woodland, and urban development. Community development group 1; capability unit IVe–2; woodland group 3s1.

Becker Series

The Becker series consists of nearly level, moderately well drained to well drained soils formed in loamy sediment underlain by sand. These corrugated, nearly level to gently undulating soils are on bottom land. The native vegetation was deciduous forest and a grassy understory.

In a representative profile the surface layer is very dark brown, black, and very dark grayish-brown very fine sandy loam about 27 inches thick. The subsoil is dark-brown and dark yellowish-brown, friable very fine sandy loam about 9 inches thick. The IIB3 horizon is dark yellowish-brown, very friable loamy fine sand about 8 inches thick. The underlying material is mottled yellowish-brown loose coarse sand.

Permeability is moderately rapid, and the available water capacity is moderate. The organic-matter content is high. The supply of available nitrogen is high, phosphorus medium, and potassium medium. This soil is occasionally flooded for short periods.

Most areas of Becker soils are cropped or wooded. A few areas are under urban development. The major limitation is the hazard of flooding.

Representative profile of Becker very fine sandy loam, 0 to 3 percent slopes, in a cultivated field, 1,520 feet south and 1,300 feet west of the center of sec. 29, T. 32 N., R. 25 W.

Ap—0 to 9 inches, very dark brown (10Y 2/2) very fine sandy loam; weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A12—9 to 18 inches, black (10YR 2/1) very fine sandy loam; weak, very fine, and fine subangular blocky structure; friable; neutral; clear, smooth boundary.

A3—18 to 27 inches, very dark grayish-brown (10Y 3/2) very fine sandy loam; weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

B21—27 to 32 inches, dark-brown (10YR 4/3) very fine sandy loam; moderate, medium, subangular blocky structure; friable; neutral, clear, smooth boundary.

B22—32 to 36 inches, dark yellowish-brown (10YR 4/4) very fine sandy loam; weak, medium, subangular blocky structure; friable; neutral; abrupt boundary.

IIB3—36 to 44 inches, dark yellowish-brown (10YR 4/4) loamy fine sand; weak, medium, subangular blocky structure; very friable; neutral; clear, wavy boundary.

IIC—44 to 60 inches, yellowish-brown (10YR 5/4) coarse sand; many medium, distinct, strong-brown (7.5YR 5/6) and yellowish-red (5YR 5/6) mottles; single grained; loose; neutral.

The thickness of the solum commonly is 30 to 48 inches.

The A horizon is black, very dark brown, or very dark grayish-brown very fine sandy loam or fine sandy loam. Typically, it is 24 to 36 inches thick.

The B2 horizon is very fine sandy loam, fine sandy loam, or sandy loam. The IIB3 horizon is the transitional horizon between the B2 horizon and the IIC horizon. It commonly is loamy fine sand or loamy very fine sand and is 12 inches thick or less.

The IIC horizon typically is distinctly mottled yellowish-brown, light yellowish-brown, or pale-brown coarse sand, sand, or fine sand. In places the IIC horizon is as much as 20 percent gravel and is not mottled.

Reaction in the profile is mostly slightly acid to neutral, but in places below a depth of 60 inches, it is mildly alkaline.

Becker soils are associated with Dickman and Hubbard soils. They differ from those soils in having thicker loamy sediment and a thicker A horizon.

Ba—Becker very fine sandy loam. This nearly level to gently undulating soil is on bottom land. Areas are 10 to 160 acres in size. They appear corrugated. Slopes are short, and the soil is thinner at the crests. Slopes are 0 to 3 percent.

Included in mapping are low-lying, poorly drained areas and small areas of Dickman and Hubbard soils.

Occasional flooding during periods of high water is the major hazard and limits the use and management of this soil for urban development and to a lesser degree for farming.

Most areas are used for crops, to which the soil is well suited. Corn and soybeans are the main crops. This soil is well suited to woodland and poorly suited to urban uses. Community development group 8; capability unit IIw–1; woodland group 2o3.

Blomford Series

The Blomford series consists of nearly level, somewhat poorly drained soils formed in a sandy mantle and the underlying loamy till or lacustrine materials. These soils are on level flats and in small, shallow depressions and drainageways in ground moraines. The

native vegetation was deciduous forest and some water-tolerant grasses.

In a representative profile the surface layer is very dark gray loamy fine sand about 9 inches thick. The subsurface layer is mottled grayish-brown fine sand about 11 inches thick. The upper 13 inches of the subsoil is mottled light brownish-gray, loose fine sand and loamy fine sand. The lower 9 inches is mottled grayish-brown, friable fine sandy loam. The underlying material is light brownish-gray fine sandy loam.

Permeability is rapid in the upper part of this soil and moderate in the lower part, and the available water capacity is moderate. The organic-matter content is low. The supply of available nitrogen is low, phosphorus medium, and potassium low.

Most areas of Blomford soils are for crops, to which they are moderately well suited. Other areas are pastured or wooded. The major limitation is the hazard of wetness.

Representative profile of Blomford loamy fine sand, in a cultivated field, 400 feet north and 90 feet east of the southwest corner of sec. 13, T. 31 N., R. 22 W.

Ap—0 to 9 inches, very dark gray (10YR 3/1) loamy fine sand; weak, fine, subangular blocky structure; very friable; medium acid; abrupt, smooth boundary.

A2—9 to 20 inches, grayish-brown (10YR 5/2) fine sand; few, medium, distinct, brown (10YR 5/3), yellowish-brown (10YR 5/6), and strong-brown (7.5YR 5/6) mottles; massive in place breaking to single grained; loose; strongly acid; clear, smooth boundary.

B1—20 to 28 inches, light brownish-gray (10YR 6/2) fine sand; common, coarse, distinct, strong-brown (7.5YR 5/8) and yellowish-red (5YR 5/6) mottles; massive in place breaking to single grained; loose; strongly acid; clear, smooth boundary.

B21—28 to 33 inches, light brownish-gray (10Y 6/2) loamy fine sand; many, coarse, distinct strong-brown (7.5YR 5/8) and yellowish-red (5YR 5/6) mottles; weak, thick, platy structure parting to weak, fine, subangular blocky; very friable; about 2 percent coarse fragments; strongly acid; clear, smooth boundary.

IIB22tg—33 to 42 inches, grayish-brown (2.5Y 5/2) fine sandy loam; common, medium, distinct, brown (10YR 5/3) and yellowish-brown (10YR 5/6) mottles; moderate, medium, subangular blocky structure; friable; few thin patchy clay films on faces of peds and in old root channels; about 5 percent coarse fragments; neutral; clear, smooth boundary.

IICg—42 to 60 inches, light brownish-gray (2.5Y 6/2) fine sandy loam; many, coarse, distinct, brownish-yellow (10YR 6/6) and strong-brown (7.5YR 5/8) mottles; massive; friable; about 6 percent coarse fragments; mildly alkaline; strongly effervescent.

The thickness of the solum commonly is 36 to 52 inches. The depth to loamy materials is 20 to 40 inches.

The Ap or A1 horizon is black, very dark gray, or very dark brown, and is loamy fine sand, loamy sand, sandy loam, or fine sandy loam. Undisturbed soils have A1 and A2 horizons.

The part of the B horizon in the sandy sediment is grayish brown or light brownish gray loamy fine sand, loamy sand, fine sand, or sand. The IIB2tg horizon is grayish brown or gray and contains many distinct mottles. It is fine sandy loam, sandy loam, or sandy clay loam. The thickness of the part of the B horizon in the sandy sediment is 10 to 25 inches and the IIB2tg horizon is 8 to 14 inches.

The IIC horizon is mottled light brownish gray, grayish brown, or gray fine sandy loam, loam, silt loam, or sandy clay loam.

The upper sandy mantle commonly lacks coarse fragments, and the lower loamy part is as much as 10 percent coarse fragments. Reaction is strongly acid to medium acid in the upper sandy horizons, medium acid to neutral in the IIB horizon, and neutral to moderately alkaline in the IIC horizon.

Blomford soils are associated with Braham and Kratka soils. They have grayer colors and more mottling in the B horizon than Braham soils. They have a thinner A1 horizon and are not so gray in the B horizon as Kratka soils.

Bm—Blomford loamy fine sand. This nearly level soil is on broad flats and in small drainageways. Areas are 5 to 60 acres in size. In undisturbed areas the profile is similar to the one described as representative of the series, but the surface layer is thinner. Included in mapping are areas of Nowen, Dundas and Lino soils.

The seasonal high water table and the resulting hazard of wetness limit this soil for both farm and urban use.

Most areas are cropped. Drainage is needed for crop production. If adequately drained, the soil is well suited to corn and soybeans. It is poorly suited to most urban uses. Community development group 5; capability unit IIIw–1; woodland group 3w1.

Braham Series

The Braham series consists of undulating to hilly, somewhat excessively drained soils formed in a sandy mantle and the underlying loamy till. These soils are on upland ground moraines. Slopes are short, irregular, and undulating. The native vegetation was primarily deciduous forest.

In a representative profile the surface layer is very dark grayish-brown loamy fine sand about 8 inches thick. The upper 16 inches of the subsoil is brown, very friable loamy fine sand. The lower 18 inches is dark yellowish-brown, firm and friable sandy clay loam. The underlying material is light olive-brown sandy clay loam (fig. 8).

Permeability is rapid in the upper part of this soil and moderate in the lower part, and the available water capacity is moderate. The organic-matter content is low. The supply of available nitrogen is low, phosphorus medium, and potassium low.

Most areas of Braham soils are used for crops and urban development. The chief limitations are the moderate available water capacity and the resulting hazards of erosion and droughtiness.

Representative profile of Braham loamy fine sand, 2 to 6 percent slopes, in a cultivated field, 200 feet south and 50 feet east of the northwest corner SW¼ sec. 27, T. 31 N., R. 22 W.

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) loamy fine sand; weak, very fine, subangular blocky structure; very friable; slightly acid; abrupt, smooth boundary.

B1—8 to 24 inches, brown (10YR 5/3) loamy fine sand; weak, fine, subangular blocky structure; very friable; slightly acid; abrupt, smooth boundary.

IIB21—24 to 29 inches, dark yellowish-brown (10YR 4/4) sandy clay loam; weak, medium, prismatic structure parting to moderate, medium, subangular blocky; firm; about 5 percent coarse fragments; few, 1- to 3-millimeter, dark-colored concretions; medium acid; clear, wavy boundary.

IIB22t—29 to 38 inches, dark yellowish-brown (10YR 4/4) sandy clay loam; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; firm; few, thin, dark-brown (10YR 4/3) clay films on vertical faces of peds; about

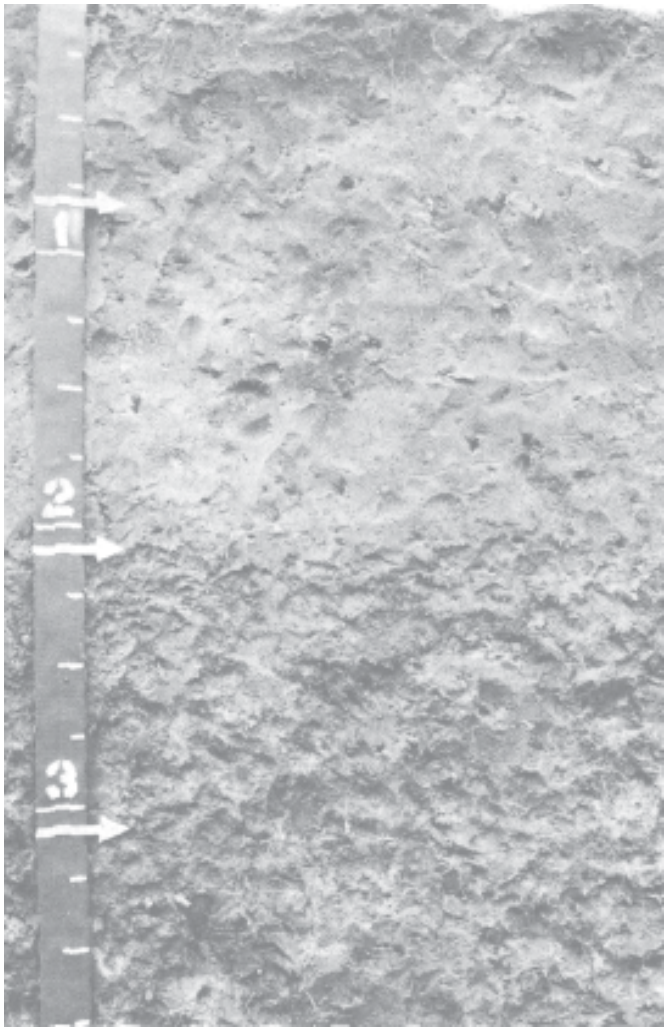

Figure 8.—**Profile of Braham loamy fine sand showing sandy upper layers over loamy glacial till.**

5 percent coarse fragments; medium acid; clear, wavy boundary.

IIB3t—38 to 42 inches, dark yellowish-brown (10YR 4/4) sandy clay loam; few, fine, faint light brownish-gray (10YR 6/2) and brownish-yellow (10YR 6/6) mottles; massive; friable; very few, thin, dark-brown (10YR 3/3) clay films on vertical fractures and in root channels; about 5 percent coarse fragments; few, soft, 1- to 3-millimeter, dark-colored masses; slightly acid; clear, wavy boundary.

IIC—42 to 60 inches, light olive-brown (2.5Y 5/4) sandy clay loam; massive; friable; about 5 percent coarse fragments; few, soft, 1- to 3-millimeter, dark-colored masses; few masses of lime in the form of threads along faces of fractures; mildly alkaline; strongly effervescent.

The thickness of the solum commonly is 40 to 50 inches. The depth to loamy material typically is 20 to 40 inches.

The Ap horizon is dark grayish brown, very dark grayish brown, or brown. In undisturbed areas the soil has an A1 horizon that is 2 to 4 inches thick and is black or very dark gray. In places it has an A2 horizon as much as 6 inches thick. The A horizon typically is loamy fine sand, but ranges to fine sand, sand, and loamy sand.

The B1 horizon is dark yellowish-brown, yellowish-brown, yellowish-brown or brown loamy fine sand, loamy sand, fine sand, or sand. The IIB2 horizon is dark yellowish brown or brown. In places it is mottled in the lower part. Typically it is sandy clay loam, sandy loam, fine sandy loam, or loam. In some places clay films are lacking.

The IIC horizon is light olive-brown, yellowish-brown, or dark yellowish-brown loam, fine sandy loam, sandy clay loam, or silt loam.

Reaction in the A and B horizons is commonly slightly acid, but ranges from medium acid to neutral. The IIB horizon is strongly acid to neutral. The IIC horizon is neutral or mildly alkaline. Typically the upper sandy mantles have no coarse fragments and the IIB and C horizons are as much as 10 percent coarse fragments.

Braham soils are associated with Blomford and Kratka soils and are similar to Zimmerman soils. They are better drained than Blomford and Kratka soils and have brighter colors in the B horizon. They are loamy in the lower part of the B horizon and in the C horizon, unlike Zimmerman soils, which are sandy in those horizons.

BtB—Braham loamy fine sand, 2 to 6 percent slopes. This gently undulating soil is in low convex areas that are 10 to 160 acres in size. It has the profile described as representative of the series.

Included with this soil in mapping are small areas of Hayden and Zimmerman soils. Also included are small drainageways and depressions of Blomford and Kratka soils.

The chief limitations to the use and management of this soil are the moderate available water capacity and the resulting hazards of droughtiness and erosion by water and wind.

Most areas are used for crops and urban development. This soil is moderately well suited to crops and well suited to woodland and urban development. Some areas are still wooded. Community development group 2; capability unit IIIs–2; woodland group 2o2.

BtC—Braham loamy fine sand, 6 to 18 percent slopes. This gently rolling to hilly soil is on crests and hillsides. Areas are 5 to 30 acres in size. Slopes are short and irregular.

Included with this soil in mapping are areas that have lighter surface colors. Also included and identified on the soil map by spot symbols are small depressions of Blomford and Kratka soils. In some places there are also small areas of Hayden and Zimmerman soils.

The chief limitation for both farm and urban use is the hazard of erosion. Steep slopes are also a limitation.

Most areas are used for crops and urban development, to which the soil is poorly suited. This soil is better suited to pasture, woodland, and recreation. Community development group 2; capability unit IVe–2; woodland group 2o2.

Brickton Series

The Brickton series consists of nearly level, poorly drained soils formed in lacustrine sediments. These soils are on flats and in slightly concave depressions of glacial lake plains. The native vegetation was deciduous forest.

In a representative profile the surface layer is very dark gray silt loam about 7 inches thick. The subsurface layer is dark-gray silt loam about 2 inches thick. The subsoil is mottled light brownish-gray and grayish-brown, firm silty clay and silty clay loam about

31 inches thick. The underlying material is mottled light olive-brown silt loam.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is low. The supply of available nitrogen is medium, phosphorus medium, and potassium medium.

Most areas of Brickton soils are cropped and pastured. Some are still wooded. The major limitation is the hazard of wetness.

Representative profile of Brickton silt loam, in a cultivated field, 1,120 feet west and 1,280 feet north of the southeast corner of sec. 2, T. 32 N., R. 25 W.

Ap—0 to 7 inches, very dark gray (10YR 3/1) silt loam; moderate, fine, subangular blocky structure; friable; slightly acid; abrupt, smooth boundary.

A2—7 to 9 inches, dark gray (10YR 4/1) silt loam; moderate, thin, platy structure; friable; many vesicular pores; medium acid; abrupt, wavy boundary.

B21tg—9 to 24 inches, grayish-brown (10YR 5/2) silty clay; many, fine, faint gray (10YR 5/1) and yellowish-brown (10YR 5/6) mottles; strong, fine, angular blocky structure; firm; thin, continuous clay films on vertical ped faces and patchy clay films on horizontal faces; medium acid; clear, smooth boundary.

B22tg—24 to 31 inches, light brownish-gray (10YR 6/2) silty clay; many, medium, faint, yellowish-brown (10YR 5/8) and brown (10YR 5/3) mottles; moderate, medium, prismatic structure parting to strong, medium, subangular blocky; firm; thin, patchy clay films on vertical ped faces and in root channels; medium acid; gradual, smooth boundary.

B3tg—31 to 40 inches, light brownish-gray (2.5Y 6/2) silty clay loam; common, medium, distinct, brownish-yellow (10YR 6/8), yellowish-brown (10YR 5/4), and light-gray (10YR 7/2) mottles; moderate, medium, prismatic structure parting to weak, fine, platy; firm; few, thin clay films on vertical fracture faces and in root channels; mildly alkaline; slightly effervescent; gradual, smooth boundary.

C—40 to 60 inches, light olive-brown (2.5Y 5/4) silt loam; common, medium, faint light-gray (10YR 7/2) and brownish-yellow (10YR 6/8) mottles; massive breaking to weak, thick, platy structure; friable; some limy masses in the form of threads on horizontal fracture faces; moderately alkaline; strongly effervescent.

The thickness of the solum ranges from 28 to 42 inches. The Ap horizon is black, very dark gray, or very dark brown. A black or very dark gray A1 horizon 2 to 5 inches thick occurs in undisturbed areas. The A2 horizon is dark gray or gray and in places is mottled. The A horizon is silt loam, loam or fine sandy loam. The A2 horizon is lacking in cultivated areas.

The B horizon is 19 to 35 inches thick. It is silty clay or clay in the upper part and silty clay or silty clay loam in the lower part. The clay content ranges from 35 to 60 percent.

The C horizon is light olive brown, grayish brown or yellowish brown and has faint to prominent mottles. It is silt loam, silty clay loam, or silty clay, and commonly contains strata of very fine sandy loam and silt loam.

The A horizon is slightly acid to medium acid. The B2 horizon is medium acid to strongly acid, and the B3 horizon is slightly acid to mildly alkaline. In most places some soft to hard limy masses are in this horizon.

Brickton soils are associated with Dalbo soils and are similar to Dundas soils. They have a grayer and more mottled B horizon than Dalbo soils. They contain less sand and more clay than Dundas soils.

Bx—Brickton silt loam. This nearly level soil is in slightly concave depressions in low-lying flats. Areas are of small acreage. In undisturbed areas the surface layer is thinner than is typical.

Included with this soil in mapping are very poorly drained soils that have a grayer subsoil and underlying material than is described in the representative profile. Also included are small areas of Dalbo soils and areas where the soil is underlain by sand at a depth of 50 to 70 inches.

The moderately slow permeability and high seasonal water table and the resulting hazard of wetness are limitations for both farm and urban use.

Most areas are cropped. Drainage is needed for crop production. If well managed, the soil is suited to corn and soybeans. It is poorly suited to most urban uses. Community development group 5; capability unit IIIw–2; woodland group 3w1.

Cathro Series

The Cathro series consists of nearly level, very poorly drained soils formed in shallow deposits of organic soil material over loamy glacial materials. These soils are in bogs in the glacial till plains. The native vegetation was mostly herbaceous plants, sedges, grasses, and reeds and some birch, elm, and willow.

In a representative profile the surface layer is black muck about 9 inches thick. Below this is black or very dark brown muck or dark brown mucky peat. The underlying material is black in the upper part and greenish gray below. It is mucky silt loam and silt loam.

Permeability is moderately slow, and the available water capacity is very high. The organic-matter content is very high. The supply of available nitrogen is high, phosphorus low, and potassium low. The water table is at or near the surface unless these soils are drained.

Most areas of Cathro soils are used for crops, to which the soils are moderately well suited. The major limitations are the hazards of wetness, ponding, and unseasonable frost.

Representative profile of Cathro muck, in a cultivated field, 1,360 feet north and 90 feet east of the southwest corner NW¼ sec. 34, T. 34 N., R. 2 W.

Oap—0 to 9 inches, black (10YR 2/1 broken face and rubbed) sapric material; about 10 percent fiber unrubbed, all fiber destroyed on rubbing; weak, medium, subangular blocky structure; very friable; herbaceous fiber; about 20 percent mineral material; slightly acid; abrupt, smooth boundary.

Oa1—9 to 21 inches, very dark brown (10YR 2/2 broken face) and black (10YR 2/1 broken face) sapric material; black (10YR 2/1 rubbed); about 40 percent fiber unrubbed, about 10 percent rubbed; massive; very friable; herbaceous fiber; about 15 percent mineral material; slightly acid; abrupt, smooth boundary.

Oa2—21 to 26 inches, black (10YR 2/1 broken face and rubbed) sapric material; about 15 percent fiber unrubbed, less than 5 percent rubbed; massive; very friable; herbaceous fiber; about 10 percent mineral material; slightly acid; abrupt, smooth boundary.

Oe—26 to 31 inches, dark-brown (7.5YR 3/2 broken face) hemic material; black (10YR 2/1 rubbed); about 60 percent fiber unrubbed, about 20 percent rubbed; weak, medium, platy structure; friable; herbaceous fiber; about 10 percent mineral material; neutral; abrupt, smooth boundary.

IIA11b—31 to 40 inches, black (10YR 2/1) mucky silt loam; massive; friable, slightly sticky; common coarse sand grains, some plant fiber and seeds; neutral; clear, smooth boundary.

IIA12b—40 to 46 inches, black (10YR 2/1) silt loam; many, medium, faint, dark yellowish-brown (10YR 4/4) and dark-gray (10YR 4/1) mottles; massive; friable, slightly sticky; neutral; clear, smooth boundary.

IICg—46 to 60 inches, greenish-gray (5BG 6/1) silt loam; massive; friable, slightly sticky; neutral.

The thickness of the organic soil material is 16 to 51 inches. In places there are hemic layers as much as 10 inches thick. The content of mineral material in the organic soil layers ranges from 10 to 40 percent. Reaction in the organic layers range from medium acid to neutral.

The IIAb horizon typically is black, very dark brown, or very dark gray mucky slit loam, but ranges to sandy loam, loam, and silty clay loam. This horizon typically is 4 to 18 inches thick; it does not occur in some soils.

The IIC horizon is gray, dark-gray or greenish-gray sandy loam to clay loam. Reaction in the IIC horizon commonly is neutral, but ranges from slightly acid to mildly alkaline.

Cathro soils are associated with Rifle and Seelyeville soils and are similar to Markey soils. They have loamy material at a depth of less than 51 inches, whereas Markey soils have sandy material to a depth of less than 51 inches. Rifle and Seelyeville soils are organic to a depth of more than 51 inches.

Cb—Cathro muck. This nearly level soil is in small depressions and in small drainageways in the till plain. Included in mapping are a few small areas of Seelyeville and Rifle soils.

Wetness is a major limitation to the use and management of this soil. Soil blowing and unseasonable frost are hazards.

If drained, this soil is suited to such crops as silage corn, soybeans, truck crops, and cultured sod. It is poorly suited to urban development. Community development group 6; capability unit IIIw–3; woodland group 5w1.

Chetek Series

The Chetek series consists of gently undulating to gently rolling, somewhat excessively drained soils formed in glacial outwash. These soils are on short, irregular hillsides and summits of hills in terminal moraines. The native vegetation was deciduous forests of aspen, elm, and oak.

In a representative profile the surface layer is very dark grayish-brown sandy loam about 8 inches thick. The upper 9 inches of the subsoil is reddish-brown, friable sandy loam. The lower 4 inches is reddish-brown, very friable gravelly loamy sand. The underlying material is dark-brown gravelly coarse sand.

Permeability is moderately rapid, and the available water capacity is low. The organic-matter content is low. The supply of available nitrogen is low, phosphorus medium and potassium low.

Most areas of Chetek soils are pastured, wooded, or cropped. The chief limitations are the low available water capacity and the resulting hazards of erosion and droughtiness.

Representative profile of Chetek sandy loam, 6 to 12 percent slopes, in a cultivated field, 250 feet east and 500 feet south of the northwest corner of sec. 33, T. 34 N., R. 25 W.

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) sandy loam; weak, fine, subangular blocky structure; very friable; medium acid; abrupt, smooth boundary.

B2t—8 to 17 inches, reddish-brown (5YR 4/4) sandy loam; moderate, medium, subangular blocky structure; hard; friable; thin, patchy clay films on faces of peds; common clayey bridging of sand grains; about 8 percent gravel; medium acid; clear, wavy boundary.

IIB3—17 to 21 inches, reddish-brown (5YR 4/4) gravelly loamy sand; weak, medium, fine, subangular blocky structure; very friable; 20 percent fine gravel; slightly acid; gradual, smooth boundary.

IIC—21 to 60 inches, dark-brown (7.5YR 4/4) gravelly coarse sand; single grained; loose; neutral.

The thickness of the solum ranges from 14 to 22 inches. In undisturbed areas, the A1 horizon is very dark gray or very dark grayish-brown sandy loam 2 to 4 inches thick and the A2 horizon is grayish-brown or dark grayish-brown sandy loam 2 to 6 inches thick. Cultivation commonly mixes the entire A2 horizon with the Ap horizon.

The B2t horizon is reddish-brown or dark-brown sandy loam or loam. Thin clay films are patchy to continuous on faces of peds. The IIB3 horizon is reddish-brown or dark-brown loamy sand, gravelly loamy sand, or gravelly sandy loam. Clay bridging of sand grains occurs in this horizon in some places.

The IIC horizon is reddish-brown or dark brown. It typically is sand, coarse sand, or gravelly coarse sand, but in some areas it occurs as alternate strata of sand and gravel.

Reaction typically is slightly acid to strongly acid in the A and B horizons and medium acid to neutral in the IIC horizon. The content of gravel ranges from 0 to 10 percent in the A horizon, from 5 to 20 percent in the B horizon, and from 20 to 35 percent in the IIB3 horizon.

Chetek soils are associated with Emmert and Kingsley soils. They have a loamy A and B horizon, whereas Emmert soils are sandy or gravelly throughout. They have a sandy and gravelly IIC horizon, unlike Kingsley soils, which are loamy throughout.

CkB—Chetek sandy loam, 2 to 6 percent slopes. This gently undulating soil is in areas 5 to 20 acres in size. It has a profile similar to the one described as representative of the series, but in undisturbed areas, the surface layer is thinner.

Included with this soil in mapping are soils underlain by alkaline material. Also included are small areas where the surface layer is loamy and the subsoil is thinner than 12 inches and small areas of Emmert and Kingsley soils.

The low available water capacity and the resulting hazard of droughtiness limit the use and management of this soil for farming. Also, erosion is a hazard. This soil has few limitations for urban uses.

Most areas are planted to corn and soybeans, to which this soil is moderately well suited. Some areas are wooded or under urban development, to which the soil is well suited. Community development group 1; capability unit IIIe–1; woodland group 3s1.

CkC—Chetek sandy loam, 6 to 12 percent slopes. This gently rolling soil is on crests and hillsides. Areas are 5 to 20 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small eroded areas where the surface layer is brown. Also included are small areas of Emmert and Kingsley soils and small areas of soils underlain by alkaline material.

The low available water capacity and the resulting hazard of droughtiness limit the use and management of this soil for farming and urban development. Also, erosion is a hazard.

Some areas are used for crops, to which the soil is poorly suited. Other areas are used for pasture, woodland, or recreation, to which the soil is moderately

well suited. Community development group 1; capability unit IVe–2; woodland group 3s1.

Cut and Fill Land

Cu—Cut and fill land. This is land that has been leveled for schools, shopping centers, industrial parks, and playgrounds. Leveling is done either by cutting down the higher areas and filling the lower areas or by hauling in material to fill depressed lowlands.

Depth to the water table, the number of stones and the amount of manmade material vary from place to place. After settling, the cut and fill is typically suited to parking lots and playgrounds, but requires onsite investigation for all structures with foundations. Onsite investigation also is needed before determining the ability of the cut and fill to support specific vegetative plantings. Not assigned to any grouping.

Dalbo Series

The Dalbo series consists of nearly level to gently sloping, moderately well drained soils formed in lacustrine sediments. These soils are on plane to convex small glacial lake plains. Native vegetation was deciduous forest dominated by elm, basswood, and oaks.

In a representative profile the surface layer is very dark grayish-brown silt loam about 6 inches thick. The subsurface layer is grayish-brown silt loam about 3 inches thick. The subsoil is about 19 inches thick. The upper 5 inches is dark-brown, firm silty clay loam. The next 9 inches is dark yellowish-brown very firm clay. The lower 5 inches is mottled yellowish-brown very firm clay. The underlying material is mottled light yellowish-brown silty clay loam in the upper part grading to silt loam in the lower part.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is low. The supply of available nitrogen is low, phosphorus medium, and potassium medium. In most areas these soils are underlain by sandy material at a depth of 4 to 8 feet.

Most areas of Dalbo soils are used for crops, to which they are well suited. The major limitation is the hazard of a moderately high seasonal water table during wet seasons.

Representative profile of Dalbo silt loam, 1 to 5 percent slopes, in a cultivated field, 1,290 feet west and 200 feet south of the midpoint of sec. 2, T. 32 N., R. 25 W.

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) silt loam; moderate, fine and medium, granular structure; friable; slightly acid; abrupt, smooth boundary.

A2—6 to 9 inches, grayish-brown (10YR 5/2) silt loam; moderate, thin, platy structure; friable; medium acid; abrupt, smooth boundary.

B&A—9 to 14 inches, dark-brown (10YR 4/3) silty clay loam (B2); and grayish-brown (10YR 5/2) silt loam (A2); moderate, medium, platy structure parting to moderate, very fine, subangular blocky; firm; medium acid; clear, smooth boundary.

B21t—14 to 23 inches, dark yellowish-brown (10YR 4/4) clay; moderate, medium, prismatic structure parting to strong, medium, subangular blocky; very firm; strongly acid; clear, smooth boundary.

B22t—23 to 28 inches, yellowish-brown (10YR 5/4) clay; common, fine, faint, grayish-brown (10YR 5/2) and brownish-yellow (10YR 6/6) mottles; moderate, medium, prismatic structure parting to strong, medium, subangular blocky; very firm; thin, continuous very dark grayish-brown clay films on vertical faces of peds and thin patchy clay films on horizontal faces of peds; strongly acid; clear, smooth boundary.

C1—28 to 35 inches, light, yellowish-brown (10YR 6/4) silty clay loam; few, medium, distinct, light brownish-gray (10YR 6/2) and dark reddish-brown (5YR 3/4) mottles; moderate, thick, platy structure; friable; thin patchy, very dark grayish-brown clay films on vertical faces and in some old root channels; mildly alkaline; slightly effervescent; clear, smooth boundary.

C2—35 to 60 inches, light yellowish-brown (10YR 6/4) silt loam; few, medium, distinct gray (10YR 6/1) and yellowish-brown (10YR 5/8) mottles; moderate, thin and medium, platy structure; friable; few, thin, very dark grayish-brown clay films in some root channels; moderately alkaline; strongly effervescent.

The thickness of the solum ranges from 24 to 40 inches. The solum typically is free of coarse fragments.

The Ap horizon is very dark grayish brown or very dark gray. In undisturbed areas the A1 horizon is black, very dark brown, or very dark gray and is 2 to 4 inches thick. The A2 horizon is grayish brown or light brownish gray. The A horizon typically is silt loam, but ranges to loam, sandy loam, and fine sandy loam.

The B2t horizon is clay or silty clay 10 to 16 inches thick. The C horizon is light yellowish brown or pale brown. It is typically silt loam, but ranges to silty clay loam and silty clay.

Reaction in the A horizon is slightly acid to medium acid. In the B horizon it is slightly acid to strongly acid. In the C horizon it is mildly alkaline to moderately alkaline.

Dalbo soils are associated with Brickton soils from which they differ in having brighter colors and only a few mottles throughout the B horizon.

D1A—Dalbo silt loam, 1 to 5 percent slopes. This nearly level to gently sloping soil occupies broad, low flats. Areas are 5 to 25 acres in size. In undisturbed areas the surface layer is thinner than is typical. In more sloping areas the subsurface layer has been mixed with the surface layer by erosion and cultivation.

Included with this soil in mapping and identified on the soil map by spot symbols are small areas of steeper soils. Also included are small areas where sand is at a depth of 50 to 70 inches.

The chief limitations to the use and management of this soil, and more restrictive for urban use than for farming, are the moderately high seasonal water table and moderately slow permeability and the resulting hazard of wetness.

This soil is used mainly for crops, to which it is well suited. Commonly grown crops are corn, soybeans, and alfalfa. Community development group 3; capability unit IIe–2; woodland group 2o1.

Dickman Series

The Dickman series consists of nearly level to gently sloping, somewhat excessively drained soils formed in glacial outwash consisting of a loamy mantle over sands. These soils are on broad, nearly level to gently sloping outwash plains. Native vegetation was tall prairie grass and in places scattered oak trees.

In a representative profile the surface layer is black and very dark brown sandy loam about 12 inches thick. The upper 6 inches of the subsoil is dark-brown friable sandy loam. The lower 20 inches is dark-brown and

yellowish-brown very friable loamy fine sand and fine sand. The underlying material is yellowish-brown and light yellowish-brown loose sand and coarse sand.

Permeability is moderately rapid in the upper part of this soil and rapid in the lower part. The available water capacity is low. The organic-matter content is moderate. The supply of available nitrogen is low, phosphorus medium, and potassium low.

Most areas of Dickman soils are cropped. Some are under urban development. The major limitations are the low available water capacity and the resulting hazard of droughtiness.

Representative profile of Dickman sandy loam, 2 to 6 percent slopes, in a grassy wooded area 700 feet east and 620 feet south of the northwest corner of sec. 36, R. 2 W., T. 32 N.

A1—0 to 7 inches, black (10YR 2/1) sandy loam, moderate, medium, granular structure; very friable; medium acid; clear, smooth boundary.
A3—7 to 12 inches, very dark brown (10YR 2/2) sandy loam; weak, medium, granular structure; very friable; medium acid; clear, smooth boundary.
B2—12 to 18 inches, dark-brown (10YR 3/3) sandy loam; moderate, medium, subangular block structure; friable; strongly acid; clear, smooth boundary.
B31—18 to 22 inches, dark-brown (10YR 4/3) loamy fine sand; weak, fine, subangular blocky structure; very friable; medium acid; clear, smooth boundary.
IIB32—22 to 38 inches, yellowish-brown (10YR 5/6) fine sand, single grained; loose; medium acid; clear, smooth boundary.
IIC1—38 to 50 inches, yellowish-brown (10YR 5/4) sand; single grained; loose; slightly acid; clear, wavy boundary.
IIC2—50 to 60 inches, light yellowish-brown (10YR 6/4) coarse sand; few, medium, distinct, yellowish-red (5YR 5/8) and reddish-yellow (5YR 6/8) mottles; single grained; loose; neutral.

The thickness of the solum ranges from 30 to 48 inches. The depth to loamy fine sand or coarse textured material is 12 to 20 inches.

The A horizon is black or very dark brown and is 10 to 14 inches thick. It is sandy loam or fine sandy loam.

The B2 horizon is dark-brown or brown sandy loam or fine sandy loam. The B3 horizon is dark-brown, dark yellowish-brown, or yellowish-brown loamy fine sand, loamy sand, fine sand, or sand.

The IIC horizon is yellowish brown, light yellowish brown, or pale brown, and the lower part of some soils is faintly mottled. This horizon is fine sand, sand, or coarse sand and is commonly stratified. It is 0 to 5 percent gravel.

Reaction in the A and B horizons ranges from strongly acid to slightly acid. Reaction in the C horizon is slightly acid to neutral.

Dickman soils are associated with Hubbard soils and are similar to Chetek soils. The upper part of the B horizon is loamy, whereas Hubbard soils are sandy in that horizon. They have a thicker A1 horizon and have less gravel throughout than Chetek soils.

DnA—Dickman sandy loam, 0 to 2 percent slopes. This nearly level soil is in broad outwash areas 5 to 30 acres in size. Included in mapping are soils that have a dark surface layer less than 10 inches thick and small areas of Hubbard soils.

The low available water capacity and the resulting hazard of droughtiness is a limitation for farming, but less of a limitation for urban use.

Most areas are under urban development, to which this soil is well suited. The rest is planted to corn, soybeans, alfalfa, and pasture, to which the soil is moderately well suited. Community development group 1; capability unit IIIs–1; woodland group 3s1.

DnB—Dickman sandy loam, 2 to 6 percent slopes. This gently sloping soil is in areas 3 to 20 acres in size. It has the profile described as representative of the series.

Included in mapping and identified on the soil map by spot symbols are small depressions. Also included are small areas where erosion has left a lighter colored surface layer and small areas of Hubbard soils.

The chief limitations to the use and management of this soil for farming are the hazard of erosion and the low available water capacity and resulting hazard of droughtiness. This soil has few limitations for urban use.

Large areas of this soil are under urban development, to which it is well suited. The rest of the acreage is planted to corn, soybeans, alfalfa, and pasture, to which the soil is moderately well suited. Community development group 1; capability unit IIIe–1; woodland group 3s1.

Duelm Series

The Duelm series consists of nearly level, somewhat poorly drained soils formed in outwash sands. These soils are in small depressions and small drainageways and on low-lying flats of outwash plains. Native vegetation was tall prairie grass and in places scattered elm and oak trees.

In a representative profile the surface layer is very dark brown loamy coarse sand about 11 inches thick. The upper 4 inches of the subsoil is mottled brown, very friable coarse sand. The lower 27 inches is mottled, grayish-brown, loose coarse sand. The underlying material is light olive-brown coarse sand.

Permeability is rapid, and the available water capacity is low. The organic-matter content is moderate. The supply of available nitrogen is low, phosphorus medium, and potassium low. The water table is commonly 2 to 5 feet below the surface.

Most areas of Duelm soils are cropped or pastured. Some areas are under urban development. The major limitation is the hazard of wetness.

Representative profile of Duelm loamy coarse sand, in a pastured field, 400 feet west and 300 feet north of the center of sec. 31, T. 32 N., R. 24 N.

A1—0 to 11 inches, very dark brown (10YR 2/2) loamy coarse sand; weak, fine, subangular structure; very friable; neutral; clear, smooth boundary.
B2—11 to 15 inches, brown (10YR 5/3) coarse sand; many, medium, distinct, gray (10YR 5/1), dark-brown (7.5YR 4/4) and strong-brown (7.5Y 5/8) mottles; massive in place breaking to weak, medium, subangular blocky structure; very friable; neutral; clear, smooth boundary.
B31—15 to 20 inches, grayish-brown (10YR 5/2) coarse sand; many, medium, distinct, dark-brown (7.5 YR 4/4) and strong-brown (7.5Y 5/8) mottles; massive in place breaking to single grained; loose; slightly acid; clear, smooth boundary.
B32—20 to 42 inches, grayish-brown (10YR 5/2) coarse sand; many, coarse, prominent, strong-brown (7.5YR 5/8), dark reddish-brown (5YR 3/4) and yellowish-red (5YR 4/6) mottles; single grained; loose; strong-brown mottles are weakly cemented; few soft black concretions; slightly acid; clear, smooth boundary.
C—42 to 60 inches, light olive-brown (2.5Y 5/4) coarse sand; common, coarse, faint, yellowish-brown

(10YR 5/6) and grayish-brown (2.5Y 5/2) mottles; single grained; loose; neutral.

The thickness of the solum ranges from 32 to 50 inches.

The A1 horizon is black or very dark brown and is 10 to 14 inches thick. It typically is loamy coarse sand, but ranges to loamy sand, sandy loam, and coarse sandy loam. Reaction ranges from medium acid to neutral.

The B2 horizon is grayish-brown or brown coarse sand and loamy coarse sand or loamy sand. The B3 horizon is grayish-brown or light brownish-gray coarse sand or sand that has many distinct or prominent mottles. Reaction is medium acid to slightly acid.

The C horizon is light olive brown, light yellowish-brown, or pale brown, and has faint to distinct mottles. It is coarse sand or sand. In some soils the C horizon is as much as 15 percent fine gravel.

Duelm soils are associated with Hubbard and Isan soils and are similar to Meehan soils. They are mottled in the B and C horizon, unlike Hubbard soils. They are not so gray as Isan soils and are better drained. They have a thicker A1 horizon and have more coarse sand than Meehan soils.

Dp—Duelm loamy coarse sand. This nearly level soil is in small depressions and small drainageways and on low-lying flats. Areas are 5 to 30 acres in size. Included in mapping are small areas where the surface layer is less than 10 inches thick and small areas of Isan soils.

The chief limitations for both farm and urban use are the moderately high water table and the resulting hazard of wetness. Soil blowing is a hazard to immature crops during dry periods.

Most areas are used for crops, to which this soil is moderately well suited. Commonly grown crops are corn and soybeans. Some areas are pastured, and others are under urban use. Community development group 4; capability unit IVw–1; woodland group 3s1.

Dundas Series

The Dundas series consists of nearly level, poorly drained soils formed in calcareous loamy glacial till. These soils are on nearly level plains and slightly concave slopes on ground moraines. Native vegetation was deciduous forest and a grassy understory.

In a representative profile the surface layer is black loam about 10 inches thick. The subsurface layer is mottled gray fine sandy loam about 5 inches thick. The upper 5 inches of the subsoil is distinctly mottled, dark-gray, firm sandy clay loam. The next 7 inches is distinctly mottled, olive-gray sandy clay loam. The lower 12 inches is distinctly mottled, light olive-gray, friable sandy clay loam. The underlying material, beginning at a depth of about 39 inches, is distinctly mottled gray fine sandy loam.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is moderate. The supply of available nitrogen, phosphorus, and potassium is medium.

Most areas of Dundas soils are cropped. If drained, they are well suited to this use. The major limitation is the hazard of wetness during the wetter part of the year.

Representative profile of Dundas loam, in a cultivated field, 2,200 feet west and 880 feet south of the northeast corner of sec. 23, T. 31 N., R. 22 W.

Ap—0 to 10 inches, black (10YR 2/1) loam; moderate, fine and medium, subangular blocky structure; friable; slightly acid; abrupt, smooth boundary.

A2—10 to 15 inches, gray (10YR 5/1) fine sandy loam; common, fine, distinct, dark-brown (7.5Y 4/4) and strong-brown (7.5Y 5/6) mottles; weak, medium, platy structure; friable; slightly acid; clear, smooth boundary.

B21tg—15 to 20 inches, dark-gray (10YR 4/1) sandy clay loam; common, fine, distinct, dark-brown (10YR 4/3) and brown (10YR 5/3) mottles; moderate, coarse, prismatic structure parting to strong, medium subangular and angular blocky; firm; medium, continuous black (10YR 2/1) clay films on faces of peds and penetrating peds; few, thin, porous, gray (10YR 5/1) coatings on faces of peds in upper part; about 5 percent coarse fragments; slightly acid; clear, smooth boundary.

B22tg—20 to 27 inches, olive-gray (5Y 5/2) sandy clay loam; common, fine, distinct, strong-brown (7.5YR 5/8), yellowish-brown (10YR 5/4), and brownish-yellow (10YR 6/6) mottles; weak, coarse, prismatic structure parting to moderate, medium and coarse, angular and subangular blocky; firm; medium, patchy and continuous black (10YR 2/1) and very dark gray (10YR 3/1) clay films on faces of peds and in tubular pores; about 5 percent coarse fragments; neutral; clear, smooth boundary.

B3tg—27 to 39 inches, light olive-gray (5Y 6/2) sandy clay loam; few, fine, distinct, olive-yellow (5Y 6/6) and yellowish-brown (10YR 5/6) mottles; weak, coarse, subangular blocky structure; friable; medium, patchy black (10YR 2/1) and very dark gray (10YR 3/1) clay films on upper faces of peds; many, medium, thick clay films in tubular pores; about 5 percent coarse fragments; neutral; gradual, smooth boundary.

Cg—39 to 60 inches, gray (5Y 6/1) fine sandy loam; many, medium and coarse, distinct, yellowish-brown (10YR 5/6) and light olive-brown (2.5Y 5/4) mottles; massive parting to weak, medium and coarse, subangular blocky structure; friable; few, thin and medium, black (10YR 2/1) clay films in old root channels in upper part; few masses of lime in form of soft threads and coatings on vertical faces of peds and in some root channels; about 10 percent coarse fragments; strongly effervescent; moderately alkaline.

The thickness of the solum ranges from 30 to 48 inches. The upper part of the solum is as much as 5 percent coarse fragments, and the lower part and the C horizon 2 to 8 percent.

The Ap horizon is black or very dark gray. In undisturbed areas the soil has an A1 horizon that is black or very dark gray and 3 to 6 inches thick. The Ap or A1 horizon typically is fine sandy loam or loam, but ranges to silt loam. The A2 horizon is gray or grayish brown and is 5 to 9 inches thick in most places. The A2 horizon is fine sandy loam or loam. Cultivation can destroy all evidence of an A2 horizon.

The B horizon is gray, dark gray, olive gray, light olive gray, and brownish gray. It typically is sandy clay loam but in places is clay loam. The B21 horizon contains few to many bleached silt and sand grains on the faces of peds. Clay films in the B horizon are continuous to patchy and commonly black or very dark gray.

The C horizon is gray or grayish-brown fine sandy loam or loam. Reaction is mildly to moderately alkaline in the C horizon, medium acid to slightly acid in the upper part of the solum, and slightly acid to neutral in the lower part.

The Dundas soils of Anoka County have more sand, less clay, and grayer colors in the B horizon and more sand and less silt in the C horizon than is typical for the series. These differences, however, do not significantly affect use and management.

Dundas soils are associated with Nessel and Webster soils and are similar to Nowen soils. They have grayer B and C horizons than Nessel soils. They differ from Webster soils in having an A2 horizon and clay accumulation in the B horizon. They differ from Nowen soils in having less sand and more clay in the B horizon.

Du—Dundas loam. This nearly level soil is in small

depressions and small drainageways and on low flats. Areas are 5 to 60 acres in size. In undisturbed areas the surface layer is thinner than is typical.

Included with this soil in mapping are small areas of Kratka, Nessel, and Webster soils. Areas having a sandy mantle are identified by spot symbols on the soil map.

The chief limitations for both farm and urban use are the high seasonal water table and the resulting hazard of wetness.

Most areas are used for crops. If drained, this soil is well suited to such crops as corn and soybeans. It is poorly suited to most urban uses. Community development group 5; capability unit IIIw–2; woodland group 3w1.

Emmert Series

The Emmert series consists of gently undulating to steep, excessively drained soils formed in gravelly sands. These soils are on crests of hills and the sides of kames, eskers, and moraines. Native vegetation was deciduous forest, mainly oak trees.

In a representative profile the surface layer is very dark gray gravelly coarse sandy loam about 2 inches thick. The subsoil is dark-brown, loose gravelly coarse sand about 21 inches thick. The underlying material is brown, pale brown, very pale brown, and light yellowish-brown gravelly coarse sand.

Permeability is very rapid, and the available water capacity is very low. The organic-matter content is low. The supply of available potassium, nitrogen, and phosphorus is low.

Most areas of Emmert soils are in woodland and wooded pasture. The chief limitations are the low available water capacity and the resulting hazard of droughtiness.

Representative profile of Emmert gravelly coarse sandy loam, 12 to 25 percent slopes, in a wooded field 600 feet south and 650 feet east of the northwest corner NE¼ sec. 32, T. 34 N., R. 23 W.

A1—0 to 4 inches, very dark gray (10YR 3/10) gravelly coarse sandy loam; weak, medium, granular structure; very friable; about 35 percent gravel; slightly acid; abrupt, smooth boundary.

B1—4 to 16 inches, dark-brown (7.5YR 4/4) gravelly coarse sand; massive in place breaking to single grained; loose; about 60 percent gravel; medium acid; clear, wavy boundary.

B21—16 to 23 inches, dark-brown (7.5Y 4/4) gravelly coarse sand; weak, medium, subangular blocky structure breaking readily to single grained; loose; about 65 percent gravel; medium acid; clear, wavy boundary.

C1—23 to 32 inches, brown (7.5Y 5/4) gravelly coarse sand; massive in place breaking to single grained; loose; about 65 percent gravel; neutral; clear, wavy boundary.

C2—32 to 38 inches, pale-brown (10YR 6/3) gravelly coarse sand; single grained; loose; about 65 percent gravel; slightly acid; abrupt, wavy boundary.

C3—38 to 60 inches, light yellowish-brown (10YR 6/4) and very pale brown (10YR 7/4) gravelly coarse sand; single grained; loose; about 75 percent gravel; slightly effervescent; mildly alkaline.

The thickness of the solum ranges from 12 to 28 inches. The gravel content is commonly 45 to 75 percent, but ranges as low as 15 percent.

The A1 horizon is black, very dark brown, or very dark gray coarse sandy loam or gravelly coarse sandy loam. It is 1 to 4 inches thick. In some places the soil has a thin, grayish discontinuous A2 horizon.

The B horizon is dark reddish-brown, dark-brown, or reddish-brown sand, loamy sand, loamy coarse sand, coarse sand, and gravelly coarse sand.

The upper part of the C horizon is reddish-brown or brown gravelly coarse sand or gravelly sand. The lower part is pale-brown, light yellowish-brown, or very pale brown gravelly coarse sand or gravelly sand.

Reaction in the solum is medium acid or slightly acid. Reaction in the C horizon is slightly acid to mildly alkaline.

The Emmert soils of Anoka County commonly are yellower and less acid in the lower part of the C horizon than the defined range in the series. This difference, however, does not affect use or management.

Emmert soils are associated with Chetek and Kingsley soils. They have a coarser B horizon than Chetek soils and coarser B and C horizons than Kingsley soils.

EmC—Emmert gravelly coarse sandy loam, 6 to 12 percent slopes. This gently rolling soil is on hillcrests and hillsides. Areas are 10 to 40 acres in size. Included in mapping are areas of Chetek soils and of sandy soils that are less than 15 percent coarse fragments.

The low available water capacity and the resulting hazards of erosion and droughtiness are limitations to the use and management of this soil.

Large areas are still wooded or are used as wooded pasture, to which this soil is moderately well suited. Some areas are cropped, to which the soil is poorly suited. This soil is a good source of sand and gravel. Community development group 1; capability unit VIs–1; woodland group 3s1.

EmD—Emmert gravelly coarse sandy loam, 12 to 25 percent slopes. This moderately steep to steep soil is on a hilly morainic landscape. Areas are 10 to 60 acres in size. This soil has the profile described as representative of the series. The surface layer mainly is gravelly coarse sandy loam, but in places is gravelly coarse sand and coarse sand. Included in mapping are small areas of Chetek and Kingsley soils.

The steep slopes, the low available water capacity, and the resulting hazards of erosion and droughtiness are limitations to use and management of this soil.

Large areas are still wooded or are in wooded pasture. This soil is very poorly suited to crops. It is a good source of sand and gravel. Community development group 1; capability unit VIIs–1; woodland group 3s2.

EpC—Emmert complex, 4 to 12 percent slopes. This gently undulating to rolling mapping unit occurs on a morainic landscape. It is 60 to 80 percent Emmert soils and 20 to 40 percent Chetek, Kingsley, Hayden, or Heyder soils or any combination of those soils. Areas are 5 to 80 acres in size.

The Emmert soils in this mapping unit have characteristics similar to those described as representative of the series. The surface layer commonly is gravelly coarse sandy loam, but in places is gravelly loamy coarse sand, loamy coarse sand, or sandy loam. In areas of Kingsley, Hayden, and Heyder soils, the subsoil is sandy loam, loam, or sandy clay loam and the underlying material is sandy loam or fine sandy loam.

The slopes, the low available water capacity, and the resulting hazards of erosion and droughtiness, are limitations to use and management.

Most areas of this unit are wooded or pastured. Some are used for crops and urban development. Com-

munity development group 1; capability unit VIs–1; woodland group 3s1.

EpD—Emmert complex, 12 to 25 percent slopes. This hilly to steep mapping unit occurs on a morainic landscape. It is 75 to 90 percent Emmert soils and 10 to 25 percent Chetek, Kingsley, Hayden, or Heyder soils or any combination of those soils.

The Emmert soils in this mapping unit have characteristics similar to those described as representative of the series. The surface layer mainly is gravelly coarse sandy loam, but in places is gravelly loamy coarse sand, loamy coarse sand, or sandy loam. In areas of Kingsley and Hayden soils, the subsoil is sandy loam, loam, or sandy clay loam, and the underlying material is sandy loam or loam.

The steep slopes and the low available water capacity are limitations to use and management.

Large areas of this unit are wooded. Some areas are wooded pasture. This unit is very poorly suited to crops. Community development group 1; capability unit VIIs–1; woodland group 3s2.

Glencoe Series

The Glencoe series consists of nearly level, very poorly drained soils formed in loamy alluvial sediments and glacial till. These soils are in shallow depressions of slightly depressed lowlands in ground moraines. Native vegetation was water-tolerant grasses and sedges.

In a representative profile the surface layer is black loam grading to very dark gray fine sandy loam in the lower part. It is about 27 inches thick. The subsoil is mottled dark-gray and greenish-gray loam and silt loam about 18 inches thick. The underlying material is gray fine sandy loam.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is high. The supply of available phosphorus is low and potassium high. In undrained areas, the water table is near the surface.

Most drained areas of Glencoe soils are cropped. The major limitation is the hazard of wetness.

Representative profile of Glencoe loam (0.5 percent slope) in a cultivated field, 360 feet north and 210 feet east of the southwest corner NE¼ sec. 13, T. 31 N., R. 22 W.

Ap—0 to 9 inches, black (N 2/0) loam; weak, medium, subangular blocky structure; friable; about 1 percent coarse fragments; neutral; abrupt, smooth boundary.

A1—9 to 20 inches, black (N 2/0) fine sandy loam; weak, medium and fine, subangular blocky structure; friable; about 1 percent coarse fragments; neutral; abrupt, clear boundary.

A3g—20 to 27 inches, very dark gray (10YR 3/1) fine sandy loam; few, fine, faint, dark-brown (7.5YR 4/4) mottles; weak, medium, subangular blocky structure; friable; about 2 percent coarse fragments; thin, discontinuous strata of coarse sand; neutral; abrupt, wavy boundary.

B21g—27 to 33 inches, dark-gray (5Y 4/1) loam; common, medium, prominent, strong-brown (7.5YR 5/6) mottles; weak, medium, subangular blocky structure; friable; about 1 percent coarse fragments; mottles mostly along old root channels; neutral; abrupt, smooth boundary.

B22g—33 to 45 inches, greenish-gray (5GY 5/1) silt loam; common, medium, prominent, strong-brown (7.5YR 5/8) mottles; weak, medium, subangular blocky structure; friable; about 1 percent coarse fragments; mottles mostly along old root channels; mildly alkaline; clear, smooth boundary.

Cg—45 to 60 inches, gray (5Y 5/1) fine sandy loam; common, medium, prominent, strong-brown (7.5YR 5/8) and yellowish-red (5Y 5/8) mottles, massive; friable; about 4 percent coarse fragments; slightly effervescent; mildly alkaline.

The thickness of the solum ranges from 36 to 56 inches. The solum is 0 to 5 percent coarse fragments and the C horizon 2 to 8 percent.

The A1 or Ap horizons typically are loam or silty clay loam. The A1 and A3 horizons typically are loam or fine sandy loam. The A horizon is 24 to 32 inches thick.

The B horizon is dark gray, gray, or greenish gray and has common prominent mottles. It is loam, silt loam, or silty clay loam.

The C horizon is gray or grayish-brown loam or fine sandy loam. Reaction is mildly to moderately alkaline in the C horizon and is typically neutral in the solum.

The Glencoe soils of Anoka County have more sand and less silt and clay than the defined range of the series. This difference, however, does not alter use or management.

Glencoe soils are associated with Webster and Dundas soils. They have a thicker A horizon and are more poorly drained than those soils.

Gc—Glencoe loam. This nearly level soil is in shallow depressions and low-lying drainageways. Areas are 5 to 80 acres in size. Included in mapping are areas of soils that have strata of coarse sand and small areas of Webster and Kratka soils.

The chief limitations for both farm and urban use are the seasonal high water table and the resulting hazard of wetness.

Most areas are drained and used for crops, to which they are moderately well suited. Commonly grown crops are corn and soybeans. Community development group 6; capability unit IIIw–4; woodland group 5w1.

Growton Series

The Growton series consists of nearly level and gently sloping, moderately well drained soils formed in sandy loam till. These soils are on undulating to hilly ground moraines. Native vegetation was deciduous forest. Basswood, elm, maple, and oak were the dominant trees.

In a representative profile the surface layer is very dark grayish-brown fine sandy loam about 9 inches thick. The subsurface layer is grayish-brown loamy sand about 14 inches thick. The subsoil is mottled brown friable sandy loam about 22 inches thick. The underlying material is mottled dark-brown sandy loam.

Permeability is moderate, and the available water capacity is moderate. The organic-matter content is low. The supply of available nitrogen is low and phosphorus and potassium medium.

Most areas of Growton soils are cropped. A few areas are pastured, and some are still wooded. A slight limitation to the use of this soil for farming is the moderate available water capacity. A moderately high seasonal water table is a moderate hazard to urban use.

Representative profile of Growton fine sandy loam, 1 to 4 percent slopes, in a cultivated field, 600 feet east and 50 feet south of the northwest corner of sec. 29, T. 33 N., R. 25 W.

Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2)

fine sandy loam; moderate, fine and medium, granular structure; very friable; about 5 percent coarse fragments; slightly acid; abrupt, smooth boundary.

A2—9 to 23 inches, grayish-brown (10YR 5/2) loamy sand; many, medium, distinct, dark reddish-brown (5YR 3/4) and reddish-brown (5YR 5/4) mottles; weak, medium, platy structure; very friable; about 5 percent coarse fragments; slightly acid; abrupt, wavy boundary.

A&B—23 to 28 inches, grayish-brown (10YR 5/2) loamy sand interfingering with weak, medium, platy structure; brown (10YR 5/3) sandy loam ped interiors having weak, medium, subangular blocky structure; many, medium, faint, yellowish-brown (10YR 5/6) mottles; friable; about 10 percent coarse fragments; slightly acid; clear, wavy boundary.

The thickness of the solum ranges from 40 to 55 inches. It is 2 to 15 percent coarse fragments.

The Ap horizon is very dark grayish brown or dark grayish brown. In undisturbed areas, the A1 horizon is black or very dark gray and 2 to 4 inches thick. The Ap and A1 horizons typically are fine sandy loam, but range to sandy loam or loam. The A2 horizon is grayish brown or light brownish gray. Mottles typically are common but in places are lacking. The texture typically is loamy sand, but ranges to fine sandy loam and sandy loam. The A&B horizon is similar in color and texture to the A2 horizon and the B horizon.

The B horizon typically is sandy loam but in places has thin, irregular strata of loamy sand, loam, or sandy clay loam. This horizon is 16 to 20 inches thick.

The C horizon is dark brown, brown, dark grayish brown, or grayish brown and has common to many, distinct or prominent mottles. In places the C horizon has strata of redder hues. It is mostly sandy loam, but in places has strata or pockets of sand, loamy sand, and sandy clay loam. Reaction is slightly acid to medium acid throughout.

Growton soils are associated with Heyder and Nowen soils and are similar to Nessel soils. They differ from Heyder soils in having mottles in the B horizon. They are better drained and have higher chroma in the solum than Nowen soils. They have less clay in the B horizon than Nessel soils.

GrA—Growton fine sandy loam, 1 to 4 percent slopes. This nearly level to gently undulating soil is on low relief in small drainageways and on low broad flats. Areas are 3 to 20 acres in size. In undisturbed areas, the surface layer is thinner than is typical.

Included with this soil in mapping are soils that are not mottled in the upper part of the subsoil. Also included are soils that are more poorly drained than this Growton soil.

The seasonal moderately high water table and the resulting hazard of wetness are limitations to the use and management of this soil. These limitations restrict use for urban purposes more than for farming. Moderate available water capacity is a slight limitation to farming.

This soil is used mainly for crops, to which it is well suited. Commonly grown crops are corn, soybeans, and alfalfa. Community development group 2; capability unit IIe–1; woodland group 2o2.

Hayden Series

The Hayden series consists of gently undulating to steep, well-drained soils formed in limy glacial till. These soils are on hills and hillsides and the gently sloping summits of ground and terminal moraines. Native vegetation was deciduous forest of basswood, elm, maple, and oak.

In a representative profile the surface layer is very dark gray fine sandy loam about 6 inches thick. The subsurface layer is grayish-brown fine sandy loam about 4 inches thick. The subsoil is about 27 inches thick. The upper part is dark-brown and dark yellowish-brown firm sandy clay loam. The lower part is dark-brown and dark yellowish-brown friable loam. The underlying material is light olive-brown fine sandy loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content is low. The supply of available nitrogen is low, phosphorus medium, and potassium medium.

Most areas of less sloping Hayden soils are cropped. Steeper areas are under urban development. The major limitation is the hazard of erosion.

Representative profile of Hayden fine sandy loam, 12 to 24 percent slopes, in a cultivated field, 300 feet west and 30 feet south of the northeast corner NE¼ sec. 25, T. 32 N., R. 22 W.

Ap—0 to 6 inches, very dark gray (10YR 3/1) fine sandy loam; weak, fine, subangular blocky structure; very friable; about 2 percent coarse fragments; slight acid; abrupt, smooth boundary.

A2—6 to 10 inches, grayish-brown (10YR 5/2) fine sandy loam; weak, thick, platy structure parting to weak, fine, subangular blocky; very friable; about 2 percent coarse fragments; slightly acid; clear, smooth boundary.

B21t—10 to 17 inches, dark-brown (10YR 3/3) and dark yellowish-brown (10YR 4/4) sandy clay loam; moderate, fine, subangular blocky structure; firm; about 5 percent coarse fragments; few, thin, porous dark grayish-brown (10YR 4/2) coatings on faces of peds; thin, patchy clay films on faces of peds; medium acid; clear, wavy boundary.

B22t—17 to 31 inches, dark yellowish-brown (10YR 4/4) sandy clay loam; moderate, fine, prismatic structure parting to moderate, medium, subangular blocky; firm; thin, continuous very dark brown (10YR 2/2) clay films on vertical faces of peds and thin, patchy clay films on horizontal faces of peds; about 5 percent coarse fragments; strongly acid; clear, wavy boundary.

B3t—31 to 37 inches, dark-brown (10YR 4/3) and dark yellowish-brown (10YR 4/4) loam; weak, medium, subangular blocky structure; friable; thin, continuous and patchy very dark brown (10YR 2/2) clay films on vertical faces of peds and in old root channels; about 5 percent coarse fragments; neutral; clear, wavy boundary.

C—37 to 60 inches, light olive-brown (2.5Y 5/4) fine sandy loam; massive; friable; about 5 percent coarse fragments; few limy masses in form of horizontal streaks; strongly effervescent; moderately alkaline.

The thickness of the solum ranges from 34 to 48 inches. The upper part of the solum is 0 to 8 percent coarse fragments and the lower part and the C horizon are 2 to 8 percent.

The Ap horizon is very dark gray, very dark grayish brown, or dark grayish brown. The A2 horizon is grayish brown or dark grayish brown and typically is 4 to 8 inches thick. In undisturbed areas the A1 horizon is very dark brown, very dark gray, or very dark grayish brown and is 2 to 4 inches thick. In some cultivated fields the A2 horizon is completely mixed with the Ap horizon. The A horizon typically is fine sandy loam but in places ranges to loam.

The B horizon is dark-brown, dark yellowish-brown, or yellowish-brown sandy clay loam or loam. Clay films are thin to moderately thick and continuous or patchy.

The C horizon is light olive-brown or olive-brown fine sandy loam or loam.

Reaction is medium acid to slightly acid in the A horizon, medium acid to strongly acid in the upper part of the B horizon, and slightly acid to neutral in the lower part of the B horizon, and mildly alkaline to moderately alkaline in the C horizon.

Hayden soils are associated with Nessel and Braham soils and are similar to Heyder soils. In contrast with Nessel soils, they lack mottles in the B horizon. They lack the sandy mantle that is characteristic of Braham soils. They have more clay and less sand in the B horizon than Heyder soils.

HdB—Hayden fine sandy loam, 2 to 6 percent slopes. This gently undulating soil is in slightly convex areas 5 to 40 acres in size. In undisturbed areas, the surface layer is 2 to 4 inches thick. In a few eroded areas in cultivated fields the browner sandy clay loam subsoil is exposed. Included in mapping are small narrow drainageways of Nessel and Dundas soils, and small areas of Braham soil.

The chief limitation for both farm and urban use is the hazard of erosion.

Most areas are used for crops, to which the soil is well suited. Commonly grown crops are corn, soybeans, oats, and alfalfa. Some areas are wooded or are under urban development, to which the soil is well suited. Community development group 2; capability unit IIe–1; woodland group 2o1.

HdC2—Hayden fine sandy loam, 6 to 12 percent slopes, eroded. This gently rolling soil occupies crests and hillsides. Areas are 3 to 15 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is thinner. Erosion has removed part of the original surface layer, and tillage has mixed material from the subsoil with the remaining surface layer. Thus, the present surface layer is browner than is typical. Included in mapping are small areas where the soil is only slightly eroded and has a thicker surface layer.

The chief limitation for both farm and urban use is the severe hazard of erosion.

Most areas are cropped. The soil is moderately well suited to this use. Commonly grown crops are corn, soybeans, alfalfa, and oats. Some areas are in pasture, to which the soil is well suited. Small areas are under urban development, to which the soil is moderately well suited. Community development group 2; capability unit IIIe–1; woodland group 2o1.

HdD—Hayden fine sandy loam, 12 to 24 percent slopes. This moderately steep to steep soil occupies short, narrow, irregular side slopes. Areas are 3 to 30 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas where all of the surface layer has been removed by erosion and the present surface layer is entirely subsoil material. Also included are small areas where the slope is less than 12 percent or more than 24 percent.

The chief limitations for both farm and urban use are the steep slopes and severe hazard of erosion.

Most areas are in pasture or are wooded, to which the soil is well suited. Some areas are planted to crops to which the soil is poorly suited. Steep slopes and a severe hazard of erosion limit the use of this soil for crops, such as corn and soybeans, and they also limit its use for urban development. Community development group 2; capability unit IVe–1; woodland group 2r1.

Heyder Series

The Heyder series consists of gently undulating to very steep, well-drained soils formed in sandy loam glacial till. These soils are on short irregular side slopes and gently sloping summits of ground and terminal moraines. Native vegetation was deciduous forest, chiefly sugar maple, basswood, and oak.

In a representative profile the surface layer is very dark grayish-brown fine sandy loam about 3 inches thick. The subsurface layer is grayish-brown fine sandy loam about 15 inches thick. The subsoil is dark yellowish-brown and yellowish-brown friable sandy loam and fine sandy loam about 35 inches thick. The underlying material is light olive-brown sandy loam.

Permeability is moderate, and the available water capacity is moderate to high. The organic-matter content is low. The supply of available nitrogen is low and phosphorus and potassium medium. Thin sandy strata and pockets are common throughout the profile.

Most areas of the less sloping Heyder soils are cropped. Steeper areas are pastured or wooded. The major limitation is the hazard of erosion.

Representative profile of Heyder fine sandy loam, 2 to 6 percent slopes, in a wooded pasture, 70 feet west and 20 feet south of the northeast corner SE¼ sec. 22, T. 33 N., R. 25 W.

A1—0 to 3 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; weak, very fine, subangular blocky structure; very friable; about 2 percent coarse fragments; slightly acid; abrupt, smooth boundary.

A2—3 to 18 inches, grayish-brown (10YR 5/2) fine sandy loam; weak, medium, platy structure; very friable; about 2 percent coarse fragments; slightly acid; abrupt, wavy boundary.

B&A—18 to 22 inches, yellowish-brown (10YR 5/4) fine sandy loam ped interiors having moderate, medium, subangular blocky structure; grayish-brown 10YR 5/2) fine sandy loam interfingers having weak, medium, platy structure; friable; about 5 percent coarse fragments; medium acid; clear, wavy boundary.

B21t—22 to 32 inches, dark yellowish-brown (10YR 4/4) fine sandy loam; moderate, medium, subangular blocky structure; firm; thin, patchy clay films on ped faces; thin, light gray, porous coatings on some ped faces; about 5 percent coarse fragments; medium acid; clear, smooth boundary.

B22t—32 to 43 inches, dark yellowish-brown (10YR 4/4) sandy loam; weak, medium, subangular blocky structure; friable; few, thin, dark-brown clay films on vertical ped faces; about 5 percent coarse fragments; medium acid; clear, smooth boundary.

B3—43 to 53 inches, yellowish-brown (10YR 5/4) sandy loam; moderate, medium and coarse, subangular blocky structure; friable; thin, patchy, dark-brown clay films on vertical ped faces; few, thin, light-gray, porous coats on some ped faces; about 5 percent coarse fragments; slightly acid; clear, smooth boundary.

C—53 to 60 inches, light olive-brown (2.5Y 5/4) sandy loam; massive, with a few horizontal cleavage planes; very friable; about 8 percent coarse fragments; weakly effervescent; mildly alkaline.

The thickness of the solum ranges from 38 to 56 inches. The solum and C horizon are 2 to 10 percent coarse fragments.

The A1 horizon is very dark grayish brown, very dark brown, very dark gray, or black and is 2 to 4 inches thick. The A2 horizon is grayish brown or dark grayish brown and is 6 to 15 inches thick. In cultivated fields part of the A2 horizon is mixed with the Ap horizon. The A horizon is fine sandy loam or sandy loam.

The B horizon is 24 to 37 inches thick. It is dominantly sandy loam or fine sandy loam, but has thin, irregular strata of loamy fine sand or loamy sand in some places. Clay films are thin and patchy to continuous.

The C horizon is yellowish brown or light olive brown. Thin, discontinuous, coarser-textured strata and masses are common in some places.

Reaction in the solum is slightly acid to medium acid. It is commonly mildly alkaline in the C horizon, but is neutral in the upper part in some places.

Heyder soils are associated with Growton and Nowen soils and are similar to Hayden soils. They lack the mottles in the B horizon, which are typical of Growton and Nowen soils. They have less clay and more sand in the B horizon than Hayden soils.

HeB—Heyder fine sandy loam, 2 to 6 percent slopes. This gently undulating soil is in convex areas 10 to 80 acres in size. It has the profile described as representative of the series. In cultivated areas the surface layer is 6 to 10 inches thick. Included in mapping are small narrow drainageways of Growton and Nowen soils.

The chief limitation for both farm and urban use is the hazard of erosion.

Most areas are cropped. If well managed, the soil is well suited to this use. Commonly grown crops are corn, soybeans, and alfalfa. Some areas are wooded or under urban development, to which the soil is well suited. Community development group 2; capability unit IIe–1; woodland group 2o2.

HeC2—Heyder fine sandy loam, 6 to 12 percent slopes, eroded. This gently rolling soil is on crests and hillsides. Areas are 3 to 20 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is commonly thinner. Erosion has removed part of the original surface layer, and tillage has mixed material from the subsoil with the remaining surface layer. Thus, the present surface layer is browner than is typical.

Included with this soil in mapping are small areas where all of the surface layer has been removed and the present surface layer is entirely subsoil material. Also included are small areas of Kingsley soils.

The chief limitation for both farm and urban use is the severe hazard of erosion.

Most areas are cropped. This soil is moderately well suited to crops. Commonly grown crops are corn, soybeans, alfalfa, and oats. Some areas are planted to pasture, to which the soil is well suited. Some areas are under urban development, to which the soil is moderately well suited. Community development group 2; capability unit IIIe–1; woodland group 2o2.

HeD—Heyder fine sandy loam, 12 to 18 percent slopes. This moderately steep soil is on short, narrow, irregular side slopes. Areas are 3 to 15 acres in size. This soil has a thinner profile than the one described as representative of the series. In cultivated areas, the surface and subsurface layers are mixed. Where the soil is eroded, the surface layer is mixed with material from the subsoil and is browner in color.

Included with this soil in mapping are small areas where all of the surface layer has been removed by erosion and the present surface layer is entirely subsoil material. Also included are small areas where the slope is less than 12 percent or more than 18 percent and small areas of Kingsley soils.

The chief limitations for both farm and urban use are the steep slopes and severe hazard of erosion.

Most areas are pastured or wooded, to which the soil is well suited. Some areas are cropped, to which the soil is poorly suited. Steep slopes and a severe hazard of erosion limit the use of this soil for such crops as corn and soybeans and also for urban development. Community development group 2; capability unit IVe–1; woodland group 2r1.

HeE—Heyder fine sandy loam, 18 to 30 percent slopes. This steep to very steep soil is on short narrow hillsides and escarpments adjacent to drainageways and large depressed lowland areas. Areas are 3 to 15 acres in size. This soil has a thinner profile than the one described as representative of the series. Included in mapping are small areas where the surface layer has been removed by erosion and areas where the slope is less than 18 percent.

The hazard of erosion and the steep slope are limitations for farm and urban use.

Most areas are in woodland and wooded pasture, to which the soil is moderately well suited. The steep slopes and severe hazard of erosion severely limit this soil for farming. Maintaining this soil in its natural state for wildlife and recreation should be considered. Community development group 2; capability unit VIe–1; woodland group 2r1.

H1C—Heyder complex, 4 to 12 percent slopes. This gently undulating to rolling mapping unit occurs on a morainic landscape. It is 70 to 80 percent Heyder soils and 20 to 30 percent Kingsley, Emmert, or Hayden soils or some combination of those soils. Areas are 10 to 60 acres in size.

The Heyder soils in this mapping unit have characteristics similar to those described as representative of the series. The surface layer is mainly fine sandy loam, but in places is sandy loam and coarse sandy loam. The subsoil is fine sandy loam and loam. The underlying material is sandy loam or fine sandy loam. In areas of Emmert soils, the subsoil and underlying material are gravelly coarse sand.

The hazard of erosion and the low available water capacity in areas of Emmert soils are limitations to use and management.

Most areas of this unit are cropped. Some are used for wooded pasture or homesites. This unit is poorly suited to crops, but is moderately well suited to most other uses. Community development group 2; capability unit IIIe–1; woodland group 2o2.

H1D—Heyder complex, 12 to 25 percent slopes. This hilly to steep mapping unit occurs on a morainic landscape. It is 60 to 75 percent Heyder soils and 25 to 40 percent Kingsley, Emmert, or Hayden soils or some combination of those soils and some soils that formed in stratified loamy and sandy material. Areas are 10 to 30 acres in size. Slopes are short and irregular.

The Heyder soils in this unit have characteristics similar to those described as representative of the series, but the surface layer is thinner. The surface layer is mainly fine sandy loam and sandy loam, but in places is coarse sandy loam and gravelly coarse sandy loam. The subsoil and underlying material is loam or sandy loam. In areas of Emmert soils, the subsoil and underlying material is gravelly coarse sand. Emmert

soils are most common at the crests of hillsides.

The hazard of erosion, the steep slopes, and the low available water capacity are limitations to use and management.

Most areas are pastured or wooded. This unit is very poorly suited to crops and is poorly suited to most other uses. Community development group 2; capability unit IVe–1; woodland group 2r1.

Hubbard Series

The Hubbard series consists of nearly level to sloping, excessively drained soils formed in outwash sands. These soils are on broad, smooth flats and narrow side slopes adjacent to drainageways and large depressions in the sandy outwash plains. Native vegetation was tall prairie grass and scattered oaks.

In a representative profile the surface layer is black and very dark grayish-brown coarse sand about 20 inches thick. The upper 13 inches of the subsoil is dark-brown, very friable to loose coarse sand. The lower 11 inches is yellowish-brown loose coarse sand. The underlying material is pale-brown gravelly coarse sand.

Permeability is rapid. The supply of available nitrogen is low, phosphorus medium, and potassium low.

Most areas of Hubbard soils are under urban development. Some areas are cropped. The chief limitations are the low available water capacity and the resulting hazards of soil blowing and droughtiness.

Representative profile of Hubbard coarse sand, 0 to 2 percent slopes, in a grassy field, 1,300 feet west and 200 feet south of the center of sec. 20, T. 32 N., R. 2 W.

A1—0 to 14 inches, black (10YR 2/1) coarse sand; weak, fine, subangular blocky structure; very friable; about 6 percent fine gravel; slightly acid; clear, smooth boundary.

A3—14 to 20 inches, very dark grayish-brown (10YR 3/2) coarse sand; weak, fine, subangular blocky structure; very friable; about 9 percent fine gravel; slightly acid; clear, wavy boundary.

B21—20 to 28 inches, dark-brown (7.5YR 3/2 and 4/4) coarse sand; massive breaking to weak, medium, subangular blocky structure; very friable; about 8 percent fine gravel; slightly acid; clear, smooth boundary.

B22—28 to 33 inches, dark-brown (7.5 4/4) coarse sand; single grained; loose; about 11 percent fine gravel; slightly acid; clear, smooth boundary.

B3—33 to 44 inches, yellowish-brown (10YR 5/4) coarse sand; single grained; loose; about 11 percent gravel; slightly acid; clear, wavy boundary.

C—44 to 60 inches, pale-brown (10YR 6/3) gravelly coarse sand; single grained; loose; about 25 percent fine gravel; neutral.

Reaction of the solum is medium acid to slightly acid. The thickness of the solum ranges from 30 to 46 inches.

The A1 horizon is black or very dark brown and is 10 to 16 inches thick. The A3 horizon is very dark grayish brown or very dark brown and is 3 to 8 inches thick. The A horizon is typically coarse sand, sand, loamy coarse sand, or loamy sand, but in a few places the upper part is sandy loam or coarse sandy loam.

The B horizon is mostly sand or coarse sand, but in places the upper part is loamy coarse sand or loamy sand.

The C horizon is pale-brown, very pale brown, or light yellowish-brown gravelly coarse sand, coarse sand, or sand. Typically the C horizon is stratified. It is commonly 1 to 25 percent gravel, and the gravel is dispersed or occurs in strata.

Hubbard soils are associated with Duelm and Isan soils and are similar to Nymore soils. They are deeper over the water table and have better drainage than Duelm and Isan soils. They have a thicker, dark colored A horizon and more coarse sand throughout than Nymore soils.

HuA—Hubbard coarse sand, 0 to 2 percent slopes. This nearly level soil occupies broad outwash areas. These areas are 10 to 160 acres in size. This soil has the profile described as representative of the series.

Included in some mapped areas are soils that have a sandy loam surface layer up to 10 inches thick. Also included are small areas of Duelm soils.

The chief limitations for both farm and urban use are the low available water capacity and the resulting hazards of soil blowing and droughtiness.

Large areas are under urban development. The soil is well suited to this use. It is poorly suited to corn and soybeans, and it is moderately well suited to alfalfa, pasture, and woodland. Community development group 1; capability unit IVs–1; woodland group 3s1.

HuB—Hubbard coarse sand, 2 to 6 percent slopes. This gently sloping soil is in broad outwash areas 5 to 80 acres in size. Included in mapping and identified on the soil map by spot symbols are small depressions of Isan soils. Also included are small areas where the surface layer is thinner and lighter colored than is typical as a result of soil blowing.

The chief limitations for both farm and urban use are the low available water capacity and the resulting hazards of soil blowing and droughtiness.

Large areas are under urban development. This soil is well suited to this use. It is poorly suited to corn and soybeans and is moderately well suited to alfalfa, pasture, and woodland. Community development group 1; capability unit IVs–1; woodland group 3s1.

HuC—Hubbard coarse sand, 6 to 12 percent slopes. This sloping soil occupies escarpments 100 to 300 feet wide adjacent to drainageways and large, poorly drained depressions in the outwash areas. Areas are 3 to 15 acres in size. This soil has a thinner profile than the one described as representative of the series.

Included with this soil in mapping are areas where the surface layer is lighter colored than is typical as a result of erosion by wind and water. Also included are small areas where the subsoil has gravelly strata.

The chief limitations for both farm and urban use are the low available water capacity and the resulting hazard of droughtiness, and the hazards of erosion and soil blowing.

Most areas are under urban development. This soil is moderately well suited to this use. It is very poorly suited to crops and pasture and is moderately well suited to woodland. Community development group 1; capability unit VIs–1; woodland group 3s1.

Isan Series

The Isan series consists of nearly level, very poorly drained soils formed in outwash sands. These soils are in depressions and drainageways and on low flats of outwash plains. Native vegetation was tall prairie grass, mostly sedges and grasses.

In a representative profile the surface layer is black sandy loam in the upper 11 inches and very dark gray loamy sand in the lower 13 inches. The subsoil is

distinctly mottled, dark-gray loose sand about 6 inches thick. The underlying material is gray coarse sand.

Permeability is rapid, and the available water capacity is low. The organic-matter content is high. The supply of available nitrogen and phosphorus is medium and potassium low. In undrained areas the water table is commonly at the surface or within a depth of 2 feet.

Most areas of Isan soils are pastured. Some drained areas are cropped. The major limitation is the hazard of wetness.

Representative profile of Isan sandy loam, in a pasture, 200 feet south and 300 feet west of center of sec. 31, T. 32 N., R. 24 W.

A1—0 to 11 inches, black (10YR 2/1) sandy loam; weak, very thick, platy structure breaking to a weak, fine and medium, subangular blocky; friable; slightly acid; abrupt, smooth boundary.
A3—11 to 24 inches, very dark gray (10YR 3/1) loamy sand; very weak, thick, platy structure breaking to single grained; very friable; slightly acid; clear, smooth boundary.
B2g—24 to 30 inches, dark-gray (10YR 4/1) sand; few, medium, distinct, yellowish-brown (10YR 5/6) mottles; single grained; loose; slightly acid; clear, smooth boundary.
Cg—30 to 60 inches, gray (5Y 5/1) coarse sand; single grained; loose; neutral.

The thickness of the solum ranges from 24 to 32 inches. The A1 horizon is black and is 10 to 14 inches thick. The A3 horizon is very dark gray. The A1 horizon typically is sandy loam, but ranges to loamy sand. The B horizon is dark gray or gray and has few to many mottles. The upper part is loamy coarse sand, coarse sand, loamy sand, or sand, and the lower part is sand or coarse sand. Discontinuous strata of coarse sandy loam or loamy coarse sand 1 to 6 inches thick occur in the B horizon in some places. The C horizon is sand or coarse sand and commonly has strata of fine gravel. Reaction throughout the soil typically is slightly acid, but ranges from strongly acid to neutral.

Isan soils are associated with Hubbard and Duelm soils and are similar to Isanti soils. They are grayer in the B and C horizons and are more poorly drained than Duelm and Hubbard soils. They have coarser sand throughout than Isanti soils.

Is—Isan sandy loam. This nearly level soil is in depressional positions in old drainageways and on rims 100 to 400 feet wide surrounding very poorly drained organic soils or marsh areas in the outwash plains. Included in mapping are small areas of Markey and Duelm soils.

The chief limitations for both farm and urban use are the high water table and the resulting hazard of wetness.

Most areas are pastured. Some drained areas are cropped. Commonly grown crops are corn and soybeans. Community development group 6; capability unit IVw–2; woodland group 5w1.

Isanti Series

The Isanti series consists of nearly level, very poorly drained soils formed in outwash sands. These soils are in depressions and drainageways and on low flats of outwash plains. The native vegetation was grasses, sedges, and willows.

In a representative profile the surface layer is black fine sandy loam about 10 inches thick. The subsoil is gray and dark-gray, loose fine sand about 21 inches thick. The underlying material is light brownish-gray fine sand.

Permeability is rapid, and the available water capacity is low. The organic-matter content is moderate. The supply of available nitrogen is low, phosphorus medium, and potassium low. In undrained areas the water table is commonly at the surface or within a depth of 2 feet.

Most areas of Isanti soils are pastured. Some drained areas are cropped. The major limitation is the hazard of wetness.

Representative profile of Isanti fine sandy loam, in an uncultivated field, 760 feet north and 25 feet east of the southwest corner of sec. 5, T. 31 N., R. 23 W.

A1—0 to 4 inches, black (10YR 2/1) fine sandy loam, weak, medium, platy structure; very friable; strongly acid; abrupt, smooth boundary.
A12—4 to 10 inches, black (N 2/0) fine sandy loam; weak, thin, platy structure; very friable; strongly acid; abrupt, wavy boundary.
B1g—10 to 14 inches, gray (N 5/0) fine sand; single grained; loose; common very dark gray (10YR 3/1) discontinuous horizontal streaks 1 to 3 centimeters thick and a few small black inclusions; medium acid; clear, wavy boundary.
B21g—14 to 26 inches, gray (10YR 5/1) fine sand; single grained; loose; strongly acid; abrupt, smooth boundary.
B22g—26 to 31 inches, dark-gray (10YR 4/1) fine sand; single grained; loose; medium acid; abrupt, wavy boundary.
C—31 to 60 inches, light brownish-gray (10TR 6/2) fine sand; single grained; loose; medium acid.

The thickness of the solum ranges from 20 to 40 inches. The A1 horizon is 10 to 14 inches thick. In places there is a very dark gray A3 horizon as much as 6 inches thick. The A horizon typically is fine sandy loam, but ranges to fine sand, sand, loamy sand, and loamy fine sand. The B horizon is gray or dark gray. In places it is mottled. It typically is fine sand, but ranges to sand, loamy sand, and loamy fine sand. The C horizon is gray or light brownish-gray fine sand or sand. Reaction is strongly acid to medium acid in the A and B horizons and medium acid to slightly acid in the C horizon.

Isanti soils are associated with Zimmerman, Sartell, Lino, and Soderville soils and are similar to Isan and Kratka soils. They are grayer and more poorly drained than Zimmerman, Sartell, Lino, and Soderville soils. They lack the loamy IIC horizon typical of Kratka soils. They have more fine sand and less coarse sand than Isan soils.

Iw—Isanti fine sandy loam. This nearly level soil is in small depressions, on narrow rims surrounding large areas of organic soils, and in narrow low-lying drainageways. Areas are 5 to 80 acres in size. The water table is high. Slopes are 0 to 2 percent.

Included with this soil in mapping are soils that contain strata of coarse sand. Also included are small areas of Markey and Lino soils.

The chief limitations for both farm and urban use are the high water table and the resulting hazard of wetness.

Most areas are pastured. Some drained areas are cropped. Commonly grown crops are corn and soybeans. Community development group 6; capability unit IVw–2; woodland group 5w1.

Kingsley Series

The Kingsley series consists of gently undulating to very steep, well-drained soils formed in reddish-brown glacial till. These soils are on the convex slopes

of end moraines. Native vegetation was deciduous forest.

In a representative profile the surface layer is very dark gray fine sandy loam about 3 inches thick. The subsurface layer is pale-brown fine sandy loam about 10 inches thick. The upper part of the subsoil is reddish-brown firm sandy clay loam, and the lower part is dark reddish-brown friable fine sandy loam. The underlying material is dark reddish-brown sandy loam.

Permeability is moderately slow, and the available water capacity is high. The organic-matter content is low. The supply of available nitrogen is low, phosphorus medium and potassium low.

Most areas of Kingsley soils are used for crops or wooded pasture. The major limitation is the hazard of erosion.

Representative profile of Kingsley fine sandy loam, 2 to 6 percent slopes, in a wooded pasture, 30 feet east of the southwest corner SE¼ sec. 28, T. 34 N., R. 25 W.

A1—0 to 3 inches, very dark gray (10YR 3/1) fine sandy loam; weak, fine, granular structure; very friable; about 5 percent coarse fragments; neutral; abrupt, smooth boundary.

A2—3 to 13 inches, pale-brown (10YR 6/3) fine sandy loam; weak, medium, platy structure; very friable; about 10 percent coarse fragments; slightly acid; clear, irregular boundary.

B&A—13 to 16 inches, brown (7.5Y 5/4) fine sandy loam; weak, fine, subangular blocky structure; friable; moderately thick, light-gray, porous coatings on ped faces; about 10 percent coarse fragments; medium acid; clear, wavy boundary.

B21t—16 to 25 inches, reddish-brown (5YR 5/3) sandy clay loam; moderate, medium, subangular blocky structure; firm; moderately thick, patchy clay films on ped faces; thin, light-gray, porous coatings on vertical ped faces; about 15 percent coarse fragments; strongly acid; clear, smooth boundary.

B22t—25 to 34 inches, dark reddish-brown (5YR 3/4) fine sandy loam; common, medium, faint, yellowish-red (5YR 5/6) and reddish-yellow (5YR 6/8) mottles in the lower part; weak, very thick, platy structure; friable; about 15 percent coarse fragments; moderately thick, patchy clay films on ped faces; strongly acid; clear, smooth boundary.

C1—34 to 58 inches, dark reddish-brown (5YR 3/4) sandy loam; few, medium, faint, reddish-yellow (5YR 6/8) mottles; weak, very thick, platy structure; friable; hard and slightly brittle; few clay bridges between sand grains and few thin clay films in pores; about 10 percent coarse fragments; medium acid; clear, smooth boundary.

C2—58 to 78 inches, dark reddish-brown (5YR 3/4) sandy loam; moderate, thick, platy structure; friable; hard and slightly brittle; about 10 percent coarse fragments; slightly acid.

The thickness of the solum ranges from 30 to 45 inches. The soil is commonly 10 to 20 percent coarse fragments.

The A1 horizon is black, very dark gray, or very dark brown and is 2 to 4 inches thick. The Ap horizon is very dark brown, very dark grayish brown, or dark brown. The A2 horizon is pale brown, grayish brown, or brown and is 6 to 16 inches thick. The A horizon is fine sandy loam, sandy loam, or coarse sandy loam.

The B22t horizon is reddish brown, dark reddish brown, or dark brown. Faint mottles are lacking in some places. The B horizon is sandy clay loam, loam, and fine sandy loam.

The C horizon typically is reddish brown or dark reddish brown. Thin discontinuous strata and pockets of sand and gravelly sand are common in the B and C horizons of some soils. Thin strata of yellower fine sandy loam and loam are also common.

Reaction throughout is strongly acid to neutral. The B horizon is the most acid.

Kingsley soils are associated with Mora and Ronneby soils and are similar to Heyder soils. They differ from Mora and Ronneby soils in having no mottles in the A2 horizon and upper B horizon. They differ from Heyder soils in having redder colors in the B and C horizons.

KmB—Kingsley fine sandy loam, 2 to 6 percent slopes. This gently undulating soil occupies convex sloping areas 5 to 60 acres in size. This soil has the profile described as representative of the series. In cultivated areas the surface layer is thicker. Included in mapping are small narrow drainageways of Mora and Ronneby soils.

The chief limitation for both farm and urban use is the hazard of erosion. Scattered stones can be troublesome during cultivation.

Most areas are used for crops, to which the soil is well suited. Commonly grown crops are corn, soybeans, oats, and alfalfa. Some areas are wooded. Community development group 3; capability unit IIe–1; woodland group 2o2.

KmC2—Kingsley fine sandy loam, 6 to 12 percent slopes, eroded. This rolling soil is on crests and hillsides. Areas are 3 to 15 acres in size. This soil has a profile similar to the one described as representative of the series, but the surface layer is commonly thinner. Erosion has removed part of the original surface layer, and tillage has mixed material from the subsoil with the remaining surface layer. Thus, the present surface layer is browner than is typical.

Included with this soil in mapping are small areas where all of the surface layer has been removed and the present surface layer is entirely subsoil material. Also included are small areas of Chetek soils.

The chief limitation for both farm and urban use is the severe hazard of erosion.

Most areas are cropped. This soil is moderately well suited to this use. Commonly grown crops are corn, soybeans, alfalfa, and oats. Some areas are used for pasture, to which the soil is well suited. Community development group 3; capability unit IIIe–1; woodland group 2o2.

KmD—Kingsley fine sandy loam, 12 to 18 percent slopes. This moderately steep soil is on short, narrow, irregular side slopes. Areas are 3 to 30 acres in size. This soil has a similar, but thinner, profile than the one described as representative of the series. Where eroded, the surface layer is mixed with material from the subsoil and is browner than is typical.

Included with this soil in mapping are small areas where the surface layer is entirely subsoil material. Also included are small areas of Chetek or Heyder soils.

The chief limitations for both farm and urban use are the steep slopes and severe hazard of erosion.

Most areas are pastured or wooded, to which the soil is well suited. Some areas are cropped, to which the soil is poorly suited. Steep slopes and a severe hazard of erosion limit the use of this soil for such crops as corn and soybeans. Community development group 3; capability unit IVe–1; woodland group 2r1.

KmE—Kingsley fine sandy loam, 18 to 30 percent slopes. This steep to very steep soil occurs on a morainic landscape. Areas are 10 to 30 acres in size. Slopes are short and irregular. This soil has a thinner profile than the one described as representative of the

series. Included in mapping are small areas of Emmert or Heyder soils and areas where slopes are less than 18 percent.

The chief limitations to the use and management of this soil are the steep slopes and severe hazard of erosion.

Most areas are pastured or wooded. This soil is very poorly suited to crops and poorly suited to most other uses. Community development group 3; capability unit VIe–1; woodland group 2r1.

Kratka Series

The Kratka series consists of nearly level, very poorly drained soils formed in a sandy mantle overlying loamy till or lacustrine material. These soils are on flats and in shallow depressions in glacial lake basins and gently sloping ground moraines. Native vegetation was wetland grasses and sedges and willow, alder, and scattered elm.

In a representative profile the surface layer is black loamy fine sand about 12 inches thick. The subsoil is mottled dark-gray and gray, very friable to loose fine sand and loamy fine sand about 24 inches thick. The underlying material is mottled greenish-gray fine sandy loam.

Permeability is moderately slow, and the available water capacity is moderate. The organic-matter content is moderate. The supply of available nitrogen is low, phosphorus medium, and potassium low. In undrained areas the water table is at the surface or within a depth of 24 inches for the greater part of the year.

Most areas of Kratka soils are pastured. Some drained areas are cropped. The major limitation is the hazard of wetness.

Representative profile of Kratka loamy fine sand, in an uncultivated field, 800 feet south and 265 feet west of the northeast corner of sec. 21, T. 31 N., R. 21 W.

A1—0 to 12 inches, black (10YR 2/1) loamy fine sand; weak, medium, granular structure; very friable; slightly acid; abrupt, irregular boundary.

B1g—12 to 20 inches, dark-gray (10YR 4/1) loamy fine sand; weak, coarse, platy structure; very friable; slightly acid; abrupt, wavy boundary.

B21g—20 to 27 inches, gray (10YR 6/1) fine sand; few, medium, distinct, strong-brown (7.5YR 5/6) mottles; single grained; loose; neutral; clear, wavy boundary.

B22g—27 to 36 inches, gray (10YR 6/1) fine sand; many, coarse, distinct, strong-brown (7.5YR 5/6) and brownish-yellow (10YR 6/8) mottles; massive parting to single grained; friable; neutral; abrupt, smooth boundary.

IICg—36 to 60 inches, greenish-gray (5GY 6/1) fine sandy loam; common, coarse, distinct, yellowish-brown (10YR 5/8) and light yellowish-brown (10YR 6/4) mottles; massive breaking to weak, thick, platy structure; friable; thin layer of pebbles at surface of horizon and about 5 percent coarse fragments in other part; moderately alkaline, strongly effervescent.

The thickness of the solum ranges from 24 to 48 inches. The depth to loamy material ranges from 20 to 40 inches. The A horizon is black or very dark gray loamy fine sand or fine sandy loam and is 10 to 16 inches thick. The B horizon is loamy fine sand or fine sand and is 10 to 32 inches thick. In some places there is a IIB horizon of fine sandy loam. Reaction is slightly acid to neutral. The C horizon is fine sandy loam or loam. Reaction is neutral to moderately alkaline.

The Kratka soils of Anoka County are more moist and are in a slightly warmer climate than is defined as the range for the series. This difference does not significantly alter use or management.

Kratka soils are associated with Blomford and Braham soils and are similar to Isanti soils. They have a thinner and darker-colored A horizon and are more poorly drained than Blomford soils. They are more poorly drained and have a grayer B horizon than Braham soils. They have a loamy IIC horizon or IIB horizon within a depth of 40 inches, which is lacking in Isanti soils.

Kr—Kratka loamy fine sand. This nearly level soil occurs in shallow depressions and in low-lying flats. Areas are 10 to 80 acres in size. Included in mapping are areas of Isanti and Webster soils and small areas of Blomford soils.

The chief limitations to use and management of this soil are the high water table and the resulting hazard of wetness. This soil is poorly suited to both farm and urban use.

Most areas are pastured. Some drained areas are cropped. Commonly grown crops are corn and soybeans. Community development group 6; capability unit IVw–2; woodland group 5w1.

Lake Beaches

Lb—Lake beaches. This nearly level to gently sloping land occupies shoreline areas 75 to 300 feet wide around lakes and sloughs. Few, if any, soil horizons have formed. The material is sand, coarse sand, and gravelly coarse sand. Some loamy material occurs in the glacial till areas of the county.

Lake beaches are very poorly to somewhat poorly drained. The water table is at the surface or within a depth of 4 feet. In some areas ice and wave action and the resulting ramparts and ridges have formed distinct sloping ridges 3 to 7 feet high and 3 to 30 feet wide. These pressure ridges are higher above the water table and have better internal drainage than is typical.

The hazard of wetness is a limitation to the use and management. Most areas are still in natural vegetation. Others are used for homesites, to which Lake beaches are poorly suited. Community development group 6; capability unit IVw–2; woodland group 5w1.

Langola Series

The Langola series consists of nearly level to gently sloping, well-drained soils formed in a sandy mantle and the underlying till. These soils are on low lying flats on the outwash plains. Native vegetation was tall grass prairie and open oak forest.

In a representative profile the surface layer is very dark brown loamy sand about 10 inches thick. The upper part of the subsoil is dark-brown loose sand and gravelly loamy sand, and the lower part is reddish-brown friable sandy loam. The underlying material is reddish-brown sandy loam.

Permeability is rapid in the upper part of these soils and moderately slow in the lower part. Available water capacity is low to moderate. The organic-matter content is moderate. The supply of available nitrogen is low, phosphorus medium, and potassium low.

Most areas of Langola soils are under urban develop-

ment. Some are still in forest. The major limitations to use are the low to moderate available water capacity and the resulting hazards of soil blowing and droughtiness.

Representative profile of Langola loamy sand, 0 to 6 percent slopes, in a former cultivated field, 300 feet west and 600 feet north of the center of sec. 21, T. 31 N., R. 24 W.

Ap—0 to 10 inches, very dark brown (10YR 2/2) loamy sand; weak, fine, subangular blocky structure; very friable; medium acid; abrupt, smooth boundary.

B21—10 to 27 inches, dark-brown (10YR 4/3) sand; massive in places breaking to single grained; loose; medium acid; clear, smooth boundary.

B22—27 to 31 inches, dark-brown (7.5YR 4/4) gravelly loamy sand; weak, fine, subangular blocky structure; very friable; about 30 percent gravel; slightly acid; clear smooth boundary.

IIB23—31 to 38 inches, reddish-brown (5YR 4/3) sandy loam; few, fine, faint, yellowish-red (5YR 4/8) and reddish-yellow (5YR 6/8) mottles; moderate, fine and medium, subangular and angular blocky structure; friable; common, thin clay films as bridging between sand grains and in pores; about 10 percent coarse fragments; slightly acid; clear, smooth boundary.

IIC—38 to 60 inches, reddish-brown (5YR 4/4) sandy loam; moderate, thick, platy structure; firm, about 10 percent coarse fragments; slightly acid.

The thickness of the solum ranges from 36 to 48 inches. Depth to sandy loam till is 24 to 40 inches. The surface sandy mantle commonly is free of gravel, but the horizon just above the sandy loam till is as much as 35 percent gravel. The IIB horizon and IIC horizon are 8 to 15 percent coarse fragments.

The A horizon is black, very dark brown, or very dark grayish brown and is 7 to 12 inches thick. It is loamy sand, loamy fine sand, sand, or fine sand.

The B21 horizon is dark-brown or dark yellowish-brown sand or loamy sand. The B22 horizon is a gravel, loamy sand, gravelly sand, loamy sand, or sand. This horizon is commonly called a lagline (pebble band) and it separates the sandy mantle from the underlying till material. In places it contains some cobbles and stones. It is as much as 10 inches thick. The IIB horizon is reddish-brown sandy loam or fine sandy loam. In places the faint mottling is not evident.

The IIC horizon is dark reddish-brown or reddish-brown sandy loam or fine sandy loam. Thin discontinuous strata and pockets of sand are common in the IIC horizon in some places.

Reaction is medium acid to slightly acid in the solum. It is slightly acid to neutral in the IIC horizon.

Langola soils are associated with Hubbard soils and are similar to Braham soils. They differ from Hubbard soils in having a sandy loam IIC horizon beginning at a depth of 24 to 40 inches. They differ from Braham soils in having a thicker and darker A horizon and having redder colors in the IIC horizons.

LgB—Langola loamy sand, 0 to 6 percent slopes. This nearly level to gently sloping soil occurs as an area about 435 acres in size along the Mississippi River. Included in the mapping are small areas of Hubbard and Duelm soils.

The low to moderate available water capacity and the resulting hazards of soil blowing and droughtiness are limitations to the use and management of this soil.

Most areas are under urban development, to which the soil is well suited. Some areas are still wooded. Community development group 3; capability unit IIIs–2; woodland group 2o2.

Lino Series

The Lino series consists of nearly level to gently sloping, somewhat poorly drained soils formed in outwash sands. These soils are in small drainageways and on low broad flats of glacial outwash plains. Native vegetation was deciduous forest, chiefly aspen and oaks, and an understory of water-tolerant grasses.

In a representative profile the surface layer is dark grayish-brown loamy fine sand about 7 inches thick. The subsoil is mottled brown and light brownish-gray, very friable to loose fine sand about 38 inches thick. The underlying material is mottled pale-brown fine sand.

Permeability is rapid, and the available water capacity is low. The organic-matter content is low. The supply of available nitrogen is low, phosphorus medium, and potassium low. In undrained areas the water table is commonly at a depth of 2 to 4 feet.

Most areas of the Lino soils are cropped or pastured. Some areas are still wooded, and other areas are under urban development. The major limitation is the hazard of wetness.

Representative profile of Lino loamy fine sand, 0 to 4 percent slopes, in a cultivated field, 320 feet east and 1,010 feet south of the midpoint of sec. 7, T. 31 N., R. 22 W.

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) loamy fine sand; weak, fine, subangular blocky structure; very friable; medium acid; abrupt, smooth boundary.

B2—7 to 16 inches, brown (10YR 5/3) fine sand; many, medium, faint, light brownish-gray (10YR 6/2) and yellowish-brown (10YR 5/6) mottles; weak, fine and medium, subangular blocky structure; very friable; strongly acid; gradual, wavy boundary.

B3—16 to 45 inches, light brownish-gray (10YR 6/2) fine sand, many, coarse, prominent, reddish-brown (5YR 5/3) and yellowish-red (5YR 4/6) mottles; single grained; loose; mottles mostly vertically oriented and very weakly cemented when dry; medium acid; gradual, wavy boundary.

C—45 to 66 inches, pale-brown (10YR 6/3) fine sand; many, coarse, prominent, reddish-brown (5YR 5/4), brown (10YR 5/3), and gray (10YR 6/1) mottles; massive breaking readily to single grained; very friable; reddish-brown and brown mottles weakly cemented when dry; medium acid.

The thickness of the solum ranges from 24 to 50 inches. The Ap horizon is dark-gray or dark grayish-brown loamy fine sand or fine sand. In undisturbed areas the A1 horizon is black or very dark gray. Some soils have an A2 horizon of loamy fine sand or fine sand as much as 6 inches thick. The B horizon is brown, light brownish gray, or grayish brown and has common or many distinct or prominent mottles. Reaction in the solum ranges from strongly acid to medium acid.

Lino soils are associated with Zimmerman, Sartell, Soderville, and Isanti soils. They have browner colors in the B horizon than Isanti soils. They are mottled throughout, whereas Zimmerman and Sartell soils lack mottles. They lack the finer textured layers in the B horizon that are characteristic of Soderville soils.

LnA—Lino loamy fine sand, 0 to 4 percent slopes. This nearly level to gently sloping soil is in small low-lying drainageways and small depressions and on low broad flats. They also occupy small areas that are a few feet higher than the surrounding larger, very poorly drained areas. All mapped areas are 3 to 30

acres in size. In undisturbed areas, the surface layer is darker and thinner than is typical.

Included with this soil in mapping are small areas of Zimmerman or Sartell soils. Also included and identified on the soil map by spot symbols are small depressions of Isanti soils.

The chief limitations for both farm and urban use are the moderately high water table and the resulting hazard of wetness. During dry periods soil blowing is a hazard to immature crops.

Most areas are cropped. The soil is moderately well suited to this use. Commonly grown crops are corn and soybeans. Some areas are pastured or wooded. Some areas are also under urban development, to which the soil is poorly suited. Community development group 4; capability unit IVw–1; woodland group 3s1.

Loamy Wet Land

Lw—Loamy wet land. This nearly level, very poorly drained land is in depressions and at the edges of large areas of organic soil in the loamy till areas of the county. It varies considerably in texture and in thickness and sequence of horizons.

In a representative profile the surface layer is black or very dark brown loam, sandy loam, or silt loam about 6 to 26 inches thick. The underlying material is mottled, grayish fine sandy loam, sandy loam, or loam. Thin strata of sand and coarse sand are common.

Permeability is moderately slow, and available water capacity is high. Natural fertility is moderate. The water table is at the surface or within a depth of 2 feet unless this land is drained.

Most areas are cropped or pastured. Drainage is needed for crop production. This land is poorly suited to crops and to most other uses. Community development group 6; capability unit IIIw–4; woodland group 5w1.

Lupton Series

The Lupton series consists of nearly level, very poorly drained soils formed in organic soil materials. These soils are in bogs in the sandy outwash plains. Native vegetation was mainly white-cedar forest.

In a representative profile the surface layer is dark reddish-brown and black muck about 9 inches thick. The subsurface layers are black muck. The underlying material is dark grayish-brown and black muck.

Permeability is moderately rapid, and the available water capacity is very high. The organic-matter content is very high. The supply of available nitrogen is high, phosphorus low, and potassium low. The water table is at or near the surface unless these soils are drained.

Most areas of the Lupton soils are in forest. A few small areas are wooded pasture. The major limitation is the hazard of wetness.

Representative profile of Lupton muck, in a white-cedar forest, 1,300 feet west and 100 feet north of the center of sec. 27, T. 34 N., R. 23 W.

Oa1—0 to 9 inches, dark reddish-brown (5YR 2/2 broken face and rubbed) and mixed with black (5YR 2/1 broken face and rubbed) sapric material; about 10 percent fiber, less than 5 percent rubbed; weak, fine, granular structure; woody fiber, about 20 percent mineral; few masses of yellowish-brown (10YR 5/4) bog iron; strongly acid; abrupt, smooth boundary.

Oa2—9 to 48 inches, black (5Y 2/1 broken face and rubbed) sapric material; about 20 percent fiber, about 5 percent rubbed; weak, fine, granular structure; primarily woody fiber, about 20 percent mineral; strongly acid; gradual, smooth boundary.

Oa3—48 to 58 inches, black (10YR 2/1 broken face and rubbed) sapric material; about 35 percent fiber, about 10 percent rubbed; primarily woody fiber; a few fibers are as much as 4 to 12 inches long and ½ to 2 inches wide, all breaking down on rubbing; about 30 percent mineral; strongly acid; gradual, smooth boundary.

Oa4—58 to 70 inches, dark grayish-brown (10YR 4/2 broken face) fiber and black (10YR 2/1 broken face) matrix sapric material; black (10YR 2/1) rubbed; about 40 percent fiber, less than 5 percent rubbed; massive; primarily herbaceous fibers, about 30 percent mineral; medium acid.

The thickness of the organic soil material exceeds 51 inches. This material primarily has woody fibers. Layers or masses of bog iron commonly are in the upper 10 inches; the mineral content is about 60 percent. In some places there are a few indurated iron oxide pipe-stem formations ¼ to ½ inch thick. The content of fiber, unrubbed, in the sapric material is 20 to 40 percent. These fibers break down readily when the soil is rubbed. In places a hemic layer as much as 10 inches thick is above a depth of 51 inches. The fibers in such layers are mostly of woody origin. The hemic layers below a depth of 51 inches are primarily herbaceous materials. Reaction is strongly acid to neutral.

Lupton soils of Anoka County are outside the range defined for the series because of bog iron in the upper part of the soil and a more acid reaction. These differences, however, do not alter use or management.

Lupton soils are associated with Rifle and Seelyeville soils. In contrast with Rifle soils they are dominantly sapric materials. They have fibers primarily from woody materials, whereas Seelyeville soils are dominated by fibers from herbaceous materials.

Lx—Lupton muck. This soil is at the outer edges of large enclosed depressions. It has better surface and subsurface drainage than soils in the center of the bog. Consequently, trees can grow on this soil. The surface is hummocky. There is a difference of 6 to 10 inches between the high and low positions. The greatest concentration of bog iron is in the higher parts of the hummocky surface. Included in mapping are small areas of Rifle and Seelyeville soils.

The high water table and moderately slow permeability and the resulting hazard of wetness are limitations to the use and management of this soil.

Most areas are still in native vegetation. None are cropped. This soil is poorly suited to crops and very poorly suited to most urban uses. Community development group 7; capability unit IIIw–3; woodland group 5w1.

Markey Series

The Markey series consists of nearly level, very poorly drained soils formed in organic soil material overlying sands. These soils are in small bogs and along the edge of larger bogs in the sandy outwash plains. Native vegetation was mainly sedges, grasses, cattails, and scattered willow and birch trees.

In a representative profile the surface layer is black muck about 10 inches thick. The subsurface layers are black or very dark brown muck. The upper 5 inches

of the underlying material is very dark gray fine sandy loam, and the rest is grayish-brown and gray sand and fine sand.

Permeability is moderately rapid, and the available water capacity is high. The organic-matter content is very high. The supply of available nitrogen is high, phosphorus low, and potassium low. The water table is at or near the surface unless these soils are drained.

Most areas of Markey soils are in native vegetation. Some are cropped or pastured. The chief limitations are the hazards of wetness, ponding, and unseasonable frost.

Representative profile of Markey muck, in a former cultivated field, 200 feet north and 1,220 feet west of the center of sec. 15, T. 31 N., R. 23 W.

Oap—0 to 10 inches, black (10YR 2/1 broken face, and rubbed) sapric material; about 5 percent fibers, all fibers destroyed on rubbing; weak, fine and medium, subangular blocky structure; very friable; herbaceous fiber; about 15 percent mineral material; slightly acid; abrupt, smooth boundary.

Oa1—10 to 16 inches, black (10YR 2/1 broken face and rubbed) sapric material; about 20 percent fibers, 5 percent rubbed; weak, thick, platy structure; very friable; herbaceous fiber; about 10 percent mineral material; slightly acid; clear, smooth boundary.

Oa2—16 to 26 inches, vary dark brown (10YR 2/2 broken) sapric material; black (10YR 2/1 rubbed); about 30 percent fiber, about 10 percent rubbed; weak, coarse, subangular blocky structure; very friable; herbaceous fiber; about 20 percent mineral material; slightly acid; clear, smooth boundary.

Oa3—26 to 31 inches; black (N 2/0 broken face and rubbed) sapric material; about 5 percent fibers; all fibers destroyed on rubbing; massive; very friable; herbaceous fiber; about 30 percent mineral material; slightly acid; abrupt, wavy boundary.

IIA1b—31 to 36 inches, very dark gray (10YR 2/1) fine sandy loam; few, fine, medium, faint, dark-brown 10YR 3/3) mottles; massive; friable; slightly sticky; neutral; clear, wavy boundary.

IIC1g—36 to 46 inches, grayish-brown (10YR 5/2) sand; single grained; nonsticky; a few black (10YR 2/1) convolutes and involutes of very dark gray (10YR 3/1) mucky fine sandy loam in the upper part; neutral; clear, wavy boundary.

IIC2g—46 to 62 inches, gray (10YR 6/1) fine sand; single grained; nonsticky; neutral.

The thickness of the organic soil material typically ranges from 16 to 51 inches. This is mostly sapric material, mainly of herbaceous origin. Some soils have thin hemic layers 10 inches thick or less. Reaction in the organic soil material is slightly acid to neutral. The color is black and very dark brown. The IIA1b horizon is black, very dark gray, or very dark brown sandy loam, fine sandy loam, or loamy fine sand. It is as much as 9 inches thick in some places and does not occur in others. The IIC horizon is grayish brown and gray and ranges from fine sand to coarse sand. Reaction is typically neutral but ranges from slightly acid to mildly alkaline.

Markey soils are associated with Rifle and Seelyeville soils and are similar to Cathro soils. They are shallower over mineral soil material than Rifle and Seelyeville soils. They are underlain mainly by sand, whereas Cathro soils are underlain by loamy materials.

Ma—Markey muck. This soil occurs as small bogs or as part of a larger bog in the sandy outwash areas. Included in mapping are a few small areas of Seelyeville, Rifle, and Isanti soils.

The high water table and the resulting hazard of wetness are limitations to the use and management of this soil.

Most areas are in native vegetation. Drainage is needed for crop production. The soil is poorly suited to most crops and is very poorly suited to urban uses. Community development group 6; capability unit IVw–3; woodland group 5w1.

Marsh

Mc—Marsh. Marshes are shallow lakes or ponds where water is 1 to 3 feet deep most of the year. They support aquatic vegetation, such as cattails, reeds, and sedges, and other water tolerant plants. Some marshes are self-contained depressions. Others border existing lakes and streams. The soil material is unclassified, but is similar to Loamy wet land and Markey, Millerville, and Rifle soils.

Marsh areas commonly are impractical to drain. They provide excellent habitat for wetland wildlife and open space for urban use. Community development group 7; capability unit VIIIw–1; woodland group 5w1.

Meehan Series

The Meehan series consists of nearly level, somewhat poorly drained soils formed in outwash sands. These soils are in low-lying drainageways and on low broad flats of outwash plains. The native vegetation was deciduous forest, dominantly oak, and an under-story of water-tolerant grasses.

In a representative profile the surface layer is very dark grayish-brown sand about 8 inches thick. The subsoil is mottled brown, dark-brown, and grayish-brown friable sand about 32 inches thick. The underlying material is mottled pale-brown sand.

Permeability is rapid, and the available water capacity is low. The organic-matter content is low. The supply of available nitrogen, phosphorus, and potassium is low. In undrained areas the water table is commonly at a depth of 2 to 5 feet.

Most areas of Meehan soils are cropped or pastured. Some areas are under urban development. The chief limitation is the hazard of wetness.

Representative profile of Meehan sand, in a cultivated field, 1,250 feet west and 150 feet south of the middle of sec. 7, T. 32 N., R. 25 W.

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) sand; weak, fine, subangular blocky structure; very friable; strongly acid; abrupt, smooth boundary.

B21—8 to 19 inches, brown (10YR 5/3) sand; many, medium, faint, dark-brown (7.5YR 3/2), strong-brown (7.5YR 5/6), and grayish-brown (10YR 5/2) mottles; massive breaking readily to single grained; very friable; medium acid; clear, wavy boundary.

B22—19 to 26 inches, dark-brown (10YR 4/3) sand; many, medium, distinct, yellowish-red (5YR 5/8), dark reddish-brown (5YR 3/3), reddish-yellow (5YR 6/8), and grayish-brown (10YR 5/2) mottles; massive breaking readily to single grained; very friable; mottles mostly vertically oriented and weakly cemented; medium acid; gradual, irregular boundary.

B23—26 to 40 inches, grayish-brown (10YR 5/2) sand; many, coarse, prominent, dark reddish-brown (5YR 3/3) and yellowish-red (5YR 4/6) mottles; massive breaking readily to single grained; loose; mottles mostly vertically oriented and strongly cemented; medium acid; gradual, irregular boundary.

C—40 to 60 inches, pale-brown (10YR 6/3) sand; common, coarse, distinct, strong-brown (7.5YR 5/8) and brownish-yellow (10YR 6/8) mottles; single grained; loose; medium acid.

The thickness of the solum ranges from 28 to 48 inches. The Ap horizon is black, very dark brown, very dark grayish brown, or dark brown. Undisturbed soils have an A1 horizon that is black or very dark gray and is 3 to 7 inches thick. This horizon typically is sand or loamy sand, but ranges to sandy loam. Reaction is strongly acid to medium acid. The B horizon is brown, dark brown, and grayish brown and has common or many distinct or prominent mottles. It is 22 to 41 inches thick and is medium acid. The C horizon is mottled pale brown or yellowish brown. In places it contains strata of fine sand, coarse sand, or fine gravel. Reaction is medium acid in the upper part of the C horizon and becomes neutral with increasing depth.

Meehan soils are associated with Nymore and Isan soils and are similar to Duelm and Lino soils. They have a thinner A1 horizon and are better drained than Isan soils. They have mottles in the B horizon, whereas the excessively drained Nymore soils lack mottles in that horizon. They have a thinner A horizon and less coarse sand throughout than Duelm soils. They contain more medium sand than Lino soils.

Me—Meehan sand. This nearly level soil is in small, low-lying drainageways and small depressions and on low broad flats. Areas are 5 to 40 acres in size. In undisturbed areas the surface layer is 3 to 7 inches thick.

Included with this soil in mapping are soils that have no mottling to a depth of 30 inches. Also included and identified on the soil map by spot symbols are small depressions of Isan soils.

The chief limitations for both farm and urban use are the moderately high water table and the resulting hazard of wetness. During dry periods soil blowing is a hazard to immature crops.

Most areas are cropped, to which this soil is moderately well suited. Commonly grown crops are corn and soybeans. Some areas are pastured and others are left in native woodland. Community development group 4; capability unit IVw–1; woodland group 3s1.

Millerville Series

The Millerville series consists of nearly level, very poorly drained soils formed in organic soil material and limnic material. These soils are in bogs in the sandy outwash plains. The native vegetation was grasses, sedges, cattails, and scattered alder and willow.

In a representative profile the surface layer is black muck about 4 inches thick. The subsurface layer is dark-brown mucky peat and peat. The underlying material is dark olive-gray, slightly acid, coprogenous earth limnic material.

Permeability is moderately slow, and the available water capacity is very high. The organic-matter content is very high. The supply of available nitrogen is high, phosphorus low, and potassium low. The water table is at or near the surface unless these soils are drained.

Most areas of Millerville soils are in native vegetation. Some are used for crops and pasture. The major limitations are the hazards of wetness, ponding, and unseasonable frost.

Representative profile of Millerville mucky peat, in an uncultivated bog, 1,000 feet north, 150 feet west of the southeast corner of sec. 14, T. 33., R. 23 W.

Oa—0 to 4 inches, black (10YR 2/1 broken face and rubbed) sapric material; about 10 percent fiber, 3 percent rubbed; weak, very fine, granular structure; nonsticky; primarily herbaceous fiber; about 20 percent mineral material; neutral; clear, smooth boundary.

Oe1—4 to 20 inches, dark-brown (7.5YR 3/2 broken face) fiber and very dark brown (7.5 YR 2/2 broken face) matrix hemic material, dark reddish brown (5YR 2/2 rubbed); about 55 percent fiber, 20 percent rubbed; weak, thick, platy structure; nonsticky; primarily herbaceous fiber; about 10 percent mineral material; slighty acid; clear, smooth boundary.

Oe2—20 to 27 inches, dark-brown (7.5YR 3/2 and 4/2 broken face) fiber and dark-brown (7.5YR 3/2 broken face) matrix hemic material, dark brown (7.5YR 3/2 rubbed); about 70 percent fiber, 35 percent rubbed; weak, thick, platy structure; nonsticky; primarily herbaceous fiber; about 10 percent mineral material; slightly acid; clear, smooth boundary.

Oi1—27 to 30 inches, dark-brown (7.5YR 3/2 broken face and rubbed) fibric material; about 85 percent fiber, about 70 percent rubbed; massive; nonsticky; about 60 percent hypnum moss fiber, about 40 percent herbaceous fiber; about 10 percent mineral material; slightly acid; abrupt, smooth boundary.

Lco1—30 to 68 inches, dark olive-gray (5YR 3/2 broken and rubbed) coprogenous earth; about 15 percent detritus; weak, very fine, granular structure; slightly sticky; about 30 percent mineral material; slightly acid.

The depth to coprogenous earth ranges from 16 to 51 inches. Fibers in the organic material are mainly of herbaceous origin, but in places there are thin layers of hypnum moss fibers. The organic soil material typically is 10 to 20 percent mineral material. The coprogenous earth is 15 to 70 percent mineral matter. The surface layer is dark-brown or black sapric material and typically is 3 to 10 inches thick. The subsurface layers mainly are hemic material. In some soils the layer just above the coprogenous layers is fibric material derived from hypnum mosses. The hemic and fibric materials are dark brown. The coprogenous earth is black, dark olive gray, dark olive, or olive brown. In places this material is as much as 20 percent snail shells. Reaction is slightly acid to neutral in the organic material and medium acid to mildly alkaline in the coprogenous earth.

Millerville soils are associated with Rifle and Markey soils. They differ from Rifle soils in having coprogenous earth within a depth of 51 inches. They differ from Markey soils in not having sandy material within a depth of 51 inches.

Mk—Millerville mucky peat. This nearly level soil is near the center of large bogs or in bogs adjacent to existing lakes and marshes. These bogs were postglacial lakes in sandy outwash plains.

Included with this soil in mapping are small areas of Rifle and Markey soils. Also included are two areas in sections 15 and 22 in Coon Rapids that lack layers of organic soil material and have coprogenous earth at the surface.

The chief limitations to the use and management of this soil are the high water table, the moderately slow permeability, and the resulting hazard of wetness.

Most areas are in native vegetation. Some drained areas are cropped. Commonly grown crops are corn for silage and cultured sod. This soil is poorly suited to crops and is very poorly suited to most urban uses. Community development group 7; capability unit IVw–3; woodland group 5w1.

Mora Series

The Mora series consists of nearly level to gently sloping, moderately well drained soils formed in reddish-brown sandy loam till. These soils are in slightly convex areas and in small shallow drainageways of sloping ground moraines. Native vegetation was deciduous forest.

In a representative profile the surface layer is very dark grayish-brown fine sandy loam about 8 inches thick. The subsurface layer is mottled grayish-brown fine sandy loam about 7 inches thick. The upper part of the subsoil is faintly mottled, reddish-brown friable fine sandy loam. The lower part is faintly mottled, reddish-brown firm fine sandy loam that is hard and brittle when dry. The underlying material is firm, reddish-brown sandy loam.

Permeability is moderately slow, and the available water capacity is moderate. The organic-matter content is low. The supply of available nitrogen is low, phosphorus medium, and potassium low. Large stones scattered on the surface and through the soil are troublesome during tillage.

Most areas of Mora soils are cropped. Some are pastured or wooded. The chief limitations are the hazards of erosion, the restriction to rooting, and the moderately high seasonal water table for short periods.

Representative profile of Mora fine sandy loam, 1 to 4 percent slopes, in a cultivated field, 300 feet east and 70 feet west of the northwest corner of the southwest quarter, sec. 5, T. 33 N., R. 25 W.

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; weak, fine, subangular blocky structure; friable; about 10 percent coarse fragments; slightly acid; abrupt, smooth boundary.

A2—8 to 15 inches, grayish-brown (10YR 5/2) fine sandy loam; weak, medium, platy structure; friable; about 10 percent coarse fragments; medium acid; clear, smooth boundary.

B2t—15 to 22 inches, reddish-brown (5YR 5/4) fine sandy loam; few, fine, faint, light reddish-brown (5YR 6/3) and yellowish-red (5YR 4/6) mottles; moderate, medium, subangular blocky structure; friable; about 15 percent coarse fragments; thin, porous coats on vertical ped faces; few clay films on ped faces; slightly acid; clear, smooth boundary.

Bx—22 to 41 inches, reddish-brown (5YR 4/4) fine sandy loam; many, medium, faint, reddish-gray (5YR 5/2) and yellowish-red (5YR 5/8) mottles; moderate, medium and thick, platy structure; firm; hard; peds crush abruptly under pressure; about 15 percent coarse fragments; slightly acid; clear, smooth boundary.

Cx—41 to 60 inches, reddish-brown (5YR 4/4) sandy loam; many, medium, faint, reddish-gray (5YR 5/2) and yellowish-red (5YR 5/8) mottles; moderate, medium and thick, platy structure; firm; hard; peds crush abruptly under pressure; about 15 percent coarse fragments; neutral.

The thickness of the solum ranges from 40 to 60 inches, and the depth to the fragipan ranges from 22 to 32 inches. The soil is commonly 10 to 20 percent coarse fragments, but in places the upper part is less than 10 percent.

The A horizon is black, very dark brown, very dark gray, or very dark grayish brown and is 2 to 8 inches thick. The A2 horizon is faintly mottled or mottle-free; is gray, dark grayish brown, or grayish brown; and is 4 to 13 inches thick. The A horizon is fine sandy loam or sandy loam.

The upper part of the B horizon is reddish-brown, yellowish-red, or dark-brown loam, sandy loam, or fine sandy loam. The Bx horizon is reddish-brown or dark reddish-brown sandy loam or fine sandy loam.

The C horizon is reddish-brown, dark reddish-brown, or dark-brown sandy loam. Thin, discontinuous strata and masses of sand and gravelly sand are in the B and C horizon of some soils.

Reaction is strongly acid to slightly acid in the solum and slightly acid to neutral in the C horizon.

Mora soils are associated with Kingsley and Ronneby soils. Unlike Kingsley soils, they have reddish-gray mottles in the lower part of the B horizon. They are better drained and have more reddish colors in the upper part of the B horizon than Ronneby soils.

MoA—Mora fine sandy loam, 1 to 4 percent slopes. This nearly level to gently sloping soil occupies small drainageways and areas of low relief. Areas are 3 to 30 acres in size. Included in mapping are small areas of Kingsley and Ronneby soils and areas where stoniness is excessive. The stony areas are identified by spot symbols on the soil map.

The slight hazard of erosion, the restriction to proper rooting, the moderately high seasonal water table, and the resulting hazard of wetness are slight limitations to the use and management of this soil. Wetness is more restrictive for urban development than for farming. Large surface stones have to be removed before the soil can be cultivated.

This soil is used chiefly for crops, to which it is well suited. Commonly grown crops are corn, soybeans, clover, and alfalfa. Community development group 3; capability unit IIe–2; woodland group 2o2.

Nessel Series

The Nessel series consists of nearly level to gently sloping, moderately well drained soils formed in limy glacial till. These soils are on the plane to slightly convex slopes of ground moraines. The native vegetation was deciduous forest.

In a representative profile the surface layer is very dark grayish-brown fine sandy loam about 9 inches thick. The subsurface layer is grayish-brown fine sandy loam about 7 inches thick. The subsoil is mottled, yellowish-brown, and light olive-brown firm fine sandy loam and sandy clay loam. The underlying material is light olive-brown and olive fine sandy loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content is moderate. The supply of available nitrogen is low and phosphorus and potassium medium.

Most areas of Nessel soils are for crops, to which they are well suited. The major limitations are the hazard of erosion and the moderately high seasonal water table.

Representative profile of Nessel fine sandy loam, 1 to 4 percent slopes, in a cultivated field, 2,100 feet west and 890 feet south of the northeast corner of sec. 23, T. 31 N., R. 22 W.

Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; weak, fine, subangular blocky structure; friable; about 2 percent coarse fragments; medium acid; abrupt, smooth boundary.

A2—9 to 16 inches, grayish-brown (10YR 5/2) fine sandy loam; weak, thick, platy structure; very friable; about 2 percent coarse fragments; slightly acid; clear, smooth boundary.

B&A—16 to 20 inches, dark-brown (10YR 4/3) fine sandy loam; thick, porous, light brownish-gray (10YR 6/2) coatings on peds; weak, medium, subangular blocky structure; friable; about 2 percent coarse fragments; medium acid; clear, smooth boundary.

B21t—20 to 26 inches, yellowish-brown (10YR 5/4) fine sandy loam; few, medium, faint, grayish-brown (10YR 5/2) and brownish-yellow (10YR 6/6) mottles; moderate, medium, prismatic structure parting to moderate, medium and coarse, subangular blocky; firm; about 5 percent coarse fragments; thin, patchy very dark grayish-brown (10YR 3/2) clay films on faces of peds; porous, grayish-brown (10YR 5/2) ped coatings in the upper part; medium acid; clear, smooth boundary.

B22—26 to 35 inches, brown (10YR 5/3) fine sandy loam; few, fine, faint, grayish-brown (10YR 5/2) and brownish-yellow (10YR 6/6) mottles; strong, medium and coarse, prismatic structure parting to moderate, coarse, subangular blocky; firm; about 5 percent coarse fragments; moderately thick, very dark grayish-brown (10YR 3/2) clay films on all ped faces; slightly acid; clear, wavy boundary.

B23t—35 to 40 inches, light olive-brown (2.5Y 5/4) sandy clay loam; few, fine, distinct, grayish-brown (10YR 5/2) and brownish-yellow (10YR 6/6) mottles; strong, medium and coarse, prismatic structure parting to moderate, coarse subangular blocky; firm; about 5 percent coarse fragments; thin, very dark brown (10YR 2/2) clay films on all ped faces and moderately thick clay films on some vertical faces and in root channels; neutral; clear, wavy boundary.

C1—40 to 54 inches, light olive-brown (2.5Y 5/4) fine sandy loam; common, medium, distinct, grayish-brown (10YR 5/2) and yellowish-brown (10YR 5/6) mottles; massive breaking to weak, medium and coarse, subangular blocky structure; friable; thick, very dark brown (10YR 2/2) clay films on some vertical ped faces and in root channels; about 5 percent coarse fragments; mildly alkaline, slight effervescence; clear, wavy boundary.

C2—54 to 60 inches, olive (5Y 5/3) fine sandy loam; common, medium, prominent, dark yellowish-brown (10YR 4/4), yellowish-brown (10YR 5/6) and olive-gray (5Y 5/2) mottles; massive; friable; thick, very dark brown (10YR 2/2) clay films on some vertical faces in root channels; about 5 percent coarse fragments; moderately alkaline, strong effervescence.

The thickness of the solum ranges from 32 to 46 inches. The content of coarse fragments ranges from 0 to 6 percent in the upper part of the solum and from 2 to 8 percent in the rest of the profile.

The Ap horizon is very dark grayish brown or dark brown. Undisturbed soils have an A1 horizon that is 2 to 4 inches thick and is black, very dark gray, or very dark brown. The A2 horizon is grayish brown or light brownish gray and is 7 to 14 inches thick. The A horizon is fine sandy loam or loam.

The upper part of the B horizon is brown, dark brown, or yellowish brown and has faint mottles. Thin to moderately thick, patchy to continuous clay films are common. The B horizon is brown, olive brown, or light olive brown and has distinct mottles. Thin, patchy or continuous clay films are common.

The C horizon is light olive brown or olive. It is sandy loam or loam.

Reaction is strongly acid to slightly acid in the upper part of the solum and medium acid to neutral in the lower part. It is mildly alkaline or moderately alkaline in the C horizon.

Nessel soils are associated with Dundas and Hayden soils and are similar to Growton soils. They are less gray in the B horizon and are better drained than Dundas soils. They differ from Hayden soils in having mottles in the B horizon. They differ from Growton soils in having more clay in the B horizon.

NeA—Nessel fine sandy loam, 1 to 4 percent slopes. This nearly level to gently sloping soil is in areas of low relief, in small drainageways, and on slight convex slopes. Areas are 5 to 50 acres in size. In undisturbed areas the surface layer is 2 to 4 inches thick.

Included with this soil in mapping are small areas of Hayden and Dundas soils. Also included are small areas of Braham or Blomford soils and deep sandy areas, which are identified on the soil map by spot symbols.

A slight hazard of erosion, a seasonal high water table, and the resulting hazard of wetness are limitations to the use and management of this soil. Wetness is more restrictive for urban development than for farming.

This soil is used for crops, to which it is well suited. Commonly grown crops are corn, soybeans, and alfalfa. Community development group 2; capability unit IIe–1; woodland group 2o1.

Nowen Series

The Nowen series consists of nearly level, somewhat poorly drained, and poorly drained soils formed in sandy loam till. These soils are on small broad flats and in small depressions and drainageways in an undulating to rolling ground moraine. Native vegetation was deciduous forest and an understory of water tolerant grasses.

In a representative profile the surface layer is very dark grayish-brown sandy loam about 9 inches thick. The subsurface layer is grayish-brown fine sandy loam about 6 inches thick. The subsoil is mottled light brownish-gray and gray friable fine sandy loam about 34 inches thick. The underlying material is mottled gray sandy loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content is moderate. The supply of available nitrogen, phosphorus, and potassium is medium.

Most areas of Nowen soils are cropped. Small areas are still in pasture and forest. The major limitation is the hazard of wetness.

Representative profile of Nowen sandy loam, in a cultivated field, 1,600 feet east and 50 feet south of the northwest corner of sec. 29, T. 33 N., R. 25 W.

Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2) sandy loam; weak, fine, subangular blocky structure; very friable; about 5 percent coarse fragments; slightly acid; abrupt, smooth boundary.

A2—9 to 15 inches, grayish-brown (10YR 5/2) fine sandy loam; common, fine, distinct, brownish-yellow (10YR 6/6) and strong-brown (7.5YR 5/8) mottles; weak, medium, platy structure; very friable; about 5 percent coarse fragments; slightly acid; clear, wavy boundary.

B21tg—15 to 20 inches, light brownish-gray (10YR 6/2) fine sandy loam; few, fine, distinct, strong-brown (7.5YR 5/6) and reddish-yellow (7.5YR 6/6) mottles; weak, medium, subangular blocky structure; friable; about 5 percent coarse fragments; slightly acid; clear, wavy boundary.

B22tg—20 to 30 inches, light brownish-gray (10YR 6/2) fine sandy loam; fine, prominent, strong-brown (7.5 YR 5/6) and yellowish-red (5YR 5/6) mottles; weak, coarse, prismatic structure parting to moderate, medium and coarse, subangular blocky; friable to firm; thin patchy clay films in pores and on some vertical ped faces; thin coatings of bleached sand grains on faces of prisms; about 5 percent coarse fragments; slightly acid; clear, wavy boundary.

B23tg—30 to 42 inches, gray (10YR 6/1) fine sandy loam; common, medium, distinct, yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) mottles; weak, medium, subangular blocky structure; friable; about 5 percent coarse fragments; slightly acid; clear, wavy boundary.

B3g—42 to 49 inches, gray (10YR 6/1) fine sandy loam; many, medium, prominent, strong-brown (7.5YR 5/6)) and yellowish-red (5YR 5/8) mottles; weak, very thick, platy structure parting to weak, medium, angular blocky; friable; about 5 percent coarse fragments; neutral; clear, wavy boundary.

C—49 to 60 inches, gray (10YR 6/1) sandy loam; common, medium, prominent, reddish-yellow (7.5YR 7/8) and yellowish-red (5YR 4/8) mottles; massive; about 10 percent coarse fragments; friable; neutral.

The thickness of the solum ranges from 42 to 56 inches. The solum is 2 to 10 percent coarse fragments.

The Ap horizon is very dark grayish brown or dark grayish brown. Undisturbed soils have an A1 horizon that is black or very dark brown and is 3 to 5 inches thick. The Ap or A1 horizon typically is sandy loam or fine sandy loam but ranges to loam. The A2 horizon is dark gray, grayish brown, gray, or light brownish gray and is 5 to 7 inches thick. It has distinct mottles. It is sandy loam or fine sandy loam but ranges to loamy sand and loamy fine sand.

The B horizon is light brownish gray or gray and is 29 to 39 inches thick. It is fine sandy loam or sandy loam.

The C horizon is gray or light brownish gray. In some soils it has thin bands of redder hue. It is sandy loam, but contains common strata or pockets of loamy sand and sandy clay loam.

Reaction is medium acid to slightly acid in the upper part of the solum and becomes neutral in the lower part.

Nowen soils are associated with Heyder and Growton soils and are similar to Dundas soils. They are more poorly drained and have grayer B and C horizons that are more prominently mottled than those of Growton and Heyder soils. They have less clay in the B horizon than Dundas soils.

No—Nowen sandy loam. This nearly level soil is in small depressions and small drainageways and on low lying flats 3 to 30 acres in size. In undisturbed areas the surface layer is 3 to 5 inches thick.

Included with this soil in mapping are small rises of Growton soils. Small, very poorly drained areas are identified on the soil map by spot symbols.

The chief limitations for both farm and urban use are the high seasonal water table and the resulting hazard of wetness.

Most areas are cropped. Drainage is needed for crop production. If well managed, this soil is suited to corn and soybeans. It is poorly suited to most urban uses. Community development group 5; capability unit IIw–2; woodland group 3w1.

Nymore Series

The Nymore series consists of nearly level to steep, excessively drained soils formed in outwash sands. These soils are on broad smooth flats and narrow hillsides adjacent to drainageways and large depressions in sandy outwash plains. Native vegetation was mixed oak forest and tall grass prairie.

In a representative profile the surface layer is very dark gray and very dark grayish-brown loamy sand about 7 inches thick. The subsoil is dark-brown loose loamy sand about 19 inches thick. The underlying material is yellowish-brown sand.

Permeability is rapid, and the available water capacity is low. The organic-matter content is low. The supply of available nitrogen and potassium is low, and phosphorus medium. The water table is at a depth of more than 6 feet.

Most areas of Nymore soils are under urban development. Some areas are cropped, forested, or pastured. The major limitations are the low available water capacity and the resulting hazards of droughtiness and soil blowing.

Representative profile of Nymore loamy sand, 0 to 2 percent slopes, in a wooded pasture, 250 feet west of the center of sec. 7, T. 32 N., R. 25 W.

A1—0 to 4 inches, very dark gray (10YR 3/1) loamy sand; weak, very fine and fine, subangular blocky structure; very friable; strongly acid; abrupt, smooth boundary.

A3—4 to 7 inches, very dark grayish-brown (10YR 3/2) loamy sand; very weak, thick, platy structure parting to weak, fine, subangular blocky; very friable; medium acid; clear, smooth boundary.

B2—7 to 26 inches, dark-brown (7.5YR 4/4) loamy sand; massive; loose; medium acid; clear, wavy boundary.

C1—26 to 34 inches, yellowish-brown (10YR 5/4) sand; single grained; loose; medium acid; clear, wavy boundary.

C2—34 to 60 inches, yellowish-brown (10YR 5/4) sand; single grained; loose; slightly acid.

The thickness of the solum ranges from 24 to 36 inches. The A1 horizon is very dark gray, very dark brown, or black and is 3 to 6 inches thick. The A3 horizon typically is 1 to 5 inches thick but is absent in some places. In cultivated fields the Ap horizon is very dark grayish brown, very dark brown, or dark brown. It typically is loamy sand but ranges from light sandy loam to sand. The B horizon is dark-brown loamy sand or sand and is 17 to 25 inches thick. Reaction is strongly acid or medium acid. The C horizon is yellowish brown or pale brown. It is sand or coarse sand but in places has strata of fine gravel or fine sand. Reaction is medium acid or slightly acid.

Nymore soils are associated with Meehan and Isan soils and are similar to Hubbard and Sartell soils. They are better drained and lack the grayish-brown and dark-gray colors in the B horizon that are typical of Meehan and Isan soils. They have a thinner A horizon and less coarse sand in the solum than Hubbard soils. They are dominantly medium sand throughout the solum, whereas Sartell soils are dominantly fine sand.

NrD—Nymore loamy coarse sand, 12 to 25 percent slopes. This moderately steep to steep soil occupies small escarpments 100 to 200 feet wide adjacent to drainageways, and large poorly drained depressions in the outwash areas. Areas are 3 to 15 acres in size. This soil has a thinner profile than the one described as representative of the series. Included in mapping are a few areas of soils that are coarser sand throughout and some areas of Hubbard soils.

Steep slopes and the resulting hazard of erosion, the low available water capacity, and the resulting hazard of droughtiness are limitations to the use and management of this soil.

Most of the acreage is in urban areas. The rest is wooded. This soil is very poorly suited to crops. Community development group 1; capability unit VIIs–1; woodland group 3s2.

NyA—Nymore loamy sand, 0 to 2 percent slopes. This nearly level soil occupies broad outwash areas 5 to 80 acres in size. It has the profile described as representative of the series.

Included with this soil in mapping are soils that are faintly mottled at a depth of 20 to 30 inches. Also included are small depressed areas where the surface layer is thicker and darker colored than is typical.

The chief limitations for both farm and urban use are the low available water capacity and the resulting hazards of soil blowing and droughtiness.

Large areas are under urban development. This soil is well suited to this use. It is poorly suited to corn, soybeans, alfalfa, and pasture crops. It is better suited to woodland. Community development group 1; capability unit IVs–1; woodland group 3s1.

NyB—Nymore loamy sand, 2 to 6 percent slopes. This gently sloping soil occupies broad outwash areas 10 to 160 acres in size. Included in mapping are small depressed areas where the surface layer is thicker and darker colored than is typical. Also included and identified on the soil map by spot symbols are small depressions that have poor drainage.

The chief limitations for both farm and urban use are the low available water capacity and the resulting hazards of soil blowing and droughtiness.

Large areas are under urban development. This soil is well suited to this use. It is poorly suited to corn, soybeans, alfalfa and pasture. It is better suited to woodland. Community development group 1; capability unit IVs–1; woodland group 3s1.

NyC—Nymore loamy sand, 6 to 12 percent slopes. This sloping soil is on escarpments 100 to 300 feet wide adjacent to drainageways, and in large, poorly drained depressions in the outwash areas. Soil areas are 3 to 20 acres in size. This soil has a thinner profile than the one described as representative of the series. Included in mapping are small areas of Hubbard soils.

The chief limitations for both farm and urban use are the low available water capacity and the resulting hazards of droughtiness and of erosion by water and wind.

Large areas are under urban development. Much of the rest is pastured or wooded. The hazards of low available water capacity and slope make the soil poorly suited to most crops. Community development group 1; capability unit VIs–1; woodland group 3s1.

Rifle Series

The Rifle series consists of nearly level, very poorly drained soils formed in organic soil material. These soils are in bogs in both sandy outwash plains and moraines. The native vegetation was reeds, sedges, cattails, and a few scattered trees, such as birch and elm. Some areas supported dense stands of tamarack.

In a representative profile the surface layer is very dark brown mucky peat about 8 inches thick. The subsurface layer and underlying material are dark yellowish-brown and very dark grayish-brown mucky peat.

Permeability is moderately rapid, and the available water capacity is very high. The organic-matter content is very high. The supply of available nitrogen is high, phosphorus low, and potassium low. The water table is at or near the surface unless these soils are drained.

Most areas of Rifle soils are in native vegetation. Some are cropped (fig. 9). The major limitations are the hazards of wetness, ponding, and unseasonable frost.

Representative profile of Rifle mucky peat, in a bog 200 feet east and 250 feet south of the midpoint of sec. 7, T. 32 N., R. 22 W.

Oe1—0 to 8 inches, very dark brown (10YR 2/2 broken face) hemic material, very dark grayish brown (10YR 3/2 rubbed); about 60 percent fiber, about 40 percent rubbed; massive; very friable; about 80 percent herbaceous fiber, about 20 percent hypnum moss fiber; about 10 percent mineral material; neutral; gradual, smooth boundary.

Oe2—8 to 34 inches, dark yellowish-brown (10YR 4/4 broken face) hemic material, very dark grayish brown (10YR 3/2 rubbed); about 60 percent fiber, about 35 percent rubbed; massive; very friable; mainly herbaceous fiber; about 10 percent mineral material; neutral; gradual, smooth boundary.

Oe3—34 to 70 inches, very dark grayish-brown (10YR 3/2 broken face) hemic material, dark yellowish brown (10YR 3/4 rubbed); about 70 percent fiber, about 40 percent rubbed; massive; very friable; mainly herbaceous fiber; about 10 percent mineral material; neutral; gradual, smooth boundary.

The thickness of the organic soil material is more than 51 inches. Fiber in this material is mainly of herbaceous origin, but in places there are thin layers as much as 10 percent woody fibers or hypnum moss fibers. In some places the upper 10 to 20 inches is as much as 20 percent wood fragments. The surface layer ranges from hemic to sapric material; sapric material is more common in cultivated areas. The Oe layers commonly are very dark grayish brown or very dark brown, but range to dark yellowish brown. The color commonly darkens when the soil is rubbed. In places layers less then 10 inches thick of sapric or fibric material are below a depth of 12 inches. Reaction is medium acid to neutral.

Rifle soils are associated with Seelyeville, Millerville, Markey, and Cathro soils. They are dominated by hemic material, whereas Seelyeville soils are dominated by sapric material. They are organic to a depth of at least 51 inches, whereas Cathro and Markey soils have mineral soil material beginning within a depth of 51 inches, and Millerville soils have coprogenous earth beginning within a depth of 51 inches.

Rf—Rifle mucky peat. This soil is in large shallow depressions, mainly in the sand plain but also in the glacial moraines. It has the profile described as representative of the series. Slopes are 0 to 1 percent. This organic soil has poor natural drainage outlets. Included in mapping are small areas of Seelyeville, Cathro, Markey, and Millerville soils.

The chief limitations to the use and management of this soil are soil blowing, unseasonable frost, and wetness.

About one-third of the acreage is used for vegetables and cultured sod. The chief vegetables are radishes, carrots, potatoes, and turnips. Some areas are used for pasture. Others are in native vegetation. Community development group 7; capability unit IIIw–3; woodland group 5w1.

Rg—Rifle muck, woody. This soil is in bogs in the outwash plains, in areas of 100 or more acres. It has poor natural drainage outlets. Slopes are 0 to 1 percent. This soil has a profile similar to the one described as representative of the series, but the upper 10 to 20 inches is 10 to 20 percent wood fragments. Included in mapping are small areas of Rifle mucky peat and Markey soils.

The chief limitations to use and management of this soil for farming, especially truck farming, are

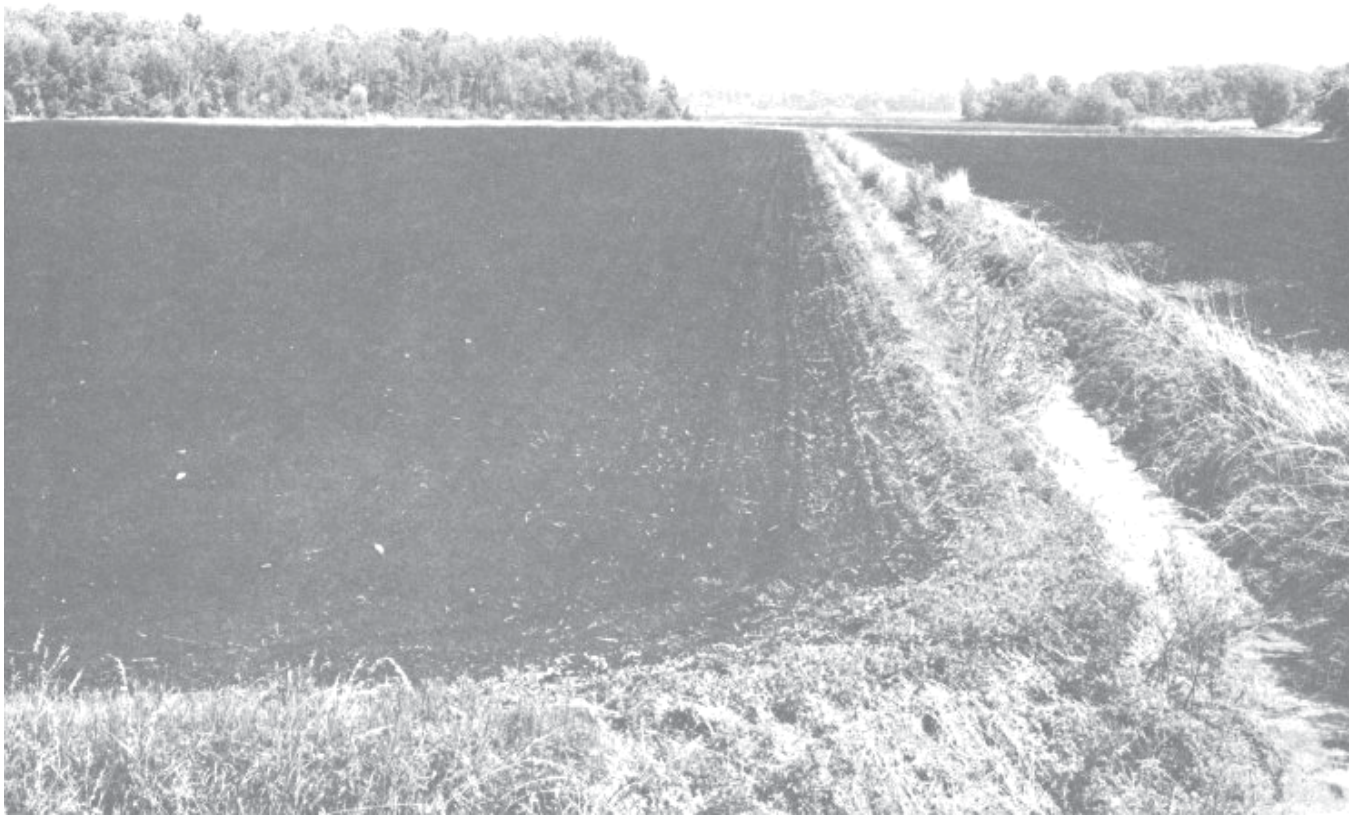

Figure 9.—**Drained field of Rifle muck, woody, ready for planting.**

wetness, soil blowing, unseasonable frost, and the high percentage of wood fragments in the surface layer.

Most areas are used for truck crops, to which the soil is moderately well suited. This soil is very poorly suited to most urban uses. Community development group 7; capability unit IIIw–3; woodland group 5w1.

Rh—Rifle soils, ponded. These soils are in the Carlos Avery Game Refuge. They are flooded with about 12 to 36 inches of water. Dikes have been constructed in this area to improve habitat for waterfowl. Slopes are 0 to 1 percent. Included in mapping are small areas of Cathro, Markey, Millerville, and Seelyeville soils.

Unless flooded, these soils have the same hazards, limitations, and use and management characteristics as Rifle mucky peat. Community development group 7; capability unit VIIIw–1; woodland group 5w1.

Rondeau Series

The Rondeau series consists of nearly level, very poorly drained soils formed in organic material overlying marl. These soils are in bogs on level outwash plains and till moraines. Native vegetation was sedges and grasses and scattered willow, alder, and birch.

In a representative profile the surface layer is black muck about 9 inches thick. The next layer is black muck about 35 inches thick. The upper 5 inches of the underlying material is coprogenous earth. The rest is violently effervescent marl.

Permeability is slow, and the available water capacity is very high. The organic-matter content is very high. The supply of available nitrogen is high, phosphorus low, and potassium low. In undrained areas, the water table is at or near the surface.

Most areas of Rondeau soils are used for hay or pasture, to which they are poorly suited. The major limitations are the hazards of wetness, ponding, and unseasonable frost.

Representative profile of Rondeau muck, in a bog, 2,240 feet south and 1,200 feet east of the northwest corner of sec. 30, T. 31 N., R. 22 W.

Oa1—0 to 9 inches, black (10YR 2/1 broken face and rubbed) sapric material; about 10 percent fiber, essentially none after rubbing; weak, fine, granular structure; very friable; herbaceous fiber; mildly alkaline; clear, smooth boundary.

Oa2—9 to 15 inches, black (10YR 2/1 broken face) and very dark grayish-brown (10YR 3/2 broken face) fiber, sapric material, very dark brown (10YR 2/2 rubbed); about 40 percent fiber, about 15 percent rubbed; weak, medium, platy structure; very friable; herbaceous fiber; mildly alkaline; clear, smooth boundary.

Oa3—15 to 37 inches, black (10YR 2/1 broken face and rubbed) sapric material; less than 5 percent fiber; massive; very friable; herbaceous fiber; mildly alkaline; clear, smooth boundary.

Oa4—37 to 42 inches, black (10YR 2/1 broken face) and very dark grayish-brown (10YR 3/2 broken face) sapric material, and black (10YR 2/1 rubbed); about 20 percent fiber, about 5 percent rubbed; massive; very friable; herbaceous fiber; mildly alkaline; clear, smooth boundary.

Oa5—42 to 44 inches, black (10YR 2/1 broken face and rubbed) sapric material; about 10 percent fiber, about 5 percent rubbed; weak, medium, subangular blocky structure; very friable; herbaceous fiber; mildly alkaline; clear, smooth boundary.

Lco—44 to 49 inches, black (N 2/0 broken face) and very dark gray (N 3/0 broken face) coprogenous earth; trace of fiber; massive; friable; slightly sticky; about 10 percent snail shell and shell fragments 1 to 3 millimeters in size; violent effervescence; mildly alkaline; clear, smooth boundary.

Lca—49 to 66 inches, light-gray (10YR 7/1) marl; few, fine, distinct, light olive-brown (2.5Y 5/4) mottles; massive; friable; slightly sticky; about 5 percent plant detritus; mildly alkaline; violent effervescence.

The thickness of organic soil material over marl ranges from 16 to 51 inches. The organic soil material has mainly herbaceous fiber. The Oap layers are black sapric material 6 to 12 inches thick. The underlying layers are typically black sapric material, but in some places there is a hemic layer as much as 10 inches thick. Reaction in the organic material is neutral to mildly alkaline. The Lco layer is black, dark gray, very dark brown, or dark grayish brown. It does not occur in some soils. Snail shells are common. Reaction in this layer is neutral to mildly alkaline. The Lca layer is light-gray or grayish-brown marl. The marl is more than one-half calcium carbonate. Snail shells are common. Typically the marl is thick, but in some places it occurs as thin strata between the layers of organic soil material.

Rondeau soils are associated with Seelyeville soils and are similar to Millerville soils. They differ from Seelyeville soils in having marl within a depth of 51 inches. They have limnic sediments of marl, whereas Millerville soils have limnic sediments of coprogenous earth.

Ru—Rondeau muck. This soil is in bog areas which are commonly adjacent to existing lakes and marshes. Included in mapping are small areas of Seelyeville, Cathro, and Markey soils.

The high water table, the slow permeability, and the resulting hazard of wetness are limitations to the use and management of this soil and are more restrictive to urban use than to farming.

Most areas are used for hay and pasture. Drainage is needed for crop production. This soil is poorly suited to most crops and is very poorly suited to most urban uses. Community development group 7; capability unit IVw–3; woodland group 5w1.

Ronneby Series

The Ronneby series consists of nearly level, somewhat poorly drained soils formed in reddish sandy loam till. These soils are on small broad flats and in small depressions and drainageways in sloping ground moraines. The native vegetation was deciduous forest.

In a representative profile the surface layer is very dark gray fine sandy loam about 5 inches thick. The subsurface layer is mottled grayish-brown fine sandy loam about 10 inches thick. The upper 17 inches of the subsoil is mottled grayish-brown and pinkish-gray, friable sandy loam and fine sandy loam. The lower 10 inches is mottled reddish-brown, firm fine sandy loam that is hard and brittle when dry. The underlying material is firm, reddish-brown fine sandy loam.

Permeability is moderately slow, and the available water capacity is moderate. The organic-matter content is moderate. The supply of available nitrogen is low, phosphorus medium, and potassium low. Large stones scattered on the surface and throughout the soil are troublesome during tillage.

Most areas of Ronneby soils are cropped or pastured. The rest is still wooded. The major limitation is the hazard of wetness.

Representative profile of Ronneby fine sandy loam, in a permanent pasture, 1,700 feet east and 1,160 feet north of the southwest corner of sec. 4, T. 33 N., R. 25 W.

A1—0 to 5 inches, very dark gray (10YR 3/1) fine sandy loam; moderate, medium, granular structure; very friable; medium acid; abrupt, clear boundary.

A2g—5 to 15 inches, grayish-brown (10YR 5/2) fine sandy loam; common, medium, distinct, dark-brown (7.5YR 4/4) and yellowish-red (5YR 4/6) mottles; moderate, medium, platy structure; very friable; about 5 percent coarse fragments; strongly acid; clear, smooth boundary.

B1g—15 to 24 inches, grayish-brown (10YR 5/2) sandy loam; many, medium, distinct, brown (7.5YR 5/4) and strong-brown (7.5YR 5/6) mottles; weak, medium, subangular blocky structure; friable; about 10 percent coarse fragments; strongly acid; clear, smooth boundary.

B2tg—24 to 32 inches, pinkish-gray (7.5YR 6/2) fine sandy loam; many, medium, distinct, reddish-yellow (7.5YR 6/8) and reddish-brown (5YR 5/4) mottles; moderate, medium, subangular blocky structure; friable; many, thin clay films in tubular pores and around sand grains and pebbles; about 10 percent coarse fragments; strongly acid; clear, smooth boundary.

Bx—32 to 42 inches, reddish-brown (5YR 5/4) fine sandy loam; many, medium, faint, reddish-gray (5YR 5/2) and yellowish-red (5YR 4/8) mottles; moderate, thick, platy structure parting to moderate, medium, angular blocky; firm; hard; peds crush abruptly under pressure; some thin clay films on horizontal ped faces and around sand grains; about 10 percent coarse fragments; slightly acid; clear, wavy boundary.

Cx—42 to 60 inches, reddish-brown (5YR 4/3) fine sandy loam; few, medium, faint, reddish-gray (5YR 5/2) mottles; moderate, thick, platy structure; firm; hard; peds crush abruptly under pressure; about 10 percent coarse fragments; neutral.

The thickness of the solum ranges from 40 to 60 inches. Depth to the fragipan ranges from 22 to 36 inches. The soil typically is 8 to 20 percent coarse fragments, but in places the upper part is 0 to 8 percent.

The A horizon is black, very dark brown, or very dark gray and is commonly 3 to 6 inches thick. The A2 horizon is grayish brown or light grayish brown and is commonly 6 to 12 inches thick. The A horizon is sandy loam or fine sandy loam.

The upper part of the B horizon is grayish-brown, light brownish-gray, or pinkish-gray sandy loam, fine sandy loam, or loam. Thin patchy clay films are common. The Bx horizon is reddish-brown, dark reddish-brown, or dark reddish-gray sandy loam or fine sandy loam. It has a few thin clay films on horizontal ped faces and around sand grains and pebbles.

The C horizon is reddish-brown or dark reddish-brown sandy loam or fine sandy loam. In places there are thin discontinuous strata and pockets of sand and gravelly sand in the B and C horizons.

Reaction is strongly acid to slightly acid in the solum and slightly acid to neutral in the C horizon.

Ronneby soils are associated with Kingsley and Mora

soils. They are more poorly drained and have grayer colors in the B horizon than Kingsley and Mora soils.

Ry—Ronneby fine sandy loam. This nearly level soil is on low-lying flats and in small depressions and small drainageways. Areas are 3 to 20 acres in size. In plowed areas the surface layer has been mixed with the subsurface layer.

Included with this soil in mapping are areas of Mora soils. Also included and identified on the map by spot symbols are excessively rocky areas and very poorly drained spots.

A limitation for both farm and urban use is the hazard of wetness. Only a few large surface stones have to be removed before cultivation.

The use of this soil is equally divided among crops, pasture, and woodland. Drainage is needed for crop production. If drained and well managed, the soil is well suited to corn and soybeans. Community development group 5; capability unit IIw–3; woodland group 2o4.

Sartell Series

The Sartell series consists of gently undulating to steep, excessively drained soils formed in outwash sands. These soils are on an undulating to hilly, old dune-shaped landscape of sandy outwash plains. The native vegetation was a mixed tall grass prairie and oak forest.

In a representative profile the surface layer is very dark grayish-brown fine sand about 9 inches thick. The subsoil is dark yellowish-brown and yellowish-brown loose fine sand about 17 inches thick. The underlying material is light yellowish-brown fine sand.

Permeability is rapid, and the available water capacity is low. The organic-matter content is low. The supply of available nitrogen is low, phosphorus medium, and potassium low.

Most areas of Sartell soils are under urban development. Most of the rest is cropped, pastured, or forested. The major limitations are the low available water capacity and the resulting hazards of droughtiness and soil blowing.

Representative profile of Sartell fine sand, 6 to 12 percent slopes, in a wooded area, 200 feet north and 55 feet east of the southwest corner NW¼ sec. 1, T. 33 N., R. 23 W.

A1—0 to 9 inches, very dark grayish-brown (10YR 3/2) fine sand; single grained; loose; very strongly acid; clear, smooth boundary.

B2—9 to 26 inches, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/4) fine sand; single grained; loose; strongly acid; gradual, smooth boundary.

C—26 to 60 inches, light yellowish-brown (10YR 6/4) fine sand; single grained; loose; medium acid.

The thickness of the solum ranges from 24 to 40 inches. The A1 horizon is very dark grayish brown, very dark gray, or very dark brown and is 4 to 10 inches thick. It typically is fine sand, but ranges to loamy fine sand. The B horizon is dark yellowish brown, yellowish brown, or brown. The C horizon is brown, pale brown, or light yellowish brown. It typically is fine sand, but ranges to sand. Reaction is very strongly acid to medium acid in the solum and medium acid to slightly acid in the C horizon.

Sartell soils are associated with Zimmerman, Lino, and Isanti soils. Unlike Zimmerman soils, they lack the thin bands of illuviated clay. They differ from Lino and Isanti soils in having better drainage and brighter colors in the B horizon.

SbB—Sartell fine sand, 2 to 6 percent slopes. This gently undulating soil is in broad outwash areas 5 to 80 acres in size. Included in mapping and identified on the soil map by spot symbols are small depressions that are poorly drained.

The chief limitations for both farm and urban use are the low available water capacity and the resulting hazards of soil blowing and droughtiness.

Large areas are under urban development. This soil is well suited to this use. It is poorly suited to corn, soybeans, alfalfa, and pasture. It is better suited to woodland. Community development group 1; capability unit IVs–1; woodland group 3s1.

SbC—Sartell fine sand, 6 to 12 percent slopes. This gently rolling soil is on the sand plains. Slopes are short and irregular. Areas are 5 to 20 acres in size. This soil has the profile described as representative of the series. Included in mapping and identified on the soil map by spot symbols are scattered active or recently active blowouts.

The chief limitations for both farm and urban use are the low available water capacity and the resulting hazards of soil blowing and droughtiness.

Large areas are under urban development. This soil is moderately well suited to this use. It is very poorly suited to crops and pasture. It is better suited to woodland. Community development group 1; capability unit VIs–1; woodland group 3s1.

SbC2—Sartell fine sand, 6 to 12 percent slopes, eroded. This gently rolling soil is on the sand plain. Slopes are short and irregular. Areas are 5 to 80 acres in size. Active and inactive dunes are common. The sand blows from the southwest to the northeast.

This soil has a thinner profile than the one described as representative of the series, as a result of soil blowing. In duned areas the solum has been completely removed by soil blowing. Severely eroded areas make up 25 to 50 percent of this mapping unit.

The chief limitations to the use and management of this soil are the low available water capacity and the resulting hazards of soil blowing and droughtiness.

Large areas are under recreational and urban development. This soil is poorly suited to this use. It is very poorly suited to crops and pasture. It is better suited to woodland. Community development group 1; capability unit VIs–1; woodland group 3s1.

SbD2—Sartell fine sand, 12 to 24 percent slopes, eroded. This hilly to steep soil is on the sand plain. Slopes are short and irregular. Areas are 10 to 40 acres in size. Active and inactive dunes are common. The sand blows from the southwest to the northeast.

This soil has a thinner profile than the one described as representative of the series, as a result of soil blowing. In duned areas the solum has been completely removed by soil blowing. Severely eroded areas make up 30 to 70 percent of this mapping unit.

The chief limitations to the use and management of this soil are the steep slopes, low available water capacity, and the resulting hazards of soil blowing and droughtiness.

Large areas are used for recreation. Some areas are under urban development, and some are still in wood-

land. This soil is poorly suited to all of these uses. It is very poorly suited to crops and pasture. Community development group 1; capability unit VIIs–1; woodland group 3s2.

Seelyeville Series

The Seelyeville series consists of level, very poorly drained soils formed in organic soil material. These soils are in bogs in the sandy outwash plains and the till plains. Native vegetation was mainly sedges and grasses. Some areas have scattered alders, willow, tamarack, and bog birch.

In a representative profile the surface layer is black muck to a depth of 57 inches. The underlying layers are black or very dark brown muck.

Permeability is moderately rapid, and the available water capacity is very high. The supply of available nitrogen is high, phosphorus low, and potassium low. Unless these soils are drained, the water table is at or near the surface.

Most areas of the Seelyeville soils are still in native vegetation. Some are pastured or cropped. The major limitations are the hazards of wetness, flooding or ponding, and unseasonable frost.

Representative profile of Seelyeville muck, in a cultivated field, 1,150 feet south and 200 feet west of the northwest corner NE¼ sec. 18, T. 32 N., R. 24 W.

Oap—0 to 10 inches, black (10YR 2/1 broken face and rubbed) sapric material; about 5 percent fiber; trace rubed; weak, fine and very fine, granular structure; very friable; herbaceous fiber; about 40 percent mineral material; neutral; abrupt, smooth boundary.

Oa2—10 to 16 inches, black (10YR 2/1 broken face and rubbed) sapric material; about 15 percent fiber, about 5 percent rubbed; weak, medium and fine, subangular blocky structure; very friable; herbaceous fiber; about 35 percent mineral material; neutral; abrupt, smooth boundary.

Oa3—16 to 20 inches, very dark brown (10YR 2/2 broken face) and dark-brown (10YR 3/3 broken face) sapric material, black (10YR 2/1 rubbed); about 50 percent fiber, about 15 percent rubbed; massive; nonsticky; mostly herbaceous fiber with 30 percent hypnum moss fiber; about 20 percent mineral material; neutral; abrupt, smooth boundary.

Oa4—20 to 46 inches, black (10YR 2/1 broken face and rubbed) sapric material; about 25 percent fiber, about 10 percent rubbed; massive; nonsticky; herbaceous fiber; about 20 percent mineral material; neutral; clear, smooth boundary.

Oa5—46 to 57 inches, very dark brown (10YR 2/2 broken face) sapric material, black (10YR 2/1 rubbed); massive; nonsticky; herbaceous fiber; about 25 percent mineral material; neutral; clear, smooth boundary.

Oe—57 to 65 inches, very dark brown (10YR 2/2 broken face) and very dark grayish-brown (10YR 3/2 broken face) hemic material, very dark brown (10YR 2/2 rubbed); about 50 percent fiber, 20 percent rubbed; massive; primarily herbaceous fiber; about 20 percent mineral material; neutral.

The thickness of the organic material is more than 51 inches. Fiber in this material is mainly of herbaceous origin, but in places there are thin layers of wood or moss fibers. The soil typically contains no woody fragments, but in places small amounts are in the surface layer. The surface layer typically is black and entirely sapric material, but in some places hemic materials make up part or all of this layer. The underlying layers typically are sapric material, but in places layers of hemic material less than 10 inches thick occur between depths of 16 and 51 inches. Reaction throughout ranges from medium acid to neutral.

Seelyeville soils are associated with Cathro, Markey, and Rifle soils. They are dominated by sapric material, whereas Rifle soils are dominated by hemic material. They have mineral soil material below a depth of 51 inches, but Cathro and Markey soils have mineral soil material within a depth of 51 inches.

Se—Seelyeville muck. This nearly level soil occurs as narrow strips along small streams or in bogs that have good natural drainage outlets. Included in mapping were a few small areas of Rifle, Cathro, and Markey soils.

This soil is very poorly drained, has a high water table, and is subject to seasonal flooding or ponding. The resulting hazard of wetness is a major limitation. Soil blowing and unseasonable frost are hazards to crops. Drainage is needed for crop production.

This soil is very poorly suited to urban use. Most areas are still in native vegetation. Some are used for pasture and for such crops as cultured sod, corn silage, and truck crops. Commonly grown truck crops are cabbage, carrots, potatoes, and radishes. Community development group 7; capability unit IIIw–3; woodland group 5w1.

Soderville Series

The Soderville series consists of nearly level and gently sloping, somewhat poorly drained soils formed in sandy outwash material. These soils are in small drainageways and on low broad flats of glacial outwash plains. Native vegetation was aspen and oak trees and some water-tolerant grasses.

In a representative profile the surface layer is very dark gray fine sand about 9 inches thick. The subsurface layer is mottled brown and grayish-brown fine sand 27 inches thick. The subsoil is mottled brown and reddish brown, friable loamy fine sand 10 inches thick. It is weakly cemented when dry. The underlying material is mottled very pale brown fine sand.

Permeability is rapid, and the available water capacity is low. The organic-matter content is low. The supply of available nitrogen, phosphorus, and potassium is low. In undrained areas, the water table is commonly at a depth of 2 to 4 feet.

Most areas of Soderville soils are cropped and pastured. Some areas are still in forest, and other areas are under urban development. The major limitation is the hazard of wetness.

Representative profile of Soderville fine sand, 0 to 4 percent slopes, in a cultivated field, 800 feet west and 650 feet south of the center of sec. 14, T. 32 N., R. 22 W.

Ap—0 to 9 inches, very dark gray (10YR 3/1) fine sand; weak, fine, subangular blocky structure; very friable; strongly acid; abrupt, smooth boundary.

A21—9 to 26 inches, brown (10YR 5/3) fine sand; few, medium, faint, light brownish-gray (10YR 6/2) and strong-brown (7.5YR 5/6) mottles; single grained; loose; strongly acid; clear, wavy boundary.

A22—26 to 36 inches, grayish-brown (10YR 5/2) fine sand; many, coarse, distinct, strong-brown (7.5YR 5/6) and yellowish-red (5YR 4/6) mottles; massive parting readily to single grained; very friable; yellowish-red mottles; weakly cemented; medium acid; abrupt, smooth boundary.

B21t—36 to 40 inches, reddish-brown (5YR 4/3) loamy fine sand; many, medium, faint, dark reddish-gray (5YR 4/2) and yellowish-red (5YR 5/8) mottles; massive; friable; many clay bridges between sand grains; weakly cemented when dry; medium acid; clear, smooth boundary.

B22t—40 to 46 inches, brown (10YR 5/3) loamy fine sand; many, coarse, distinct, light-gray (10YR 7/1) and strong-brown (7.5YR 5/6) mottles; weak, thick, platy structure breaking to weak, fine, subangular blocky; friable; many clay bridges between sand grains and few, thin clay films on faces of peds; weakly cemented when dry; strongly acid; clear, smooth boundary.

C—46 to 60 inches, very pale brown (10YR 7/3) fine sand; common, medium, distinct, light-gray (10YR 7/2), brownish-yellow (10YR 6/8), and strong-brown (7.5YR 5/8) mottles; massive parting readily to single grained; loose; several dark-brown and strong-brown (7.5YR 4/4 and 5/6), irregular and discontinuous weakly cemented, loamy fine sand bands ¼ to 1 inch thick; medium acid.

The thickness of the solum ranges from 36 to 60 inches. Depth to the B2t horizon ranges from 30 to 50 inches.

The Ap horizon is black, very dark gray, very dark grayish brown, or very dark brown. In undisturbed areas the A1 horizon is black or very dark gray and is 2 to 6 inches thick. The A2 horizon is brown and grayish brown and has few to many, faint and distinct mottles. The A horizon typically is fine sand, but ranges to loamy fine sand.

The B2t horizon typically is loamy fine sand or fine sand high in clay content, but in some places part of this horizon is fine sandy loam. In places the B2t horizon has strata of fine sand 1 to 6 inches thick.

Reaction in the solum ranges from strongly acid to medium acid.

Soderville soils are associated with Anoka, Isanti, Lino, and Zimmerman soils. They have mottles throughout the A2 and B2 horizons, whereas Anoka and Zimmerman soils do not. They have more clay in the B horizon than Lino and Isanti soils.

SoA—Soderville fine sand, 0 to 4 percent slopes. This nearly level to gently sloping soil is in small low-lying drainageways and small depressions, on low broad flats, and in small areas that are a few feet higher than the surrounding larger, very poorly drained areas. Areas are 4 to 60 acres in size. In undisturbed areas, the surface layer is 2 to 6 inches thick.

Included with this soil in mapping are areas of soils that are not mottled within a depth of 30 inches and areas of Lino soils. Also included and identified by spot symbols on the soil map are small depressions of Isanti soils.

The moderately high water table and the resulting hazard of wetness are the major limitations for both farm and urban use. During dry periods, soil blowing is a hazard to immature crops.

Most areas are used for crops, to which this soil is moderately well suited. Commonly grown crops are corn and soybeans. Community development group 4; capability unit IVw–1; woodland group 3s1.

Webster Series

The Webster series consists of nearly level, poorly drained soils formed in limy glacial till. These soils are on broad flats and on slightly concave slopes on gently sloping ground moraines. Native vegetation was water-tolerant grasses and a few scattered trees.

In a representative profile the surface layer is black and very dark gray loam and sandy clay loam about 16 inches thick. The subsoil is mottled gray and light olive-gray, friable sandy clay loam. The underlying material is mottled light olive-gray and gray fine sandy loam.

Permeability is moderate, and the available water capacity is high. The organic-matter content is high. The supply of available nitrogen is high, phosphorus low, and potassium high.

Most areas of Webster soils are cropped. If drained, the soils are well suited to this use. The major limitation is the hazard of wetness.

Representative profile of Webster loam, in a cultivated field, 1,900 feet west and 1,050 feet south of the northeast corner of sec. 23, T. 31 N., R. 22 W.

Ap—0 to 10 inches, black (10YR 2/1) loam; moderate, fine, granular structure; friable; about 1 percent coarse fragments; neutral; abrupt, smooth boundary.

A1—10 to 14 inches, black (10YR 2/1) loam; weak, thick, platy structure parting to moderate, fine, subangular blocky; friable; about 2 percent coarse fragments; neutral; abrupt, smooth boundary.

A3—14 to 16 inches, black (10YR 2/1) and very dark gray (5Y 5/2) sandy clay loam; few, fine, distinct, yellowish-brown (10YR 5/4) mottles; weak, medium, subangular blocky structure; friable; about 6 percent coarse fragments; neutral in most parts and mildly alkaline in pockets; few, thin very dark gray (10YR 3/1) coatings on some vertical faces and in old root channels; clear, smooth boundary.

B2g—16 to 19 inches, gray (5Y 5/1) and olive-gray (5Y 5/2) sandy clay loam; few, fine, distinct yellowish-brown mottles; weak, medium, subangular blocky structure; friable; about 6 percent coarse fragments; few, thin, very dark gray (10YR 3/1) coatings on vertical ped faces and in old root channels; neutral; clear, smooth boundary.

B3g—19 to 23 inches, light olive-gray (5Y 6/2) sandy clay loam; few, fine and medium, distinct, yellowish-brown (10YR 5/4) mottles; weak, medium and coarse, subangular blocky structure; friable; about 3 percent coarse fragments; mildly alkaline; clear, smooth boundary.

C1g—23 to 36 inches, light olive-gray (5Y 6/2) fine sandy loam; few, fine and medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; friable; about 2 percent coarse fragments; moderately alkaline; strongly effervescent; gradual, smooth boundary.

C2g—36 to 60 inches, gray (5Y 6/1) fine sandy loam; many, medium, distinct, yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) mottles; massive with a few vertical fracture faces; friable; about 4 percent coarse fragments; moderately alkaline; strongly effervescent.

The thickness of the solum ranges from 22 to 36 inches. The solum is 2 to 6 percent coarse fragments. The lower part of the A horizon is very dark gray in some soils. The A horizon is loam or sandy clay loam. The B horizon is gray, light olive-gray, or grayish-brown loam or sandy clay loam. The C horizon is gray, light olive-gray, or light brownish-gray fine sandy loam or loam.

The Webster soils of Anoka County have more sand and less silt and clay than is defined in the range for the series. This difference, however, does not affect use or management.

Webster soils are associated with Dundas and Glencoe soils. They have a thicker A horizon than Dundas soils. They have a thinner A horizon than Glencoe soils.

Wb—Webster loam. This nearly level soil is on broad flats and in small drainageways. Areas are 5 to 100 acres in size.

Included with this soil in mapping are small areas where the soil has strata of sands throughout. Small areas of Dundas and Kratka soils are also included.

The seasonal high water table and the resulting haz-

ard of wetness are limitations for both farm and urban use.

Most areas are used for crops. If drained, this soil is well suited to corn and soybeans. It is poorly suited to most urban uses. Community development group 5; capability unit IIw–2; woodland group 3w1.

Zimmerman Series

The Zimmerman series consists of nearly level to steep, excessively drained soils formed in outwash sands. These soils are in broad outwash areas and on narrow escarpments adjacent to drainageways. They also occupy large depressions in the outwash plains. The native vegetation was chiefly mixed oak forest.

In a representative profile the surface layer is very dark gray fine sand about 2 inches thick. The subsurface layer is dark-brown fine sand about 8 inches thick. The upper 18 inches of the subsoil is yellowish-brown and light yellowish-brown loose fine sand. The lower part is very pale brown fine sand that has yellowish-red, irregular, weakly cemented bands ¼ to 1½ inches thick (fig. 10).

Permeability is rapid, and the available water capacity is low. The organic-matter content is low. The supply of available nitrogen is low, phosphorus medium, and potassium low.

Most areas of Zimmerman soils are used for crops, woodland, or urban development. The major limitations are the low available water capacity and the resulting hazards of soil blowing and droughtiness.

Representative profile of Zimmerman fine sand, 2 to 6 percent slopes, in a wooded area, 300 feet east and 50 feet south of the northwest corner NE¼ sec. 20, T. 33 N., R. 22 W.

A1—0 to 2 inches, very dark gray (10YR 3/1) fine sand; weak, very fine, granular structure; very friable; strongly acid; abrupt, smooth boundary.

A2—2 to 10 inches, dark-brown (10YR 4/3) fine sand; very weak, fine, subangular blocky structure; very friable; medium acid; clear, smooth boundary.

B21—10 to 18 inches, yellowish-brown (10YR 5/4) fine sand; single grained; loose; slightly acid; clear, smooth boundary.

B22—18 to 28 inches, light yellowish-brown (10YR 6/4) fine sand; single grained; loose; slightly acid; gradual, smooth boundary.

A'2—28 to 36 inches, very pale brown (10YR 7/4) fine sand; single grained; loose; slightly acid; abrupt, irregular boundary.

A&B'—36 to 60 inches, very pale brown (10YR 7/4) (A'2) fine sand; structureless; loose; several yellowish-red (5YR 4/6), irregular and discontinuous, very weak, cemented fine sand bands ¼ to 1½ inches thick (B'2t) with appreciably more clay than A'2; neutral.

The thickness of the solum commonly is 40 to 60 inches, but ranges to 80 inches.

The A1 horizon is very dark gray, very dark grayish brown, very dark brown, or black and is 1 to 7 inches thick. The A2 horizon is dark brown or dark grayish brown and is 6 to 14 inches thick. In some cultivated fields the A2 horizon is entirely mixed with the Ap horizon. The A horizon is fine sand or loamy fine sand.

The B horizon is yellowish-brown or light yellowish-brown fine sand 12 to 28 inches thick. In the A&B' horizon the A'2 horizons are pale-brown, light yellowish-brown, or very pale brown fine sand and are 1 to 10 inches thick. The B'2t horizon consists of one or more thin, irregular discontinuous, finer textured bands less than 3 inches thick. The total thickness of the B'2t horizon is 6 inches or less. The color of these bands ranges from yellowish red to dark yellowish brown. Typically they are fine sand or loamy fine sand and have two to three times as much clay as adjacent A'2 horizons.

Zimmerman soils are associated with Anoka, Sartell, Lino, Soderville, and Isanti soils. They differ from Anoka soils in having a thinner Bt horizon and less clay. They differ from Sartell soils in having a Bt horizon. They are better drained than Isanti, Lino, and Soderville soils and have a lower water table.

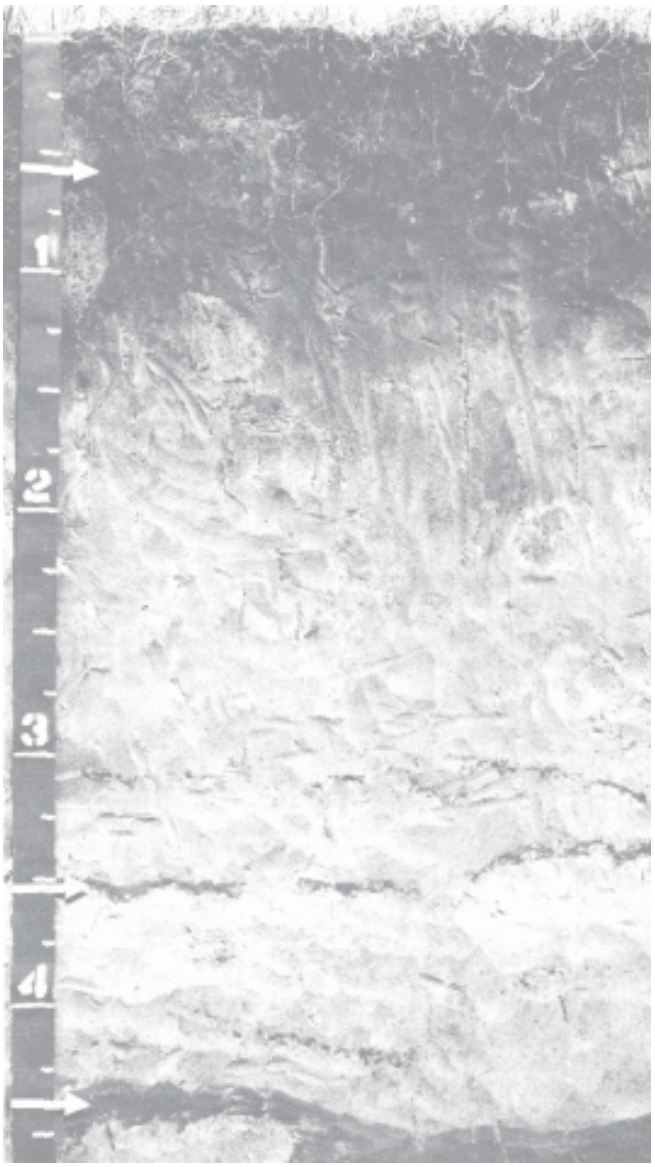

Figure 10.—**Profile of Zimmerman fine sand showing brownish, weakly cemented bands in lower part.**

ZmA—Zimmerman fine sand, 0 to 2 percent slopes. This nearly level soil is in broad outwash areas 5 to 60 acres in size. Included in mapping are small areas of Lino or Soderville soils. The acreage of included soils is larger in this mapping unit than in the more sloping units of Zimmerman soils.

The chief limitations for both farm and urban use

are the low available water capacity and the resulting hazards of soil blowing and droughtiness. Soil blowing is less severe on this soil than on the more sloping Zimmerman soils.

Large areas are under urban development. This soil is well suited to this use. It is poorly suited to corn and soybeans, moderately well suited to alfalfa and pasture, and moderately well suited to woodland. Community development group 1; capability unit IVs–1; woodland group 3s1.

ZmB—Zimmerman fine sand, 2 to 6 percent slopes. This gently undulating soil is in broad outwash areas 5 to 160 acres in size. It has the profile described as representative of the series.

Included with this soil in mapping and identified on the soil map by spot symbols are small depressions of Isanti soils. Also included are small areas of Sartell soils.

The low available water capacity and the resulting hazards of soil blowing and droughtiness are limitations for both farm and urban use.

Large areas are under urban development. This soil is well suited to this use. It is poorly suited to corn and soybeans, moderately well suited to alfalfa and pasture and moderately well suited to woodland. Community development group 1; capability unit IVs–1; woodland group 3s1.

ZmC—Zimmerman fine sand, 6 to 12 percent slopes. This rolling soil is on the sand plain. Areas are 3 to 20 acres in size. Slopes are short and irregular.

Included with this soil in mapping are areas where soil blowing and in places water erosion have removed most of the original surface layer and the present surface layer is lighter colored. Also included are soils in depressions where the surface layer is thicker and darker than is typical.

The chief limitations for both farm and urban use are the low available water capacity and the resulting hazards of soil blowing and droughtiness. Also, water erosion is a major hazard.

Large areas are under urban development. This soil is moderately well suited to this use. It is very poorly suited to crops and pasture. It is better suited to woodland. Community development group 1; capability unit VIs–1; woodland group 3s1.

ZmD—Zimmerman fine sand, 12 to 24 percent slopes. This hilly to steep soil is on escarpments 100 to 200 feet wide adjacent to drainageways and depressions in the sand plain. Slopes are short and irregular. Areas are 3 to 15 acres in size. This soil has a thinner profile than the one described as representative of the series.

Included with this soil in mapping are a few areas where the soil has coarse sand strata. Also included are small areas where erosion by water and soil blowing has removed most of the original surface layer and the present surface layer is lighter colored.

The steep slopes, the low available water capacity, and the resulting hazards of erosion and droughtiness are limitations to the use and management of this soil.

Large areas are used for recreation. Some areas are under urban development and some are still wooded. This soil is poorly suited to all of these uses. It is very poorly suited to crops and pasture. Community development group 1; capability unit VIIs–1; woodland group 3s2.

Use and Management of the Soils

The information in this section can be used in town and country planning and in planning various kinds of engineering works. It suggests use and management of the soils for crops and pasture, woodland, and wildlife.

Town and Country Planning

Anoka County is in the northern part of the Twin City Metropolitan area, which includes the cities of St. Paul and Minneapolis. The population of this area is growing rapidly. The demand for sites for homes, schools, shopping centers, churches, and industrial parks is increasing. Areas that were farms are rapidly being converted to nonfarm uses.

This section is intended to serve as a guide to homesite buyers, realtors, developers, planning commissions, health departments, and various governmental agencies to help them make sound land use decisions. This section does not restrict or control the development or use of land, which is controlled through zoning and land use policies of local government.

Soils of the survey area are grouped for town and country planning according to their properties and limitations. Important properties considered are natural soil drainage, texture, permeability, and depth to water table. The kinds of uses considered are foundations for buildings of three stories or less, local roads and streets, shallow excavations, lawns and gardens, houses with basements, and septic tank absorption fields.

Although a soil may have severe limitations for a particular use, this does not necessarily mean that it cannot successfully be put to that use. The limitations and hazards may be overcome under corrective measures, which commonly add to the expense of the project.

Any overall plan should include erosion and runoff control. Where development is intensive, the plan for erosion control should be worked out before construction begins, to avoid or decrease problems of soil erosion, runoff, and sedimentation. Special consideration should be given to adapting urban development to the site and landscape. To detract least from the natural environment, development should fit the land, grading and exposure of bare soil should be limited, and appropriate erosion control practices should be applied.

Most factors that influence development are noted in each of the eight community development groups, described on the following pages. The major soil limitations are defined for each group. Engineering tables list detailed information for each soil. Such economic factors as the distance from a street or road are not considered. The community development group to which each soil in the county is assigned can be found in the "Guide to Mapping Units" at the end of this survey.

The soil limitations described are expressed as

slight, moderate, and severe. *Slight* means that limitations are minor and are easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* indicates soil properties so unfavorable and so difficult to correct or overcome that major soil reclamation, special design, or intensive maintenance is required.

It should be emphasized that these interpretations do not eliminate the need for detailed onsite investigation. Also, engineers and others should not apply specific values to the estimates given for bearing capacity of soils.

COMMUNITY DEVELOPMENT GROUP 1

This group consists of somewhat excessively drained and excessively drained sandy and loamy soils underlain by sandy or gravelly material. These soils have slight to severe limitations for community development.

The seasonal high water table is below 6 feet. Permeability is rapid to very rapid in the underlying material. Bearing capacity is generally good. Shrink-swell potential is low. Potential frost action is low. Slopes range from 0 to 25 percent.

Limitations for foundations, local roads and streets, dwellings with basements, and septic tank absorption fields are slight if the slope is 0 to 6 percent, moderate if 6 to 12 percent, and severe if more than 12. For excavations, limitations are moderate to severe if the slope is less than 12 percent and severe if more than 12. For lawns and gardens, limitations are moderate if the slope is less than 12 percent and severe if more than 12.

Soils in this group are generally easy to work. The hazard of erosion and the costs of planning and construction are related to steepness and length of slope. Septic tank absorption fields function well but because the underlying material is rapidly permeable, there is a hazard of pollution. Sidewall stability is poor in the underlying material, and caving is a problem in excavations. Sandy soils are so difficult to vegetate that additional water and fertilizer must be added to establish and maintain a good plant cover.

COMMUNITY DEVELOPMENT GROUP 2

This group consists of dominantly well drained and moderately well drained loamy soils that have moderate to severe limitations for most uses in community development. Also included in this group are some sandy soils that have loamy underlying material.

The seasonal high water table is below 6 feet in the well-drained soils and at a depth of 3 to 5 feet in the moderately well drained soils. Permeability is moderate to moderately rapid. Bearing capacity is fair. Shrink-swell potential is low to moderate. Potential frost action is moderate to high. Slopes range from 1 to 30 percent.

Limitations for foundations, local roads and streets, and septic tank absorption fields are moderate if the slope is less than 12 percent and severe if more than 12. For excavations and dwellings with basements, limitations are slight to moderate if the slope is less than 12 percent and severe if more than 12. For lawns and gardens, limitations are mostly slight.

Soils having slopes of less than 12 percent can be used successfully in community development. To be considered are the hazard of erosion and the costs of planning and construction, as related to the steepness and length of slope. Foundations and roads are subject to structural damage because of frost action. In some areas drains are needed around footings to control water seepage into the basements. Septic tank absorption fields usually function but percolation tests are needed to determine the system needed for the filter field. In the area of moderately well drained soils, septic tank absorption fields may not function properly for short periods because the water table is seasonally high. The hazard of sidehill seepage is severe if the slope is more than 12 percent. The few sandy soils are difficult to vegetate.

COMMUNITY DEVELOPMENT GROUP 3

This group consists of dominantly well drained and moderately well drained soils that have severe limitations for most uses in community development.

The seasonal high water table is below 6 feet in the well-drained soils and at a depth of 3 to more than 5 feet in the moderately well drained soils. Permeability is moderately slow. Bearing capacity is fair to poor. Shrink-swell potential is moderate to high. Potential frost action is moderate to high. Slopes range from 0 to 30 percent.

Limitations are moderate to severe for foundations and local roads and streets; moderate for excavations; slight to moderate for lawns and gardens and dwellings with basements; and severe for septic tank absorption fields.

Soils in this group are severely limited for community development because percolation rates are too slow for a septic tank absorption field to function properly. Public sewers reduce the hazards. The hazard of erosion and costs of planning and construction in some areas are related to steepness and length of slope. Foundations and roads are subject to structural damage because of frost action and shrink-swell, especially in the more clayey soils. Drains are needed around footings in most areas to prevent seepage of water into basements. Excavations in some areas are difficult and costly because the high clay content causes poor workability. Wetness is also a hindrance to excavations in some areas.

COMMUNITY DEVELOPMENT GROUP 4

This group consists of somewhat poorly drained sandy soils that have moderate limitations for most uses in community development.

The seasonal high water table is at a depth of 2 to 5 feet. Permeability is rapid. Bearing capacity is generally good. Shrink-swell potential is low. Potential frost action is moderate. Slopes are 0 to 4 percent.

Limitations are slight for foundations; moderate for local roads and streets; severe for excavations; moderate for lawns and gardens; moderate to severe for dwellings with basements; and severe for septic tank absorption fields.

Soil limitations in this group are mainly related to the moderately high fluctuating water table. Shallow excavations often expose the water table, and there is

a hazard of caving in the underlying material. Basement seepage is a problem. Roads and streets may be structurally damaged by frost action. Septic tank absorption fields may not function properly during wet periods, and there is a hazard of contaminating the ground water. Sandy soils are so difficult to vegetate that additions of water are needed in places to establish and maintain a good plant cover.

COMMUNITY DEVELOPMENT GROUP 5

This group consists mostly of somewhat poorly drained and poorly drained soils that have severe limitations for most uses in community development. Soil properties for the group cover a wide range, but the following soil characteristics are in general common to all soils in the group.

The seasonal high water table is at a depth of 1 to 4 feet. Permeability is moderate or moderately slow. Bearing capacity is poor to fair. Shrink-swell potential is low to high. Potential frost action is high. Slopes are 0 to 2 percent.

Limitations for foundations, local roads and streets, excavations, dwellings with basements, and septic tank absorption fields are severe. For lawns and gardens, limitations are slight to moderate.

These soils are severely limited as locations for residential or commercial development as a result of the poor drainage and seasonal high water table. Even with proper design and engineering to overcome these limitations, structural damage by frost action makes maintaining parking lots, roads, and utilities expensive. Septic tank absorption fields do not function properly and there is a hazard of polluting the ground water. Many of these soils are better suited to parks, open space, or crops.

COMMUNITY DEVELOPMENT GROUP 6

This group consists mostly of very poorly drained mineral soils and shallow organic soils that have severe limitations for community development.

The seasonal high water table is at the surface or within a depth of 2 feet. Permeability ranges from slow to rapid. Bearing capacity is dominantly poor. Shrink-swell potential is moderate to low. Potential frost action is high. Slopes are 0 to 2 percent.

Limitations for all kinds of development are severe as a result of wetness, the high water table, and occasional ponding during periods of high runoff. High potential for frost action is a hazard to roads and parking lots. Drainage is needed during most construction projects (fig. 11).

COMMUNITY DEVELOPMENT GROUP 7

This group consists of very poorly drained, deep organic soils that have severe limitations in community development. The seasonal high water table is commonly at the surface. Permeability varies within a wide range. Bearing capacity is poor. Potential frost action is high. Slopes are 0 to 2 percent.

Limitations for all kinds of development are severe as a result of wetness, the high water table, and the poor bearing capacity. Organic soils have low bulk densities and are highly compressible. They generally are poorly suited to construction. Soils in this group are better suited to open space, farming, and wildlife. In landscaping, it is difficult to establish grasses, shrubs, and many species of trees.

COMMUNITY DEVELOPMENT GROUP 8

This group consists of well-drained to poorly drained soils that have severe limitations in community development because there is a danger of flooding. These soils have a broad range of characteristics, but they are all subject to occasional or frequent flooding.

Limitations for most uses in community development are severe as a result of the potential danger from flooding (fig. 12). Also, a high water table is limiting in some soils. Many areas in this group are potentially valuable as parks or open space, or for crops. A few areas have been altered and are no longer subject to flooding.

Engineering[2]

This section is useful to those who need information about soils used as structural material or as foundation upon which structures are built. Among those who can benefit from this section are planning commissions, town and city managers, land developers, engineers, contractors, and farmers.

Among properties of soils highly important in engineering are permeability, strength, compaction characteristics, soil drainage condition, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth to the water table, depth to bedrock, and soil slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to those who—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the kinds of soils on which they are built, for the purpose of predicting performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

Most of the information in this section is presented in tables 2 and 3, which show, respectively, estimates of soil properties significant in engineering and interpretations for various engineering uses of the soils.

[2] Reviewed by RICHARD D. WENDBERG, State conservation engineer, Soil Conservation Service.

Figure 11.—Water pumped from Isanti soils to lower the water table before sewer lines can be installed.

Figure 12.—**Flooded soybean field on Becker very fine sandy loam adjacent to the Rum River. Soil is severely limited as a building site.**

This information, along with the soil map and other parts of this publication, can be used to make interpretations in addition to those given in tables 2 and 3, and it also can be used to make other useful maps.

This information, however, does not eliminate need for further investigation at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables, generally depths greater than 6 feet. Also, inspection of sites, especially the small ones, is needed because many delineated areas of a given soil mapping unit may contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning in soil science that may not be familiar to engineers. The Glossary defines many of these terms.

Engineering classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system (*9*) used by the SCS engineers, Department of Defense, and others, and the AASHTO system (*1*) adopted by the American Association of State Highway and Transportation Officials.

In the Unified system soils are classified according to particle size distribution, plasticity, liquid limit, and organic matter. Soils are grouped in 15 classes. There are eight clases of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example, CL–ML.

The AASHTO system classifies soils according to those properties that affect use in highway construction and maintenance. In this system, a soil is assigned to one of seven basic groups ranging from A–1 through A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A–1 are gravelly soils, which have high bearing strength and are the best soils for subgrade (foundation). At the other extreme, in group A–7, are clay soils, which have low strength when wet and are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A–1, A–2, and A–7 groups are divided as

follows: A–1–a, A–1–b, A–2–4, A–2–5, A–2–6, A–2–7, A–7–5, and A–7–6. As additional refinement, the engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The estimated classification, without group index numbers, is given in table 2 for all soils mapped in the survey area.

Engineering properties

Estimates of soil properties significant in engineering are listed in table 2. These estimates are made for typical soil profiles, by layers that differ sufficiently to differ significantly for soil engineering. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soil in other counties. Following are explanations of some of the columns in table 2.

Depth to seasonal high water table is distance from the surface of the soil to the highest level that ground water reaches in the soil in most years.

Soil texture is described in table 2 in the standard terms used by the Department of Agriculture. These terms take into account relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, as for example, "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary of this soil survey.

Because bedrock is at a great depth in this county and is not significant to engineering, it is not mentioned in table 2.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a semisolid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material changes from semisolid to plastic; and the liquid limit, from plastic to liquid. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic. Liquid limit and plasticity index are estimated in table 2.

Permeability is that quality that enables a soil to transmit water or air. It is estimated on the basis of those soil characteristics observed in the field, particularly structure and texture. The estimates in table 2 do not take into account lateral seepage or such transient soil features as plowpans and surface crusts.

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at field capacity and the amount at the wilting point of most crop plants.

Reaction is the degree of acidity or alkalinity of a soil, expressed in pH values. The pH value and terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is the relative change in volume to be expected of soil material with changes in moisture content, that is, the extent to which the soil shrinks when dry or swells when wet. The extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils causes much damage to building foundations, roads, and other structures. A *high* shrink-swell potential indicates a hazard to maintenance of structures built in, on, or with material having this rating.

Corrosion, as used in table 2, pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such soil properties as drainage, texture, total acidity, and electrical conductivity of the soil material. Corrosion on concrete is influenced mainly by the content of sodium or magnesium sulfate, but also by soil texture and acidity. Installations of uncoated steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely in one kind of soil or in one soil horizon. A rating of *low* indicates a low probability of soil-induced corrosion damage. A rating of *high* indicates a high probability of damage, so that protective measures for steel and more resistant concrete should be used to avoid or minimize damage.

Engineering interpretations

The information in table 3 is based on the engineering properties of soils shown in table 2, on test data for soils nearby or adjoining, and on the experience of engineers and soil scientists with the soils of Anoka County. In table 3, ratings summarize limitations or the suitability of the soils for engineering. This table lists those soil features not to be overlooked in planning, installation, and maintenance.

Soil limitations are expressed as slight, moderate, and severe. *Slight* means that soil properties are generally favorable for the rated use, or in other words, limitations that are minor and are easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* indicates soil properties so unfavorable and so difficult to correct or overcome that major soil reclamation, special design, or intensive maintenance is required.

Soil suitability is rated by the terms *good*, *fair*, and *poor*, which have, respectively, meanings approximately parallel to the terms slight, moderate, and severe.

Following are explanations of some of the columns in table 3.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material from a depth of 18 inches to 6 feet is evaluated. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope affects difficulty of layout and construction and also the risk of soil erosion, lateral seepage,

and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage within a depth of 2 to 5 feet long enough for bacteria to decompose the solids. A lagoon has a nearly level floor and sides, or embankments, of compacted soil material. It is assumed that the embankment is compacted to medium density and the pond is protected from flooding. Considered are properties that affect the pond floor and the embankment. Those that affect the pond floor are permeability, organic matter, and slope. If the floor requires leveling, depth to bedrock is important. The soil properties that affect the embankment are the engineering properties of the embankment material as interpreted from the Unified Soil Classification and the stone content, if any, which influences the ease of excavation and compaction of the embankment material.

Shallow excavations are those that require digging or trenching to a depth of less than 6 feet, as for example, excavations for pipelines, sewer lines, phone and power transmission lines, basements, and open ditches. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, no rock outcrop or large stones, and no flooding or high water table.

Dwellings, as rated in table 3, are no more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings relate to capacity to support load and resist settlement under load and to ease of excavation. Soil properties that affect capacity to support load are wetness, susceptibility to flooding, density, plasticity, texture, and shrink-swell potential. Those that affect excavations are wetness, slope, depth to bedrock, and content of stones and rocks.

Sanitary landfill is a method of disposing of refuse by covering with soil material. The waste is spread in thin layers, compacted, and covered with soil throughout the disposal period. Landfill areas are subject to heavy vehicular traffic. Some soil properties that affect suitability for landfill are ease of excavation, hazard of polluting ground water, and trafficability. The best soils have moderately slow permeability, withstand heavy traffic, and are friable and easy to excavate. Unless otherwise stated, the ratings in table 3 apply only to a depth of about 6 feet. Ratings of *slight* or *moderate* therefore, may not be valid if trenches are to be much deeper than 6 feet. Although reliable predictions can be made to a depth of 10 or 15 feet for some soils, every site should be investigated before it is selected.

Local roads and streets, as rated in table 3, have an all-weather surface expected to carry automobile traffic all year. They have a subgrade of underlying soil material; a base consisting of gravel, crushed rock, or soil material stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. These roads are graded to shed water and have ordinary provisions for drainage. They are built mainly from soil at hand, and most cuts and fills are less than 6 feet deep.

Soil properties that most affect design and construction of roads and streets are load-supporting capacity and stability of the subgrade, and the workability and quantity of cut and fill material available. The AASHTO and Unified classifications of the soil material, and also the shrink-swell potential, indicate the traffic-supporting capacity. Wetness and flooding affect stability of the material. Slope, depth to hard rock, content of stones and rocks, and wetness affect ease of excavation and amount of cut and fill needed to reach an even grade.

Road fill is soil material used in embankments for roads. The suitability ratings reflect the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage and the relative ease of excavating the material at borrow areas.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 3 provide guidance about where to look for probable sources. A soil rated as a *good* or *fair* source of sand or gravel generally has a layer at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the material. Neither do they indicate quality of the deposit.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as in preparing a seedbed; natural fertility of the material, or the response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and the content of stone fragments are characteristics that affect suitability. Also considered in the ratings is damage that will result at the area from which topsoil is taken.

Embankments, dikes, and levees require soil material resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compactibility. Stones or organic material in a soil are among the factors that are unfavorable.

Drainage of cropland and pasture is affected by such soil properties as permeability, texture, and structure; depth to claypan, rock, or other layers that influence rate of water movement; depth to the water table; slope, stability in ditchbanks; susceptibility to stream overflow; salinity or alkalinity; and availability of outlets for drainage.

Irrigation of a soil is affected by such features as slope; susceptibility to stream overflow, water erosion, or soil blowing; soil texture; content of stones; accumulation of salts and alkali; depth of root zone; rate of water intake at the surface; permeability of soil layers below the surface layer and in fragipans or other layers that restrict movement of water; amount of water held available to plants; and the need for drainage, or the depth to water table or bedrock.

Terraces and diversions are embankments, or ridges, constructed across the slope to intercept runoff so that it soaks into the soil or flows slowly to a prepared outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope; depth to bedrock or other unfavorable material; stones; permeability; and resistance to water erosion, soil slipping, and soil blowing. A soil suitable for these structures provides outlets for runoff and is not difficult to vegetate.

TABLE 2.—*Estimates of soil properties*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. fully the instructions for referring to other series that appear in the first column of the table.

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification		Percentage less than 3 inches passing sieve	
				Unified	AASHTO	No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Ft	*In*					
Alluvial land, mixed, frequently flooded: Af. No valid estimates can be made.							
Anoka: AnA, AnB, AnC	>6	0–18	Loamy fine sand	SM	A–2 or A–4	100	95–100
		18–29	Fine sand	SM	A–2 or A–4	100	95–100
		29–60	Very fine sandy loam	ML or SM	A–4	100	95–100
		60–84	Fine sand	SM	A–2	100	95–100
Becker: Ba	>5	0–27	Very fine sandy loam	ML	A–4	100	100
		27–44	Loamy fine sand and very fine sandy loam.	ML	A–4	100	100
		44–60	Coarse sand	SM or SP–SM	A–1 or A–2	100	90–100
Blomford: Bm	2–4	0–9	Loamy fine sand	SM	A–2 or A–4	100	95–100
		9–33	Fine sand and loamy fine sand.	SM	A–2 or A–4	100	95–100
		33–60	Fine sandy loam	SM	A–4	100	100
Braham: BtB, BtC	>6	0–8	Loamy fine sand	SM	A–2	100	95–100
		8–24	Loamy fine sand	SM	A–2	100	95–100
		24–60	Sandy clay loam	SL or CL	A–6	100	90–100
Brickton: Bx	1–3	0–9	Silt loam	CL	A–6	100	100
		9–40	Silty clay loam and silty clay.	CH	A–7	100	100
		40–60	Silt loam	CL	A–6 or A–7	100	100
Cathro: Cb	0–2	0–26	Muck (sapric)	Pt			
		26–31	Mucky peat (hemic)	Pt			
		31–60	Silt loam	CL–ML or CL	A–4	100	97–100
Chetek: CkB, CkC	>8	0–8	Sandy loam	SM	A–2	90–100	70–80
		8–17	Sandy loam	SM or SM–SC	A–2 or A–4	85–95	65–75
		17–60	Gravelly loamy sand and gravelly coarse sand.	SM or SP–SM	A–1	80–90	30–40
Cut and fill land: Cu. No valid estimates can be made.							
Dalbo: DlA	3–6	0–9	Silt loam	CL	A–6	100	100
		9–28	Silty clay loam and clay	CH or MH	A–7	100	100
		28–60	Silty clay loam and silt loam.	CL	A–6 or A–7	100	100
Dickman: DnA, DnB	>6	0–12	Sandy loam	SM	A–2 or A–4	95–100	90–100
		12–18	Sandy loam	SM	A–2 or A–4	95–100	90–100
		18–60	Loamy fine sand, sand, and coarse sand.	SM or SP–SM	A–2 or A–3	95–100	80–95

significant in engineering

The soils in such mapping units may have different properties and limitations, and for this reason it is necessary to follow care-
Absence of data indicates that no estimate was made. The symbol > means greater than]

Percentage less than 3 inches passing sieve—cont.		Liquid limit	Plasticity index	Permeability	Available water capacity [1]	Reaction	Shrink-swell potential	Risk of corrosion to—	
No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
		Pct		*In/hr*	*In/in of soil*	*pH*			
85–95	25–45		[2]NP	6.0–20.0	0.10–0.12	5.1–6.5	Low	Low	Moderate.
85–95	20–40		NP	6.0–20.0	0.05–0.07	5.6–6.0	Low	Low	Moderate.
75–90	35–65		NP	2.0– 6.0	0.17–0.19	5.1–6.0	Low	Low	Moderate.
85–95	20–35		NP	6.0–20.0	0.08–0.10	5.6–6.5	Low	Low	Moderate.
85–95	50–65			2.0– 6.0	0.20–0.22	6.1–7.3	Low	Low	Low to moderate.
85–95	50–65			2.0– 6.0	0.17–0.19	6.1–7.3	Low	Low	Low to moderate.
45–75	5–20		NP	6.0–20.0	0.02–0.04	6.6–7.3	Low	Low	Low.
85–95	25–45			6.0–20.0	0.10–0.12	5.6–6.0	Low	Low	Moderate.
85–95	20–40			6.0–20.0	0.09–0.11	5.1–5.5	Low	Moderate	Moderate.
85–100	40–50			0.6– 2.0	0.14–0.16	6.6–7.8	Low	Moderate	Low.
85–95	25–35			6.0–20.0	0.10–0.12	5.6–7.3	Low	Low	Low to moderate.
85–95	25–35			6.0–20.0	0.09–0.11	5.6–7.3	Low	Low	Low to moderate.
80–90	40–60			0.6– 2.0	0.15–0.17	5.1–7.8	Moderate	Low	Low to moderate.
98–100	90–100	25–35	12–20	0.6– 2.0	0.22–0.24	5.6–6.5	Moderate	Moderate	Low to moderate.
100	95–100	55–70	30–45	0.2– 0.6	0.16–0.19	5.6–7.8	High	High	Low to moderate.
100	90–100	30–45	15–25	0.6–2.0	0.20–0.22	7.9–8.4	Moderate	High	Low.
				6.0–10.0	0.35–0.48	6.1–6.5		High	Moderate.
				6.0–20.0	0.48–0.58	6.6–7.3		High	Moderate.
90–100	75–90	20–30	5–10	0.2– 0.6	0.20–0.22	6.6–7.3	Low	High	Low.
60–70	25–35			2.0– 6.0	0.16–0.18	5.6–6.0	Low	Low	Moderate.
50–60	30–40			2.0– 6.0	0.15–0.17	5.6–6.0	Low	Low	Moderate.
20–30	5–15		NP	6.0–20.0	0.02–0.04	6.1–7.3	Low	Low	Moderate.
97–100	80–90	20–35	12–20	0.6– 2.0	0.22–0.24	5.1–6.5	Moderate	High	Moderate.
100	90–100	55–70	25–40	0.2– 0.6	0.10–0.14	4.5–6.0	High	High	Moderate to high.
100	90–100	35–45	15–30	0.6– 2.0	0.20–0.22	7.4–8.4	Moderate	High	Low.
55–75	20–40	18–25	0–4	2.0– 6.0	0.13–0.15	5.6–6.0	Low	Low	Moderate.
55–75	20–40	18–25	0–4	2.0– 6.0	0.12–0.14	5.1–5.5	Low	Low	Moderate.
30–60	5–15		NP	6.0–20.0	0.05–0.07	5.6–7.3	Low	Low	Moderate.

TABLE 2.—*Estimates of soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification		Percentage less than 3 inches passing sieve	
				Unified	AASHTO	No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Ft	*In*					
Duelm: Dp	2–5	0–11	Loamy coarse sand	SM	A–2	95–100	95–100
		11–42	Coarse sand	SM or SP–SM	A–2	85–98	75–98
		42–60	Coarse sand	SP	A–1 or A–3	85–98	75–98
Dundas: Du	2–3	0–15	Fine sandy loam and loam	ML	A–4	100	100
		15–39	Sandy clay loam	SC or CL	A–7	100	95–100
		39–60	Fine sandy loam	CL	A–4 or A–6	100	90–100
*Emmert: EmC, EmD, EpC, EpD— For Chetek, Hayden, Heyder, and Kingsley parts of EpC and EpD, refer to Chetek, Hayden, Heyder, and Kingsley series.	>8	0–4	Gravelly coarse sandy loam	GM or SM	A–1	65–85	50–70
		4–38	Gravelly coarse sand	SP or GP	A–1	50–70	35–50
		38–60	Gravelly coarse sand	SP or GP	A–1	50–70	25–40
Glencoe: Gc	0–3	0–27	Loam and fine sandy loam	CL	A–4 or A–6	100	97–100
		27–45	Loam and silt loam	CL	A–4 or A–6	100	97–100
		45–60	Fine sandy loam	CL or SC	A–4 or A–6	100	95–100
Growton: GrA	3–5	0–23	Loamy sand and fine sandy loam.	SM	A–2	95–100	95–100
		23–45	Sandy loam	SM	A–2 or A–4	90–95	80–95
		45–60	Sandy loam	SM	A–2 or A–4	90–95	80–95
Hayden: HdB, HdC2, HdD	>6	0–10	Fine sandy loam	SC or SM–SC	A–4 or A–6	95–100	98–100
		10–37	Loam and sandy clay loam	CL	A–6	95–100	95–100
		37–60	Fine sandy loam	SC or SM–SC	A–4 or A–6	95–100	90–100
*Heyder: HeB, HeC2, HIC, HID, HeD, HeE. For Emmert and Kingsley part of HIC and HID, refer to Emmert and Kingsley series.	>6	0–22	Fine sandy loam	SC or SM–SC	A–4 or A–2	98–100	95–100
		22–53	Fine sandy loam and sandy loam.	SC or SM–SC	A–4 or A–2	93–98	93–98
		53–60	Sandy loam	SM	A–2 or A–4	85–98	85–98
Hubbard: HuA, HuB, HuC	>6	0–20	Coarse sand	SM or SP–SM	A–1 or A–2	95–100	85–95
		20–60	Coarse sand and gravelly coarse sand.	SM or SP–SM	A–1, A–2 or A–3	85–98	80–90
Isan: Is	0–2	0–24	Sandy loam and loamy sand.	SM	A–2	95–100	95–100
		24–30	Sand	SM	A–2	95–100	95–100
		30–60	Coarse sand	SP	A–1 or A–3	85–98	75–98
Isanti: Iw	0–2	0–10	Fine sandy loam	SM	A–2	100	100
		10–60	Fine sand	SM or SP–SM	A–2 or A–3	100	100
Kingsley: KmB, KmC2, KmD, KmE.	>6	0–13	Fine sandy loam	SM	A–2 or A–4	98–100	85–95
		13–34	Sandy clay loam and fine sandy loam.	SC	A–2 or A–6	80–90	75–90
		34–78	Sandy loam	SC or SM–SC	A–2 or A–4	90–98	85–95

significant in engineering—Continued

Percentage less than 3 inches passing sieve–Cont.		Liquid limit	Plasticity index	Permeability	Available water capacity [1]	Reaction	Shrink-swell potential	Risk of corrosion to—	
No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
		Pct		*In/hr*	*In/in of soil*	*pH*			
60–75	15–30		NP	6.0–20.0	0.10–0.12	6.6–7.3	Low	Low	Moderate.
50–75	5–25		NP	6.0–20.0	0.03–0.05	6.1–7.3	Low	Low	High.
35–70	2–5		NP	6.0–20.0	0.02–0.04	6.6–7.3	Low	Low	Moderate.
85–95	50–60	30–40	6–10	0.6– 2.0	0.16–0.18	6.1–6.5	Low	High	Low.
80–95	45–60	41–50	20–27	0.2– 0.6	0.16–0.18	6.1–7.3	Moderate to high.	High	Low.
80–95	50–60	20–32	7–16	0.6– 2.0	0.14–0.16	7.9–8.4	High	High	Low.
20–30	15–25		NP	20.0	0.13–0.15	6.1–6.5	Low	Low	Moderate.
15–25	0–4		NP	20.0	0.03–0.05	5.6–7.5	Low	Low	Moderate.
10–20	0–3		NP	20.0	0.02–0.04	7.4–7.8	Low	Low	Low.
85–95	50–60	28–36	6–18	0.6– 2.0	0.20–0.22	6.6–7.3	Low	High	Low.
90–100	75–90	26–34	8–18	0.2– 2.0	0.20–0.22	6.6–7.8	Low	High	Low.
80–90	40–55	23–31	7–15	0.6– 2.0	0.14–0.16	7.4–7.8	Low	High	Low.
90–98	20–35		NP	0.6– 2.0	0.16–0.18	5.6–6.5	Low	Low	Moderate.
70–90	30–40		NP	0.6– 2.0	0.12–0.14	5.6–6.5	Low	Low	Moderate.
60–80	30–40		NP	0.6– 2.0	0.11–0.13	5.6–6.5	Low	Low	Moderate.
65–75	35–50	25–35	4–15	0.6– 2.0	0.16–0.18	5.6–6.5	Low	Low	Moderate.
70–80	50–60	32–36	14–20	0.6– 2.0	0.15–0.17	5.1–7.3	Moderate	Low	Low to moderate.
65–75	40–50	28–32	6–18	0.6– 2.0	0.14–0.16	7.4–8.4	Low	Low	Low.
80–90	30–50	25–35	4–10	0.6– 2.0	0.16–0.18	5.6–6.5	Low	Low	Low.
75–90	30–50	20–30	5–10	0.6– 2.0	0.15–0.17	5.6–6.5	Low	Low	Low to moderate.
70–85	30–40		NP	0.6– 2.0	0.11–0.13	6.6–7.8	Low	Low	Low.
50–70	10–20		NP	6.0–20.0	0.07–0.09	6.1–6.5	Low	Low	Moderate.
35–65	5–15		NP	6.0–20.0	0.02–0.04	6.1–7.3	Low	Low	Moderate.
60–75	15–35		NP	6.0–20.0	0.13–0.15	6.1–6.5	Low	High	Moderate.
50–75	10–30		NP	6.0–20.0	0.06–0.08	6.1–6.5	Low	High	Moderate.
35–70	2–5		NP	6.0–20.0	0.02–0.03	6.6–7.3	Low	High	Moderate.
95–100	15–30		NP	6.0–20.0	0.10–0.12	5.1–6.0	Low	High	Moderate.
95–100	5–20		NP	6.0–20.0	0.06–0.08	5.6–6.5	Low	High	Moderate.
65–75	25–40		NP	0.6– 2.0	0.16–0.18	6.1–7.3	Low	Low	Low to moderate.
65–75	30–50	25–30	10–15	0.6– 2.0	0.16–0.19	5.1–6.0	Low	Low	Moderate.
65–75	25–40	15–25	4–10	0.2– 0.6	0.09–0.11	5.6–6.5	Low	Low	Moderate.

TABLE 2.—*Estimates of soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification		Percentage less than 3 inches passing sieve	
				Unified	AASHTO	No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Ft	*In*					
Kratka: Kr	0–2	0–12	Loamy fine sand	SM	A–2	100	100
		12–36	Fine sand and loamy fine sand.	SM	A–2	100	100
		36–60	Fine sandy loam	SM or ML	A–4	85–100	85–100
Lake beaches: Lb	1–4						
Langola: LgB	>6	0–10	Loamy sand	SM	A–2	100	100
		10–38	Sand, gravelly loam sand, and sandy loam.	SM	A–2	85–95	70–95
		38–60	Sandy loam	SM	A–2	95–100	90–100
Lino: LnA	2–4	0–7	Loamy fine sand	SM	A–2	100	100
		7–60	Fine sand	SM	A–2	100	100
Loamy wet land: Lw	0–2						
Lupton: Lx	0–1	0–70	Muck (sapric)	Pt			
Markey: Ma	0–2	0–31	Muck (sapric)	Pt			
		31–36	Fine sandy loam	SM	A–2	100	100
		36–60	Fine sand and sand	SM	A–2	100	100
Marsh: Mc. No valid estimates can be made.	3–0						
Meehan: Me	2–5	0–8	Sand	SM or SP–SM	A–2	95–100	95–100
		8–40	Sand	SM or SP–SM	A–2 or A–3	95–100	85–100
		40–60	Sand	SP	A–3	95–100	85–100
Millerville: Mk	0–1	0–4	Muck (sapric)	Pt			
		4–30	Mucky peat (hemic)	Pt			
		30–60	Coprogenous earth	Pt			
Mora: MoA	3–5	0–15	Fine sandy loam	SM	A–2 or A–4	80–90	75–85
		15–41	Fine sandy loam	SC	A–4 or A–6	80–90	75–85
		41–60	Sandy loam	SM	A–2 or A–4	80–90	75–85
Nessel: NeA	3–5	0–16	Fine sandy loam	SM	A–2 or A–4	100	100
		16–40	Fine sandy loam and sandy clay loam.	CL or SC	A–6	100	97–100
		40–60	Fine sandy loam	SC or CL	A–6	100	95–100
Nowen: No	2–4	0–15	Fine sandy loam and sandy loam.	SM	A–4	90–95	85–95
		15–49	Fine sandy loam	SC	A–6	85–95	85–95
		49–60	Sandy loam	SC or SM–SC	A–4	85–95	80–90
Nymore: NyA, NyB, NyC, NrD.	>6	0–7	Loamy sand	SM	A–2	100	98–100
		7–26	Loamy sand	SM or SP–SM	A–2	100	98–100
		26–60	Sand	SM or SP–SM	A–2	100	95–100

significant in engineering—Continued

Percentage less than 3 inches passing sieve —cont.		Liquid limit	Plasticity index	Permeability	Available water capacity [1]	Reaction	Shrink-swell potential	Risk of corrosion to—	
No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
				In/hr	*In/in of soil*	*pH*			
95–100	12–30		NP	6.0–20.0	0.10–0.12	5.6–6.5	Low	High	Moderate.
95–100	12–20		NP	6.0–20.0	0.09–0.11	6.1–7.8	Low	High	Low to moderate.
65–85	45–60	15–20	1–4	0.2– 0.6	0.14–0.16	6.6–8.4	Moderate	High	Low.
				6.0–20.0		6.1–6.5	Low	High	Low to moderate.
70–85	25–35			6.0–20.0	0.10–0.12	5.6–6.0	Low	Low	Moderate.
45–65	20–30			6.0–20.0	0.06–0.08	5.6–6.5	Low	Low	Moderate.
45–55	25–35			0.2– 0.6	0.09–0.11	6.1–6.5	Low	Low	Moderate.
95–100	20–30		NP	6.0–20.0	0.10–0.12	5.1–6.0	Low	Low	Moderate to high.
95–100	10–20		NP	6.0–20.0	0.06–0.08	5.1–6.0	Low	Low	Moderate to high.
						6.1–7.3	Low	High	Low.
				2.0– 6.0	0.35–0.48	5.1–6.0		High	Moderate to high.
				2.0– 6.0	0.35–0.48	6.1–6.5		High	Moderate.
95–100	12–35		NP	6.0–20.0	0.14–0.16	6.6–7.3	Low	High	Low.
90–100	12–20		NP	6.0–20.0	0.08–0.10	6.6–7.3	Low	High	Low.
75–90	10–20		NP	6.0–20.0	0.07–0.09	5.1–6.0	Low	Low	Moderate.
75–90	5–15		NP	6.0–20.0	0.06–0.08	5.1–6.0	Low	Low	Moderate.
75–90	2–5		NP	6.0–20.0	0.05–0.07	5.6–7.3	Low	Low	Moderate.
				2.0– 6.0	0.35–0.48	6.6–7.3		High	Low.
				6.0–20.0	0.48–0.58	6.1–6.5		High	Moderate.
				0.2– 0.6	0.35–0.48	6.1–6.5		High	Moderate.
65–75	25–50		NP	2.0– 6.0	0.16–0.18	5.1–6.5	Low	Moderate	Moderate.
65–75	35–50	25–30	5–15	0.2– 0.6	0.15–0.17	5.6–6.5	Low	Moderate	Moderate.
65–75	25–40		NP	0.2– 0.6	0.09–0.11	6.1–7.3	Low	Moderate	Low.
90–100	30–40		NP	2.0– 6.0	0.16–0.18	5.6–6.5	Low	Moderate	Low to moderate.
85–95	40–55	30–40	15–20	0.6– 2.0	0.15–0.17	5.6–7.3	Low	Moderate to low.	Low to moderate.
85–95	45–55	25–35	12–15	2.0– 6.0	0.14–0.16	7.4–8.4	Low	Low	Low.
85–95	35–50		NP	0.6– 2.0	0.16–0.18	6.1–7.3	Low	Moderate	Moderate.
85–95	40–50	25–35	12–20	0.6– 2.0	0.16–0.18	6.1–7.3	Low	Moderate	Moderate.
70–85	35–45	20–30	5–10	0.6– 2.0	0.11–0.13	6.6–7.8	Low	Moderate	Moderate.
70–80	15–25		NP	6.0–20.0	0.13–0.15	5.1–6.0	Low	Low	Low to moderate.
80–90	10–20		NP	6.0–20.0	0.09–0.11	5.1–6.0	Low	Low	Low to moderate.
65–75	10–20		NP	6.0–20.0	0.05–0.07	5.1–6.5	Low	Low	Low to moderate.

TABLE 2.—*Estimates of soil properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	USDA texture	Classification		Percentage less than 3 inches passing sieve	
				Unified	AASHTO	No. 4 (4.7 mm)	No. 10 (2.0 mm)
	Ft	*In*					
Rifle: Rf, Rg, Rh	0–1	0–60	Mucky peat (hemic)	Pt			
Rondeau: Ru	0–1	0–44	Muck (sapric)	Pt			
		44–49	Coprogenous earth	Pt			
		49–66	Marl				
Ronneby: Ry	2–4	0–15	Fine sandy loam	SM	A–2 or A–4	85–95	75–85
		15–42	Fine sandy loam	SM	A–2 or A–4	80–90	75–85
		42–60	Fine sandy loam	SM	A–2 or A–4	80–90	75–85
Sartell: SbB, SbC, SbC2, SbD2.	>8	0–9	Fine sand	SM or SP–SM	A–2 or A–3	100	100
		9–26	Fine sand	SM	A–2	100	100
		26–60	Fine sand	SM or SP–SM	A–2 or A–3	100	100
Seelyeville: Se	0–1	0–57	Muck (sapric)	Pt			
Soderville: SoA	2–4	0–9	Fine sand	SM	A–2	100	100
		9–46	Fine sand and loamy fine sand.	SM	A–2	100	100
		46–60	Fine sand	SM	A–2	100	100
Webster: Wb	1–3	0–14	Loam	CL	A–4 or A–6	95–100	90–100
		14–23	Sandy clay loam	CL	A–6	100	95–100
		23–60	Fine sandy loam	CL	A–4 or A–6	95–100	90–100
Zimmerman: ZmA, ZmB, ZmC, ZmD.	>6	0–10	Fine sand	SM or SP–SM	A–2	100	100
		10–60	Fine sand	SM or SP–SM	A–2 or A–3	100	100

[1] Estimates based on soil texture, coarse fragments, structure, consistence, bulk density, and contrasting material.

[2] Nonplastic.

Recreation

Knowledge of soils is necessary in planning, developing, and maintaining areas used for recreation. In table 4 the soils of Anoka County have been grouped and are rated according to limitations that affect their suitability for camp areas, picnic areas, playgrounds, and paths and trails. Soils were grouped on the basis of common characteristics as related to the effect on recreation uses. Texture refers to the surface layer unless specified. Location, land values, or esthetic values are not considered in the table but are criteria to be considered in planning.

In table 4 the soils are rated as having slight, moderate, or severe limitations for the specified uses. For all of these ratings, it is assumed that a good cover of vegetation can be established and maintained. A limitation of *slight* means that soil properties are generally favorable and limitations are so minor that they easily can be overcome. A *moderate* limitation can be overcome or modified by planning, by design, or by special maintenance. A *severe* limitation means that costly soil reclamation, special design, intense maintenance, or a combination of these is required.

Camp areas are used intensively for tents and small camp trailers and the accompanying activities of outdoor living. Little preparation of the site is required, other than shaping and leveling for tent and parking areas. Camp areas are subject to heavy foot traffic and limited vehicular traffic. The best soils have mild slopes, good drainage, a surface free of rocks and coarse fragments, no flooding during periods of heavy use, and a surface that is firm after rains but not dusty when dry.

Picnic areas are attractive natural or landscaped tracts. They are subject to heavy foot traffic. Most of the vehicular traffic is confined to access roads. The best soils are firm when wet but not dusty when dry; are not flooded during the season of use; and do not have slopes or stoniness that greatly increases cost of leveling sites or of building access roads.

Playgrounds are areas used intensively for baseball, football, badminton, and similar organized games. Soils suitable for this use need to withstand intensive

significant in engineering—Continued

Percentage less than 3 inches passing sieve —cont.		Liquid limit	Plasticity index	Permeability	Available water capacity [1]	Reaction	Shrink-swell potential	Risk of corrosion to—	
No. 40 (0.42 mm)	No. 200 (0.074 mm)							Uncoated steel	Concrete
		Pct		*In/hr*	*In/in of soil*	*pH*			
				2.0– 6.0	0.48–0.58	5.6–7.3		High	Moderate.
				2.0– 6.0	0.35–0.48	7.4–7.8		High	Low.
				0.2– 0.6	0.35–0.48	7.4–7.8		High	Low.
				0.06– 0.2	0.20–0.22	7.4–7.8		High	Low.
70–80	25–40	15–20	1–4	0.6– 2.0	0.16–0.18	5.1–6.0	Low	Moderate	Moderate.
60–70	30–50	15–20	1–4	0.2– 0.6	0.12–0.14	5.1–6.5	Low	Moderate	Moderate.
65–75	25–40	10–20	1–4	0.2– 0.6	0.09–0.11	6.6–7.3	Low	Moderate	Low.
95–100	5–15		NP	6.0–20.0	0.07–0.09	4.5–5.0	Low	Low	High.
95–100	15–20		NP	6.0–20.0	0.06–0.08	5.6–6.0	Low	Low	Moderate.
95–100	5–15		NP	6.0–20.0	0.05–0.07	5.6–6.5	Low	Low	Moderate.
				2.0– 6.0	0.35–0.48	6.6–7.3		High	Low.
95–100	15–30		NP	6.0–20.0	0.07–0.09	5.1–6.0	Low	Low	High.
95–100	12–35		NP	6.0–20.0	0.06–0.11	5.1–6.0	Low	Low	Moderate.
90–100	12–20		NP	6.0–20.0	0.05–0.07	5.6–6.0	Low	Low	Moderate.
85–90	60–75	25–35	8–20	0.6– 2.0	0.20–0.22	6.6–7.3	Moderate	High	Low.
90–100	60–80	30–40	15–30	0.6– 2.0	0.15–0.19	6.6–7.8	Moderate	High	Low.
85–90	50–75	25–35	7–20	0.6– 2.0	0.17–0.19	7.9–8.4	Moderate	High	Low.
95–100	10–20		NP	6.0–20.0	0.07–0.09	5.1–6.0	Low	Low	Moderate.
95–100	5–20		NP	6.0–20.0	0.06–0.08	6.1–7.3	Low	Low	Moderate.

foot traffic. The best soils have a nearly level surface free of coarse fragments and rock outcrop, good drainage, no flooding during periods of heavy use, and a surface that is firm after rains but not dusty when dry. If grading and leveling are required, depth to rock is important.

Paths and trails are used for local and cross-country travel by foot or on horseback. Design and layout should require little or no cutting and filling. The best soils are at least moderately well drained, are firm when wet but not dusty when dry, are flooded no more than once during the season of use, have slopes of less than 18 percent, and have few or no rocks or stones on the surface.

The outdoor recreation groups of Anoka County are described in table 4.

Crops and Pasture

Fewer acres are cropped each year because of the rapid urbanization of Anoka County. Corn, soybeans, alfalfa, oats, and rye are the chief crops. Cultured sod, carrots, radishes, and potatoes are grown on some organic soils. Controlling erosion, increasing fertility, maintaining and improving drainage, and conserving moisture in the droughtier soils are the main considerations in managing the cultivated soils in the county.

Stripcropping, contouring, terraces, grassed waterways, minimum tillage, no-till planting, cover crops, field windbreaks, returning crop residue, and raising sod crops in the cropping sequence help in erosion control.

Applying commercial fertilizers and barnyard manure and growing legumes and green-manure crops improve or maintain fertility. Fertilizer should be carefully applied according to soil fertility tests. An excessive application of commercial fertilizer can run off into streams and lakes and infiltrate into underground water supplies. This is also true of insecticides and herbicides.

Drainage is needed on the wet, level or depressional soils if these soils are to be intensively cropped. Outlets are needed for lateral ditches and tile drains. Periodic

TABLE 3.—*Engineering*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. fully the instructions for referring to other series

Soil series and map symbols	Degree and kind of limitations for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill (area type)	Local roads and streets
Alluvial land, frequently flooded: Af.	Severe: frequent flooding.	Severe: frequent flooding.	Severe: frequent flooding.	Severe: frequent flooding.	Severe: frequent flooding.	Severe: flooding.
Anoka: AnA, AnB	Slight	Severe: moderately rapid permeability.	Severe: sandy texture; sidewall instability.	Slight	Severe: moderately rapid permeability.[1]	Slight
AnC	Moderate: slope.[1]	Severe: moderately rapid permeability; slope.	Severe: sandy texture; sidewall instability.	Moderate: slope.	Severe: moderately rapid permeability.[1]	Moderate: slope.
Becker: Ba	Moderate: occasionally flooded.[1]	Severe: moderately rapid permeability.	Severe: sandy underlying material.	Severe: occasionally flooded.	Severe: moderately rapid permeability.[1]	Moderate: occasionally flooded.
Blomford: Bm	Severe: high water table.	Severe: high water table.	Severe: somewhat poorly drained.	Severe: somewhat poorly drained.	Moderate: somewhat poorly drained.	Moderate: somewhat poorly drained.
Braham: BtB	Moderate: moderate permeability.	Moderate: moderate permeability; slope.	Moderate: sandy texture to a depth of 40 inches.	Moderate: moderate shrink-swell potential.	Slight	Moderate: fines;[2] moderately susceptible to frost action.
BtC	Moderate: slope.[1]	Severe: slope	Moderate: sandy texture; slope.	Moderate: slope.	Moderate: slope.	Moderate: fines;[2] slope; moderately susceptible to frost action.

interpretations

The soils in such mapping units may have different properties and limitations, and for this reason it is necessary to follow care-that appear in the first column of the table]

Suitability as source of—			Soil features affecting—			
Road fill	Sand and gravel	Topsoil	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Poor: poorly drained.	Poor: sands occur in bands with finer material.	Poor: poorly drained.	Frequent flooding.	Frequent flooding.	Frequent flooding.	Not needed; nearly level.
Fair: fines;[2] moderately susceptible to frost action.	Poor: fines [2]	Poor: sandy	Medium shear strength; compressibility; compacted permeability; low resistance to piping.	Somewhat excessively drained.	Moderate available water capacity; moderate intake.	Deep, sandy soils; moderately rapid permeability; somewhat excessively drained; stone free.
Fair: fines;[2] moderately susceptible to frost action.	Poor: fines [2]	Poor: sandy	Medium shear strength; compressibility; compacted permeability; low resistance to piping.	Somewhat excessively drained.	Moderate available water capacity; moderate intake.	Deep, sandy soils; moderately rapid permeability; somewhat excessively drained; stone free; slope.
Fair: fines [2]	Poor: fines [2]	Good	Medium to low shear strength; compressibility; compacted permeability; low resistance to piping.	Well drained to moderately well drained.	Moderate available water capacity; moderate intake.	Not needed; nearly level.
Fair: fines [2]	Poor: fines [2]	Poor: sandy	Medium shear strength; low to medium compressibility; medium to low compacted permeability; low resistance to piping.	High water table; somewhat poorly drained.	Moderate available water capacity; rapid intake; water table at 2 to 4 feet; drainage needed.	Not needed; nearly level.
Fair: fines;[2] moderately susceptible to frost action.	Poor: fines [2]	Poor: sandy	Surface material has low to medium compressibility; medium to low resistance to piping; underlying material has medium to low compressibility and compacted permeability.	Somewhat excessively drained.	Moderate available water capacity; rapid intake; moderate permeability in underlying material; gently sloping.	Sandy surface material; loamy underlying material; moderate permeability in underlying material; gently sloping.
Fair: fines [2]	Poor: fines [2]	Poor: sandy	Surface material has low to medium compressibility; medium to low resistance to piping; underlying material has medium to low compressibility; compacted permeability.	Somewhat excessively drained.	Moderate available water capacity; rapid intake; moderate permeability in underlying material; sloping.	Sandy surface material; loamy underlying material; moderate permeability in underlying material; sloping.

TABLE 3.—*Engineering*

Soil series and map symbols	Degree and kind of limitations for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary land fill (area type)	Local roads and streets
Brickton: Bx	Severe: high water table; moderately slow permeability.	Severe: high water table.	Severe: poorly drained; high water table.	Severe: poorly drained.	Severe: high water table.	Severe: poorly drained.
Cathro: Cb	Severe: high water table.	Severe: high water table.	Severe: high water table.	Severe: high water table.	Severe: high water table.	Severe: very poorly drained.
Chetek:						
CkB	Slight[1]	Severe: rapid permeability.	Severe: sandy texture; sidewall instability.	Slight	Severe: rapid permeability.[1]	Moderate: fines;[2] moderate susceptibility to frost action.
CkC	Moderate: slope.[1]	Severe: rapid permeability.	Severe: sandy texture; slope.	Moderate: slope.	Severe: rapid permeability.[1]	Moderate: slope; fines.[2]
Cut and fill land:[3] Cu.						
Dalbo: DlA	Severe: moderately slow permeability.	Moderate: moderate permeability in underlying material.	Moderate: fine textured subsoil.	Moderate: moderate shrink-swell in underlying material.	Moderate: moderately high water table.	Severe: high shrink-swell potential in subsoil.
Dickman: DnA, DnB	Slight[1]	Severe: rapid permeability in underlying material.	Severe: sidewall instability.	Slight	Severe: rapid permeability in underlying material.[1]	Moderate: fines.[2]
Duelm: Dp	Severe:[1] high water table.	Severe: high water table.	Severe: somewhat poorly drained.	Severe: somewhat poorly drained.	Severe: high water table[1]; rapid permeability.	Moderate: somewhat poorly drained.
Dundas: Du	Severe: moderately slow permeability in subsoil.	Severe: high water table.	Severe: poorly drained.	Severe: poorly drained.	Severe: high water table.	Severe: poorly drained.

interpretations—Continued

Suitability as source of—			Soil features affecting—			
Road fill	Sand and gravel	Topsoil	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Poor: high shrink-swell potential; poorly drained.	Unsuited	Poor: poorly drained.	Medium to low shear strength; medium to high compressibility.	Loamy material; moderately slow permeability; water table at 1 to 3 feet.	Drainage needed; high available water capacity; moderate intake; moderately slow permeability in subsoil.	Not needed; nearly level.
Poor: organic material in upper part; very poorly drained.	Unsuited	Poor: very poorly drained.	High water table; 16 to 35 inches of organic material.	High water table.	Generally not needed; wet soil.	Not needed; nearly level organic soil.
Fair: fines [2]	Fair for sand and gravel in underlying material.	Fair: 12 to 20 inches sandy loam; more than 3 percent coarse fragments.	Medium to low resistance to piping; low to medium compressibility.	Somewhat excessively drained.	Low available water capacity; gently sloping; moderate intake.	Low available water capacity; gently sloping; rapid permeability.
Fair: fines [2]	Fair for sand and gravel in underlying material.	Fair: 12 to 20 inches sandy loam; more than 3 percent coarse fragments.	Medium to low resistance to piping; low to medium compressibility.	Somewhat excessively drained.	Low available water capacity; sloping; moderate intake.	Low available water capacity; sloping; rapid permeability.
Poor: high shrink-swell potential in subsoil.	Unsuited	Fair: less than 16 inches thick.	Medium to low shear strength; medium to high compressibility.	Moderately well drained.	High available water capacity; moderate intake; moderately slow permeability in subsoil.	Clayey subsoil; moderately slow permeability in subsoil.
Fair: fines [2]	Fair in underlying material.	Good: 18 inches sandy loam over coarse textured material.	Low to medium compressibility; medium to low resistance to piping.	Somewhat excessively drained.	Low available water capacity; moderate intake; rapid permeability in underlying material.	Low available water capacity; nearly level to gently sloping; rapid permeability in underlying material.
Fair: somewhat poorly drained.	Good in underlying material.	Poor: sandy texture.	Low to medium compressibility; medium to low resistance to piping.	Sandy texture; rapid permeability; water table at 2 to 5 feet.	Low available water capacity; rapid intake; water table at 2 to 4 feet.	Not needed; level.
Fair: moderate shrink-swell potential.	Unsuited	Good	Medium to low shear strength.	Loamy texture; moderately slow permeability; poorly drained.	High available water capacity; water table at 2 to 3 feet; drainage needed; moderate intake.	Not needed; level.

TABLE 3.—*Engineering*

Soil series and map symbols	Degree and kind of limitations for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary land fill (area type)	Local roads and streets
*Emmert:						
EmC, EpC — For properties of Chetek, Hayden, Heyder and Kingsley soils in mapping unit EpC, refer to those series.	Moderate: slope.[1]	Severe: very rapid permeability.	Severe: slope; sidewall instability.	Moderate: slope.	Severe: very rapid permeability.[1]	Moderate: slope.
EmD, EpD — For properties of Chetek, Hayden, Heyder and Kingsley soils in mapping unit EpD, refer to those series.	Severe: slope.[1]	Severe: very rapid permeability.	Severe: slope; sidewall instability.	Severe: slope	Severe: very rapid permeability.[1]	Severe: slope
Glencoe: Gc	Severe: high water table.	Severe: high water table.	Severe: very poorly drained.	Severe: very poorly drained.	Severe: high water table.	Severe: very poorly drained.
Growton: GrA	Moderate: water table at 3 to 5 feet.	Moderate: moderate permeability.	Moderate: moderately well drained.	Moderate: moderately well drained.	Moderate: water table at 3 to 5 feet.	Moderate: moderate susceptibility to frost action.
Hayden:						
HdB	Moderate: moderate permeability.	Moderate: slope.	Slight	Slight	Slight	Moderate: fines;[2] moderate susceptibility to frost action.
HdC2	Moderate: slope; moderate permeability.	Severe: slope	Moderate: slope.	Moderate: slope.	Moderate: slope.	Moderate: fines;[2] moderate susceptibility to frost action.
HdD	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope
*Heyder:						
HeB	Moderate: moderate permeability.	Moderate: moderate permeability.	Slight	Slight	Slight	Moderate: moderate susceptibility to frost action.

interpretations—Continued

Suitability as source of—			Soil features affecting—			
Road fill	Sand and gravel	Topsoil	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Good	Good for sand. Fair for gravel.	Poor: sandy	Low compressibility; medium to low resistance to piping; high compacted soil permeability.	Excessively drained.	Very low available water capacity; sloping; very rapid intake.	Sloping; coarse sandy material; rapid permeability.
Fair: slope	Good for sand. Fair for gravel.	Poor: sandy	Low compressibility; medium to low resistance to piping; high compacted soil permeability.	Excessively drained.	Very low available water capacity; moderately steep; very rapid intake.	Moderately steep slopes; coarse sandy material; very rapid permeability.
Poor: very poorly drained.	Unsuited	Poor: very poorly drained.	Low resistance to piping; medium to low shear strength.	Water table at 0 to 3 feet; loamy texture; moderate permeability.	Drainage needed; high available water capacity; moderate intake.	Not needed; level.
Fair: moderate susceptibility to frost action.	Unsuited	Fair: loamy sand in subsurface layer.	Low to medium compacted permeability; low resistance to piping.	Moderately well drained.	Moderate available water capacity; moderate intake.	Not needed; level.
Fair: fines [2]	Unsuitable	Fair: less than 16 inches of suitable material.	Medium to low shear strength; compacted permeability.	Well drained	High available water capacity; moderate intake; gently sloping.	Gently sloping; moderate permeability; erosion hazard; loamy texture.
Fair: fines [2]	Unsuitable	Fair: sloping	Medium to low shear strength; compacted permeability.	Well drained	High available water capacity; moderate intake; sloping.	Sloping; moderate permeability; erosion hazard; loamy texture.
Fair: fines;[2] slope.	Unsuitable	Poor: moderately steep.	Medium to low shear strength; compacted permeability.	Well drained	High available water capacity; moderate intake; moderately steep.	Moderately steep; moderate permeability; erosion hazard; loamy texture.
Fair: moderate susceptibility to frost action.	Poor: fines [2]	Good	Medium to low compacted permeability; low resistance to piping.	Well drained	Moderate available water capacity; moderate intake; gently sloping.	Gently sloping; moderate permeability; erosion hazard; loamy texture.

TABLE 3.—*Engineering*

Soil series and map symbols	Degree and kind of limitations for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary land fill (area type)	Local roads and streets
HeC2, HIC—For properties of Emmert and Kingsley soils in mapping unit HIC, refer to Emmert and Kingsley series.	Moderate: slope.	Severe: slope	Moderate: slope:	Moderate: slope.	Moderate: slope.	Moderate: slope.
HeD, HID—For properties of Emmert and Kingsley soils in mapping unit HID, refer to Emmert and Kingsley series.	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope
HeE	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope
Hubbard:						
HuA, HuB	Slight[1]	Severe: rapid permeability.	Severe: sidewall instability.	Slight	Severe: rapid permeability.	Slight
HuC	Moderate: slope.[1]	Severe: rapid permeability.	Severe: sidewall instability.	Moderate: slope.	Severe: rapid permeability.[1]	Moderate: slope.
Isan: Is	Severe: high water table.[1]	Severe: rapid permeability.	Severe: very poorly drained.	Severe: very poorly drained.	Severe: high water table.[1]	Severe: very poorly drained.
Isanti: Iw	Severe: high water table.[1]	Severe: rapid permeability.	Severe: very poorly drained.	Severe: very poorly drained.	Severe: high water table.[1]	Severe: very poorly drained.
Kingsley:						
KmB	Severe: moderately slow permeability	Moderate: slope.	Slight	Slight	Slight	Severe: high susceptibility to frost action.
KmC2	Severe: moderately slow permeability.	Severe: slope	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: high susceptibility to frost action.
KmD, KmE	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope

interpretations—Continued

Suitability as source of—			Soil features affecting—			
Road fill	Sand and gravel	Topsoil	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Fair: moderate susceptibility to frost action.	Poor: fines [2]	Fair: slope	Medium to low compacted permeability; low resistance to piping.	Well drained	Moderate available water capacity; moderate intake; sloping.	Sloping; moderate permeability; erosion hazard; loamy texture.
Fair: slope; moderate susceptibility to frost action.	Poor: fines [2]	Poor: slope	Medium to low compacted permeability; low resistance to piping.	Well drained	Moderate available water capacity; moderate intake; moderately steep.	Moderately steep; moderate permeability; erosion hazard; loamy texture.
Poor: slope	Poor: fines [2]	Poor: slope	Medium to low compacted permeability; low resistance to piping.	Well drained	Moderate available water capacity; moderate intake; steep.	Steep; moderate permeability; erosion hazard; loamy texture.
Good	Good in underlying material.	Poor: sandy texture.	Low to medium compressibility; medium to low resistance to piping.	Excessively drained.	Low available water capacity; rapid intake; nearly level to gently sloping.	Nearly level to gently sloping; sandy texture; rapid permeability.
Good	Good in underlying material.	Poor: sandy texture.	Low to medium compressibility; medium to low resistance to piping.	Excessively drained.	Low available water capacity; rapid intake; sloping.	Sloping; sandy texture; rapid permeability.
Poor: very poorly drained.	Good in underlying material; high water table.	Poor: very poorly drained.	Low to medium compressibility; medium to low resistance to piping.	Sandy; rapid permeability; water table at 0 to 2 feet.	Low available water capacity; rapid permeability; drainage needed.	Not needed; level.
Poor: very poorly drained.	Fair in underlying material; high water table.	Poor: very poorly drained.	Low to medium compressibility; medium to low resistance to piping.	Sandy; rapid permeability; water table at 0 to 2 feet.	Low available water capacity; rapid permeability; drainage needed.	Not needed; level.
Fair: moderate susceptibility to frost action.	Unsuited	Fair: texture	Low to medium compressibility; medium to low shear strength.	Well drained	High available water capacity; moderate intake; gently sloping.	Gently sloping; erosion hazard; loamy material.
Fair: moderate susceptibility to frost action.	Unsuited	Fair: texture; slope.	Low to medium compressibility; medium to low shear strength.	Well drained	High available water capacity; moderate intake; sloping.	Sloping; erosion hazard; loamy material.
Fair: slope	Unsuited	Poor: slope	Low to medium compressibility; medium to low shear strength.	Well drained	High available water capacity; moderate intake; moderately steep and steep.	Moderately steep and steep; erosion hazard; loamy material; moderate permeability.

TABLE 3.—*Engineering*

Soil series and map symbols	Degree and kind of limitations for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary land fill (area type)	Local roads and streets
Kratka: Kr	Severe: high water table.	Severe: high water table.	Severe: very poorly drained.	Severe: very poorly drained.	Severe: high water table.	Severe: very poorly drained.
Lake beaches: Lb	Severe: high water table.[1]	Severe: rapid permeability.	Severe: very poorly drained to somewhat poorly drained.	Severe: very poorly drained to somewhat poorly drained.	Severe: high water table.[1]	Severe: very poorly drained to somewhat poorly drained.
Langola: LgB	Severe: moderately slow permeability.	Moderate: slope.	Moderate: sandy surface and subsoil.	Slight	Slight	Moderate: fines.[2]
Lino: LnA	Severe: high water table.[1]	Severe: rapid permeability.	Severe: somewhat poorly drained.	Severe: somewhat poorly drained.	Severe: somewhat poorly drained.[1]	Moderate: somewhat poorly drained.
Loamy wet land: Lw	Severe: high water table.	Severe: high water table.	Severe: very poorly drained.	Severe: very poorly drained.	Severe: high water table.	Severe: very poorly drained.
Lupton: Lx	Severe: high water table.	Severe: high water table; organic material.	Severe: high water table; organic material.	Severe: high water table; organic material.	Severe: very poorly drained; organic material.	Severe: very poorly drained.
Markey: Ma	Severe: high water table.	Severe: high water table; organic material in upper part.	Severe: high water table; organic material in upper part.	Severe: high water table; organic material in upper part.	Severe: very poorly drained.	Severe: very poorly drained.
Marsh: Mc	Severe: high water table.	Severe: high water table.	Severe: high water table.	Severe: high water table.	Severe: high water table.	Severe: very poorly drained.
Meehan: Me	Severe: high water table.[1]	Severe: high water table; rapid permeability.	Severe: somewhat poorly drained; sandy; high water table.	Severe: somewhat poorly drained.	Severe: high water table[1]; rapid permeability.	Moderate: somewhat poorly drained.
Millerville: Mk	Severe: high water table.	Severe: high water table; organic material.	Severe: high water table; organic material.	Severe: high water table; organic material.	Severe: very poorly drained; organic material.	Severe: very poorly drained; organic material.
Mora: MoA	Severe: moderately slow permeability.	Slight	Moderate: high water table.	Moderate: high water table.	Severe: high water table.	Moderate: fines.[2]

interpretations—Continued

Suitability as source of—			Soil features affecting—			
Road fill	Sand and gravel	Topsoil	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Poor: very poorly drained.	Poor: fines [2]	Poor: very poorly drained.	Low to medium compressibility; medium to low resistance to piping.	Rapid permeability in surface; moderate in underlying material; water table at 0 to 2 feet.	Moderate available water capacity; rapid intake; water table at 0 to 2 feet; drainage needed.	Not needed; level, very poorly drained.
Poor: very poorly drained to somewhat poorly drained.	Fair: in underlying material.	Poor: very poorly drained to somewhat poorly drained.	Low to medium compressibility; low resistance to piping.	Sandy; rapid permeability; water table at 0 to 4 feet.	Low available water capacity; rapid permeability; drainage needed.	Not needed; nearly level; wet soils.
Fair: fines [2]	Poor: fines [2]	Poor: sandy texture.	Low to medium compressibility; low resistance to piping.	Somewhat excessively drained.	Moderate available water capacity; rapid intake; gently sloping.	Gently sloping; rapid permeability in surface and subsoil; moderately slow permeability in underlying material.
Fair: somewhat poorly drained.	Poor: fines [2]	Poor: sandy texture.	Low compressibility; high compacted permeability.	Sandy: rapid permeability; water table at 2 to 4 feet.	Low available water capacity; rapid intake; drainage needed.	Not needed; nearly level.
Poor: very poorly drained.	Poor: fines	Poor: very poorly drained.	Low resistance to piping; medium to low shear strength.	Water table at 0 to 3 feet; loamy texture; moderate permeability.	Drainage needed; high available water capacity.	Not needed; wet soils.
Poor: very poorly drained; organic material.	Unsuited	Poor: very poorly drained; organic material.	Not suitable; organic material.	Very poorly drained; organic material.	Generally not irrigated.	Not needed; nearly level.
Poor: very poorly drained; organic material in upper part.	Poor: poorly graded sand at 16 to 51 inches.	Poor: very poorly drained; organic material over sand.	Not suitable; organic material over sand.	Very poorly drained; organic material over sand.	Generally not irrigated.	Not needed; nearly level.
Poor: very poorly drained.	Poor: variable material.	Poor: very poorly drained.	Variable material.	Very poorly drained.	Very poorly drained.	Not needed; nearly level.
Fair: somewhat poorly drained.	Good: poor on surface.	Poor: sandy	Medium shear strength; medium to low resistance to piping.	Sandy: rapid permeability; water table at 2 to 5 feet.	Low available water capacity; rapid intake.	Not needed; nearly level; sandy soils.
Poor: very poorly drained; organic material.	Unsuited	Poor: very poorly drained; organic material.	Not suitable; organic material.	Very poorly drained; organic material.	Generally not irrigated.	Not needed; nearly level.
Fair: fines [2]	Poor: fines [2]	Good	Low to medium compressibility; medium to low resistance to piping.	Moderately well drained.	Moderate available water capacity; water table at 3 to 5 feet.	Not needed; nearly level.

TABLE 3.—*Engineering*

Soil series and map symbols	Degree and kind of limitations for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary land fill (area type)	Local roads and streets
Nessel: NeA	Moderate: high water table.	Moderate: moderate permeability.	Moderate: high water table.	Moderate: high water table.	Severe: high water table.	Moderate: fines.[2]
Nowen: No	Severe: high water table.	Severe: high water table.	Severe: poorly drained.	Severe: poorly drained.	Severe: high water table.	Severe: poorly drained.
Nymore: NrD	Severe: slope.[1]	Severe: rapid permeability.	Severe: sandy texture.	Severe: slope	Severe: rapid permeability.[1]	Severe: slope
NyA, NyB	Slight[1]	Severe: rapid permeability.	Severe: sandy texture.	Slight	Severe: rapid permeability.[1]	Slight
NyC	Moderate: slope.[1]	Severe: rapid permeability.	Severe: sandy texture.	Moderate: slope.	Severe: rapid permeability.[1]	Moderate: slope.
Rifle: Rf, Rg, Rh	Severe: high water table.	Severe: high water table; organic material.	Severe: high water table; organic material.	Severe: high water table; organic material.	Severe: very poorly drained; organic material.	Severe: very poorly drained; organic material.
Rondeau: Ru	Severe: high water table.	Severe: high water table; organic material in upper part.	Severe: high water table; organic material in upper part.	Severe: high water table; organic material in upper part.	Severe: very poorly drained; organic material over marl.	Severe: very poorly drained; organic material over marl.
Ronneby: Ry	Severe: moderately slow permeability.	Severe: high water table	Severe: somewhat poorly drained.	Severe: somewhat poorly drained.	Severe: high water table.	Moderate: somewhat poorly drained.
Sartell: SbB	Slight[1]	Severe: rapid permeability.	Severe: sandy texture.	Slight	Severe: rapid permeability.[1]	Slight
SbC, SbC2	Moderate: slope.[1]	Severe: rapid permeability.	Severe: sandy texture.	Slight	Severe: rapid permeability.[1]	Moderate: slope.
SbD2	Severe: slope.[1]	Severe: rapid permeability.	Severe: sandy texture.	Severe: slope	Severe: rapid permeability.[1]	Moderate: slope.

interpretations—Continued

Suitability as source of—			Soil features affecting—			
Road fill	Sand and gravel	Topsoil	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Fair: fines [3]	Unsuited	Good	Low to medium compressibility; medium to low resistance to piping.	Moderately well drained.	High available water capacity; water table at 3 to 5 feet.	Not needed; short, gentle slopes.
Poor: poorly drained.	Poor: fines [3]	Poor: poorly drained.	Low to medium compressibility; medium to low resistance to piping.	Moderately well drained.	High available water capacity; water table at 2 to 4 feet; drainage needed.	Not needed; nearly level.
Fair: slope	Poor: fines [3]	Poor: sandy texture.	Low to medium compressibility; medium to low resistance to piping.	Excessively drained.	Low available water capacity; rapid intake; moderately steep.	Moderately steep; sandy; rapid permeability.
Good	Poor: fines	Poor: sandy texture.	Low to medium compressibility; medium to low resistance to piping.	Excessively drained.	Low available water capacity; rapid intake; nearly level to gently sloping.	Nearly level to gently sloping; sandy; rapid permeability.
Good	Poor: fines [3]	Poor: sandy texture.	Low to medium compressibility; medium to low resistance to piping.	Excessively drained.	Low available water capacity; rapid intake; sloping.	Sloping; sandy; rapid permeability.
Poor: very poorly drained; organic material.	Unsuited	Poor: very poorly drained; organic material.	Not suitable; organic material.	Very poorly drained; organic material.	Generally not irrigated.	Not needed; nearly level.
Poor: very poorly drained; organic material over marl.	Unsuited	Poor: very poorly drained; organic material over marl.	Not suitable: organic material over marl.	Very poorly drained; organic material over marl.	Generally not irrigated.	Not needed; nearly level.
Fair: fines [3]	Poor: fines	Good	Low to medium compressibility; medium to low resistance to piping.	Loamy material; moderately slow permeability; water table at 2 to 4 feet.	Moderate available water capacity; moderate intake; water table at 2 to 4 feet; drainage needed.	Not needed; nearly level.
Good	Poor: fines	Poor: sandy texture.	Low to medium compressibility; medium to low resistance to piping.	Excessively drained.	Low available water capacity; rapid intake; gently sloping.	Gently sloping; sandy; rapid permeability.
Good	Poor: fines	Poor: sandy texture.	Low to medium compressibility; medium to low resistance to piping.	Excessively drained.	Low available water capacity; rapid intake; sloping.	Sloping; sandy; rapid permeability; erosion hazard.
Fair: slope	Poor: fines	Poor: sandy texture.	Low to medium compressibility; medium to low resistance to piping.	Excessively drained.	Low available water capacity; rapid intake; moderately steep.	Moderately steep; sandy; rapid permeability; erosion hazard.

TABLE 3.—*Engineering*

Soil series and map symbols	Degree and kind of limitations for—					
	Septic tank absorption fields	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary land fill (area type)	Local roads and streets
Seelyeville: Se	Severe: high water table.	Severe: high water table; organic material.	Severe: high water table; organic material.	Severe: high water table; organic material.	Severe: very poorly drained; organic material.	Severe: very poorly drained; organic material.
Soderville: SoA	Severe: high water table.[1]	Severe: rapid permeability.	Severe: somewhat poorly drained.	Severe: somewhat poorly drained.	Severe: high water table.[1]	Moderate: somewhat poorly drained.
Webster: Wb	Severe: high water table.	Severe: high water table.	Severe: poorly drained.	Severe: poorly drained.	Severe: high water table.	Severe: poorly drained.
Zimmerman:						
ZmA, ZmB	Slight[1]	Severe: rapid permeability.	Severe: sandy texture.	Slight	Severe: rapid permeability.[1]	Slight
ZmC	Moderate: slope.[1]	Severe: rapid permeability.	Severe: sandy texture.	Moderate: slope.	Severe: rapid permeability.[1]	Moderate: slope.
ZmD	Severe: slope.[1]	Severe: rapid permeability.	Severe: slope	Severe: slope	Severe: rapid permeability.[1]	Severe: slope

[1] Possible contamination of underground water supply.

[2] Too much material smaller than 0.074 mm (No. 200 sieve size).

[3] Properties are too variable and should be determined by onsite investigation.

checking and maintenance are needed to insure continuous performance.

On droughty, sandy soils, the chief concern of management is conserving moisture by controlling soil blowing, limiting runoff, increasing infiltration, and controlling weeds. Field windbreaks, stripcropping, no-till planting, minimum tillage, maximum use of crop residue, and planting early-maturing crops also help. In places, irrigation is needed for profitable crop production.

Most soils in Anoka County need lime. Alfalfa and other deep rooted legumes will not produce well without lime. Organic soils commonly do not need lime for crop production.

The kind and amount of fertilizer and lime needed depends upon the kind of soil, the crop to be grown, and past management. It is best to have soils tested once each year or during every cropping sequence. Tests should be conducted by a reliable laboratory, which provides an analysis and interprets the results.

Soils that are used primarily for pasture may need drainage, proper fertilization, and liming. If possible, they should be reseeded to domestic grasses and legumes. Controlling grazing and controlling brush and weeds increase production. When the soils are used mainly for pasture, erosion control commonly is not needed. On steeper slopes, overgrazing or livestock trails up and down the slope can result in erosion.

Capability grouping

Capability grouping (*8*) shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made according to the limitations of the soils when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not ap-

interpretations—Continued

Suitability as source of—			Soil features affecting—			
Road fill	Sand and gravel	Topsoil	Embankments, dikes, and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Poor: very poorly drained; organic material.	Unsuited	Poor: very poorly drained; organic material.	Not suitable; organic material.	Very poorly drained; organic material.	Generally not irrigated.	Not needed; nearly level.
Fair: somewhat poorly drained.	Poor: fines [2]	Poor: sandy texture.	Low to medium compressibility; medium to low resistance to piping.	Sandy; rapid permeability; water table at 2 to 4 feet.	Low available water capacity; rapid intake.	Not needed; nearly level.
Poor: poorly drained.	Unsuited	Poor: poorly drained.	Medium to low shear strength; compacted permeability.	Loamy; moderate permeability; water table at 1 to 3 feet.	High available water capacity; moderate intake; water table at 1 to 3 feet; drainage needed.	Not needed; nearly level.
Good	Fair: fines [2]	Poor: sandy texture.	Low to medium compressibility; medium to low resistance to piping.	Excessively drained.	Low available water capacity; rapid intake; nearly level to gently sloping.	Nearly level to gently sloping; sandy; rapid permeability.
Good	Fair: fines [2]	Poor: sandy texture.	Low to medium compressibility; medium to low resistance to piping.	Excessively drained.	Low available water capacity; rapid intake; sloping.	Sloping; sandy; rapid permeability.
Moderate: slope.	Fair: fines [2]	Poor: sandy texture.	Low to medium compressibility; medium to low resistance to piping.	Excessively drained.	Low available water capacity; rapid intake; moderately steep.	Moderately steep; sandy.

ply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for forest trees or engineering.

In the capability system, all kinds of soil are grouped at three levels, the capability class, the subclass, and the unit. These levels are defined in the following paragraphs.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture or range, woodland, or wildlife. (None in Anoka County.)

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife.

TABLE 4.—*Degree and kind of limitation for recreational facilities*

Recreational groups	Camp areas	Picnic areas	Playgrounds	Paths and trails
1. Somewhat excessively drained to moderately well drained, moderately coarse textured soils; well suited to recreation use; water table usually below 3 feet; no limitations except slope; slope range 0 to 30 percent.	Slight if slope is less than 6 percent, moderate if 6 to 12, severe if more than 12.	Slight if slope is less than 6 percent, moderate if 6 to 12, severe if more than 12.	Slight if slope is less than 2 percent, moderate if 2 to 6, severe if more than 6.	Slight if slope is less than 18 percent, moderate if 18 to 30.
2. Moderately well drained soils; restricted permeability; medium textured or moderately coarse textured surface layer; fine textured subsoil or impermeable layer; soil wet for short periods; water table usually below 3 feet; slope range 1 to 5 percent.	Moderate: moderately slow permeability.	Slight	Moderate: moderately slow permeability.	Slight.
3. Somewhat poorly drained to poorly drained soils; dominantly moderately coarse textured or medium textured; water table between 1 to 3 feet at some time during season of use; slope range 0 to 2 percent.	Moderate: wet	Moderate: wet	Moderate: wet	Moderate: wet.
4. Excessively drained to somewhat poorly drained, coarse textured soils; limited for most recreation use by slope and sandy texture; water table below 2 feet during season of use in somewhat poorly drained soils and below 6 feet in the rest; slope range 0 to more than 25 percent.	Moderate if slope is less than 12 percent, severe if more than 12; too sandy.	Moderate if slope is less than 12 percent, severe if more than 12; too sandy.	Moderate if slope is less than 6 percent, severe if more than 6; too sandy.	Moderate if slope is less than 25 percent and texture is loamy sand; too sandy. Severe if slope is less than 25 percent and texture is sand; too sandy.
5. Well drained to moderately well drained Becker very fine sandy loam; subject to flooding, normally less often than once in 2 years; soil limited chiefly by frequent flooding; slope range 0 to 2 percent.	Severe: flooding	Moderate: flooding	Moderate: flooding.	Moderate: flooding.
6. Poorly drained and very poorly drained soils; texture coarse to medium; organic soils included; water table above 2 feet at some time during the season of use; hazard of flooding on some soils; slope range 0 to 2 percent.	Severe: wet	Severe: wet	Severe: wet	Severe: wet.

Class VIII soils and landforms have limitations that preclude their use for commercial crop production and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes.

CAPABILITY SUBCLASSES are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is too cold to too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and c, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–2 or IIIe–1. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

On the following pages the capability units in Anoka

County are described and the use and management of the soils is suggested.

CAPABILITY UNIT IIe–1

This unit consists of gently undulating, moderately well drained to well drained soils. These soils have a surface layer of fine sandy loam and a subsoil of fine sandy loam, sandy loam, sandy clay loam, or loam.

Permeability is moderate to moderately slow. The available water capacity is moderate to high. Natural fertility is medium, and the organic-matter content is mostly low.

Soils of this unit are easy to till because of the high content of sand. Cobbles and stones interfere with tillage in some areas and in places have to be removed. The hazard of erosion is slight because slopes are gentle and mostly short.

These soils are well suited to corn, soybeans, and small grain and to alfalfa and other hay crops. Erosion controls, such as contouring, stripcropping, and terracing, is difficult because fields are small and irregularly shaped. Minimum tillage and no-till planting are desirable alternatives. Under conventional tillage, green manure and legume-grass crops help control erosion and also preserve tilth and the level of organic matter. Waterways should be maintained in permanent sod. These soils are well suited to pasture.

CAPABILITY UNIT IIe–2

This unit consists of nearly level to gently sloping, moderately well drained soils. These soils have a surface layer of fine sandy loam or silt loam and a subsoil of fine sandy loam, silty clay loam, or clay.

Permeability is moderately slow. The available water capacity is moderate to high. Fertility is medium, and the organic-matter content is low.

Soils of this unit are easy to till. Cobbles and stones interfere with tillage in some areas and in places have to be removed. The subsoil has a weak fragipan or is clayey. As a result, the movement of water is slow through the soil and the soil is wet for short periods during heavy rainfall.

These soils are well suited to corn, soybeans, small grain, alfalfa, and other hay crops. Erosion control, such as contouring and terracing, is commonly difficult because fields are small and irregularly shaped. Minimum tillage, no-till planting, green-manure crops, and a legume-grass cropping sequence help preserve tilth and the level of organic matter. Waterways should be maintained in permanent sod. This soil is well suited to pasture.

CAPABILITY UNIT IIw–1

The one soil in this unit, Becker very fine sandy loam, is nearly level to gently undulating and moderately well drained to well drained. It has a very fine sandy loam surface layer and subsoil that is underlain by sand at a depth of 30 to 48 inches.

Permeability is moderately rapid, and the available water capacity is moderate. The level of organic matter is high, and natural fertility is moderate to high. This soil is subject to occasional flooding during periods of very high runoff. It is easy to keep in good tilth.

This soil is well suited to corn, soybeans, and small grain. Occasionally, crops are damaged or destroyed by floodwater. Minimum tillage, no-till planting, and green-manure crops help preserve tilth and the level of organic matter.

CAPABILITY UNIT IIw–2

This unit consists of nearly level, poorly drained soils. Ground water is at a depth of 1 to 4 feet during the wetter seasons. These soils have a surface layer of loam and sandy loam and a subsoil of fine sandy loam and sandy clay loam.

Permeability is moderately slow to moderate. The available water capacity is high. The level of organic matter is moderate to high, and natural fertility is medium to high.

Drainage is needed for efficient crop production. Either tile or open ditch drainage, or a combination of the two systems, can be used.

If drained, these soils are well suited to corn, soybeans, and small grain. Row crops can be grown year after year under good management that includes minimum tillage and the maximum return of crop residue. Deep-rooted legumes are difficult to grow unless the soils are adequately drained. Tilth is no problem if the soils are well managed because they are high in content of sand.

CAPABILITY UNIT IIw–3

The one soil in this unit, Ronneby sandy loam, is nearly level and somewhat poorly drained. The ground water is at a depth of 2 to 4 feet during the wetter seasons. This soil has a surface layer of fine sandy loam and a subsoil of sandy loam.

Permeability is moderately slow, and the available water capacity is moderate. The level of organic matter is moderate, and natural fertility is medium.

The subsoil has a weak fragipan which slows the movement of water through the soil. Cobbles and stones interfere with tillage in some areas and in places have to be removed. Drainage is needed for good crop production. Open ditches or tile having surface inlets can be used.

If drained, this soil is well suited to corn, soybeans, and small grain. Row crops can be grown year after year under good management that includes minimum tillage or no-till planting and the maximum return of crop residue. Deep-rooted legumes improve subsoil permeability, but unless this soil is adequately drained they are difficult to grow. This soil is well suited to pasture.

CAPABLITY UNIT IIIe–1

This unit consists mainly of gently rolling, well-drained soils. The surface layer is dominantly fine sandy loam and the subsoil is fine sandy loam, sandy loam, loam, or sandy clay loam.

Permeability is moderately rapid to moderately slow. The available water capacity is low to high. Natural fertility is medium. The level of organic matter is low to moderate.

A few areas of soils that have a surface layer of sandy loam and a subsoil of gravelly coarse sand are included in this unit. These soils are excessively drained and have a low available water capacity, a low level of organic matter, and low natural fertility.

Runoff is medium. This runoff can reduce the water available for plant growth and increase the hazard of erosion. Erosion and runoff are the major hazards. Cobbles and stones interfere with tillage in some areas and in places have to be removed.

Most of these soils are moderately well suited to corn, soybeans, and small grain, and to alfalfa and other hay crops. Erosion control, such as contouring, stripcropping, and terracing, is difficult in most areas because slopes are short and irregular. Minimum tillage and no-till planting are desirable alternatives. Green-manure crops and legume-grass crops in rotation help control erosion, preserve tilth, and maintain the level of organic matter. All waterways should be maintained in permanent sod. These soils are well suited to pasture.

CAPABILITY UNIT IIIw–1

The one soil in this unit, Blomford loamy fine sand, is nearly level and somewhat poorly drained. It has a surface layer of loamy fine sand and a subsoil of fine sand that is underlain by sandy loam, sandy clay loam, or loam at a depth of 20 to 40 inches.

Permeability is rapid in the sandy upper layers and moderate in the lower part of the subsoil. The available water capacity is moderate. The levels of organic matter and natural fertility are low. Drainage is needed for good crop production. Open ditch drainage or carefully laid tile can be used.

If drained, this soil is well suited to corn, soybeans, and small grain. Row crops can be grown year after year under continuously good management that includes minimum tillage, no-till planting, and maximum return of crop residue. Deep-rooted legumes are difficult to grow unless the soil is adequately drained. If they are grown, they improve permeability of the subsoil. This soil is well suited to pasture.

CAPABILITY UNIT IIIw–2

This unit consists of nearly level, poorly drained soils. These soils have a surface layer of silt loam or loam and a subsoil of silty clay, clay, or sandy clay loam.

Permeability is moderately slow, and the available water capacity is high. The level of organic matter is low to moderate, and natural fertility is medium.

The soils of this unit are moderately easy to till. Drainage is needed for crop production. Open ditches or tile having surface inlets, or a combination, can be used.

If drained, these soils are moderately well suited to corn, soybeans, and small grain. Row crops can be grown year after year under good management that includes minimum tillage and the maximum return of crop residue. Deep-rooted legumes are difficult to grow unless the soil is adequately drained. If they are grown, they improve permeability of the subsoil.

CAPABILITY UNIT IIIw–3

This unit consists of very poorly drained organic soils in low depressions. Most of these soils have organic layers to a depth greater than 51 inches. In a few areas loamy material is at a depth of 16 to 51 inches.

Permeability is moderately rapid to moderately slow. The available water capacity is very high. The organic-matter content is very high, and natural fertility is low.

Drainage is needed for crop production. Open ditches are preferred, but tile carefully installed can be used if outlets are adequate. These soils are easy to till.

If drained and adequately fertilized, these soils are moderately well suited to corn and soybeans and are well suited to select truck crops and cultured sod. They are poorly suited to small grain and deep-rooted legumes. In some years, crops are damaged by early or late frost. In some areas where drainage outlets are poor, crops are subject to flooding or ponding. Soil blowing is a hazard in some large fields. Minimum tillage and cover crops help to reduce this hazard.

CAPABILITY UNIT IIIw–4

This unit consists of nearly level to slightly depressional, very poorly drained soils. These soils have a surface layer and subsoil of sandy loam, fine sandy loam, or loam.

Permeability is moderate to moderately slow, and the available water capacity is high. The level of organic matter is high, and natural fertility is moderate to high.

Drainage is needed for crop production. Open ditches or tile, or a combination can be used. Some places lack adequate drainage outlets.

If drained, these soils are moderately well suited to corn, soybeans, and small grain. Row crops can be grown year after year under good management that includes minimum tillage and the maximum return of crop residue. In some areas where drainage outlets are poor, crops are subject to flooding or ponding.

CAPABILITY UNIT IIIs–1

The one soil in this unit, Dickman sandy loam, 0 to 2 percent slopes, is nearly level and excessively drained. It has a sandy loam surface layer and subsoil that is underlain by sand at a depth of 12 to 24 inches.

Permeability is moderately rapid, and the available water capacity is low. The level of organic matter is moderate, and natural fertility is medium.

This soil is easy to keep in good tilth. It is best suited to early maturing crops, such as small grain. Crop production is limited unless rainfall is well distributed throughout the growing season. The low available water capacity is the main limitation.

This soil is moderately well suited to corn, soybeans, small grain, and alfalfa. Minimum tillage, no-till planting, and green-manure crops help preserve tilth and the level of organic matter and reduce soil blowing. Irrigation increases production of most crops.

CAPABILITY UNIT IIIs–2

This unit consists of nearly level to gently undulating, somewhat excessively drained and well-drained soils. These soils have a surface layer of loamy sand, loamy fine sand, or fine sand. In some areas they are underlain by deep sand and thick bands of fine sandy loam and very fine sandy loam at a depth of 20 to 40 inches. In other areas they are underlain by sandy loam, sandy clay loam, or loam.

Permeability is rapid in the sandy upper layers and moderately rapid to moderately slow in the subsoil.

Available water capacity is low to moderate, depending on the depth to loamy material. The organic-matter content is low to moderate. Natural fertility is low to medium.

The soils dry at the surface soon after the spring thaw and after rains. They are subject to soil blowing if bare of vegetation. The low available water capacity is the main limitation. Crop production is severely reduced unless rainfall is well distributed throughout the growing season.

These soils are moderately well suited to corn, soybeans, small grain, and alfalfa. Minimum tillage, no-till planting, and cover crops help to maintain the organic-matter content, reduce soil blowing, and conserve moisture. Irrigation increases production of most crops.

CAPABILITY UNIT IVe–1

This unit consists mainly of moderately steep and steep, well-drained soils. The surface layer is fine sandy loam, and the subsoil is fine sandy loam, sandy loam, sandy clay loam, or loam.

Permeability is moderate to moderately slow. The available water capacity is moderate to high. Natural fertility is medium, and the level of organic matter is low.

A few areas where the surface layer is gravelly coarse sandy loam and the subsoil is gravelly coarse sand are included in this unit. These areas are excessively drained. They have a low available water capacity, a low level of organic matter, and low natural fertility.

Runoff is medium to rapid. Runoff reduces the water available for plant growth and increases the hazard of erosion. Runoff and erosion are the major hazards. Cobbles and stones interfere with tillage in some areas and in places have to be removed.

These soils are poorly suited to corn, soybeans, and small grain. They are moderately well suited to alfalfa and other hay crops. Contour stripcropping and terracing are difficult because slopes are steep, short, and irregular. Minimum tillage, no-till planting, and no cultivation are ways to reduce soil loss and water runoff. Areas where the slopes are dominantly steeper than 18 percent should be maintained in sod, hay, or pasture. Waterways should be maintained in permanent sod. Good soil management is most important for sustained production on soils of this unit.

CAPABILITY UNIT IVe–2

This unit consists of sloping or rolling to hilly, somewhat excessively drained soils. These soils have a surface layer of sandy loam, fine sand, or loamy fine sand. In some areas they are underlain by deep sand and thick bands of fine sandy loam and very fine sandy loam. In other areas they are underlain by sandy clay loam at a depth of 20 to 40 inches, and in still others they are underlain by gravelly sand at a depth of 14 to 22 inches.

Permeability is moderate to moderately rapid, and the available water capacity is moderate to low. The level of organic matter is low, and natural fertility is medium to low.

These soils dry at the surface soon after the spring thaw and after rains. Runoff and erosion are the major hazards. The moderate to low available water capacity is the main limitation. Crop production is severely reduced unless rainfall is well distributed throughout the growing season.

These soils are poorly suited to corn, soybeans, and small grain and are moderately well suited to alfalfa. Irrigation is difficult because of slope. Erosion control, such as contour stripcropping and terracing, commonly is difficult because slopes are short and irregular. Minimum tillage, no-till planting, and no cultivation reduce soil loss and water runoff. Waterways should be maintained in permanent sod. Good soil management is most important for sustained production on soils of this unit.

CAPABILITY UNIT IVw–1

This unit consists of nearly level to gently sloping, somewhat poorly drained soils. These soils have a surface layer of loamy sand or sand and a sand subsoil.

Permeability is rapid. The available water capacity and natural fertility are low. The level of organic matter is low to moderate.

No drainage is needed if adjacent, low-lying areas are adequately drained. If drainage is not adequate, these soils are too wet for good crop production.

If drained, the soils are moderately well suited to corn, soybeans, small grain, and alfalfa. Row crops can be grown year after year under good management that includes minimum tillage or no-till planting and maximum return of crop residue.

CAPABILITY UNIT IVw–2

This unit consists of nearly level to slightly depressional, very poorly drained to somewhat poorly drained soils. These soils have a surface layer of sandy loam, fine sandy loam, sand, or fine sand and a subsoil of fine sand, sand, or coarse sand. In some areas they are underlain by fine sandy loam at a depth of 20 to 40 inches.

Permeability is rapid. In areas where the underlying material is fine sandy loam, permeability is moderately slow. The available water capacity is low to moderate. The level of organic matter is mostly moderate, and natural fertility is low.

Drainage is needed for crop production. Open ditch drainage or a combination of open ditch drainage and carefully laid tile can be used. Some places lack drainage outlets.

If drained, these soils are moderately well suited to corn, soybeans, and small grain. Row crops can be grown year after year under good management that includes minimum tillage and the maximum return of crop residue. In areas where drainage outlets are poor, crops are subject to damage by flooding or ponding.

CAPABILITY UNIT IVw–3

This unit consists of very poorly drained organic soils in low depressions. The organic material is underlain by sandy material, coprogenous earth, or marl at a depth of 16 to 51 inches.

Permeability is moderately rapid to slow. The organic-matter content is very high, and natural fertility is low.

Drainage is needed for crop production. Open ditch drainage is preferred, but carefully laid tile can be used

where outlets are adequate. These soils are easy to till.

If drained, these soils are moderately well suited to corn, soybeans, select truck crops, and cultured sod. They are poorly suited to small grain and deep-rooted legumes. Crops are sometimes damaged by early or late frost. In some areas where drainage outlets are poor, they are subject to damage by flooding or ponding. Soil blowing is a hazard in some large fields. Minimum tillage and cover crops help to reduce this hazard.

CAPABILITY UNIT IVs–1

This unit consists of nearly level to gently sloping or undulating, excessively drained soils. These soils have a surface layer of fine sand, loamy sand, or coarse sand and a subsoil of fine sand, loamy sand, sand, or coarse sand.

Permeability is rapid. The available water capacity, organic-matter content, and natural fertility are low. Soil blowing is a hazard if fields are left bare. The low available water capacity and the resulting hazard of droughtiness are limitations. Blowing sand can damage young crops and reduce organic-matter content and fertility.

Unless irrigated, these soils are poorly suited to corn, soybeans, and small grain and are only moderately well suited to alfalfa. Minimum tillage, no-till planting, and green-manure crops or cover crops help maintain the level of organic matter, conserve moisture, and reduce soil blowing. Irrigation increases production of most crops.

CAPABILITY UNIT VIe–1

This unit consists of steep and very steep, well-drained soils. These soils have a surface layer of fine sandy loam and a subsoil of fine sandy loam, sandy loam, and sandy clay loam.

Permeability is moderate to moderately slow, and the available water capacity ranges from moderate to high. The organic-matter content is low, and natural fertility is medium.

Rapid runoff reduces the water available for plant growth and increases the hazard of erosion. Runoff and erosion are the major hazards.

This soil is poorly suited to cultivated crops. It is better suited to hay and pasture. Erosion control, such as contour stripcropping and contouring, is difficult because slopes are short, irregular, and steep. Areas should be left in woods or permanent pasture, and areas now cultivated should be established in permanent vegetation. Gullies and severely eroded waterways should be shaped and reseeded to grasses. Erosion control structures are needed before some of the larger gullies can be stabilized.

CAPABILITY UNIT VIw–1

The one soil in this unit, Alluvial land, mixed, frequently flooded, is on flood plains along rivers and streams and is subject to frequent flooding. It is very poorly drained to somewhat poorly drained and commonly is dissected by old channels and oxbows where ponding is frequent. The texture of the surface layer and subsoil is variable, ranging from sand to organic material.

Permeability, available water capacity, organic-matter content, and natural fertility are variable. Drainage is not feasible because of the flood hazard and the lack of drainage outlets. Diking as protection against flooding commonly is too costly because the acreage is small.

This alluvial land is poorly suited to crops. Some areas are planted to corn and soybeans, but there is a hazard of damage from flooding or ponding. Some areas are pastured and could be improved if well managed. Streambank erosion is a hazard, and stabilization is needed. This land is best suited as natural environment areas.

CAPABILITY UNIT VIs–1

This unit consists of sloping and gently rolling, excessively drained soils. These soils have a surface layer of gravelly sandy loam, loamy gravelly sand, coarse sand, sand, or fine sand and a subsoil of gravelly coarse sand, coarse sand, sand, or fine sand.

Permeability is rapid to very rapid, and the available water capacity, organic-matter content, and natural fertility are low to very low.

Small areas of a soil that has a surface layer of fine sandy loam and a subsoil of fine sandy loam and sandy clay loam are included in this unit. This soil is well drained. It has moderately slow permeability, a high available water capacity, a low organic-matter content and medium natural fertility.

Erosion by wind and water are hazards when fields are bare. The low available water capacity and the resulting hazard of droughtiness are limitations. Runoff is only moderate, but gullies form when traffic or cultivation is up and down the slope.

These soils are very poorly suited to corn, soybeans, and small grain and poorly suited to alfalfa and other hay crops. They can be stripcropped on the contour, but other erosion control is difficult because slopes are short and irregular. The slope also makes irrigation difficult. Minimum tillage, no-till planting, and cover crops help maintain organic-matter content, conserve moisture, and reduce erosion. This unit is best suited to permanent vegetation.

CAPABILITY UNIT VIIs–1

This unit consists of sloping or rolling to steep, excessively drained soils. These soils have a surface layer of gravelly sandy loam, loamy gravelly sand, coarse sand, sand, or fine sand and a subsoil of gravelly coarse sand, coarse sand, sand, or fine sand.

Permeability is rapid, and the available water capacity, organic-matter content, and natural fertility are low. Small areas of a soil that has a surface layer of fine sandy loam and a subsoil of fine sandy loam is included in this unit. This soil is well drained and has moderately slow permeability, a high available water capacity, a low organic-matter content, and medium natural fertility.

Runoff is moderate to rapid, and erosion is a hazard. The low available water capacity and the resulting hazard of droughtiness are limitations. Gullies form where traffic or cultivation is up and down the slope.

These soils are very poorly suited to corn, soybeans, and small grain and are poorly suited to alfalfa and other hay crops. They can be stripcropped on the contour, but other erosion control is difficult because

TABLE 5.—*Estimated average yields per acre of principal crops*

[Yield figures represent an average to be expected over a 10 year period. Absence of figures indicates the crop is not suited to or is not commonly grown on the soil specified. Only arable soils are listed]

Soil	Corn for grain	Corn for silage	Soybeans	Oats	Alfalfa	Permanent bluegrass pasture
	Bu	*Tons*	*Bu*	*Bu*	*Tons*	*AUM* [1]
Alluvial land, mixed, frequently flooded						3.5
Anoka loamy fine sand, 0 to 2 percent slopes	60	12	22	55	3.5	2.5
Anoka loamy fine sand, 2 to 6 percent slopes	60	12	20	50	3.5	2.5
Anoka loamy fine sand, 6 to 12 percent slopes	50	10	16	45	3.0	2.2
Becker very fine sandy loam	80	16	30	60	4.0	3.3
Blomford loamy fine sand	65	13	22	50	3.0	3.0
Braham loamy fine sand, 2 to 6 percent slopes	60	12	20	55	3.5	2.3
Braham loamy fine sand, 6 to 18 percent slopes	50	10	18	50	3.0	2.0
Brickton silt loam	80	16	28	70	4.0	4.2
Cathro muck	75	15	26			3.3
Chetek sandy loam, 2 to 6 percent slopes	55	11	18	50	3.0	2.3
Chetek sandy loam, 6 to 12 percent slopes	45	9	14	45	2.5	2.0
Dalbo silt loam, 1 to 5 percent slopes	80	16	30	75	4.0	4.3
Dickman sandy loam, 0 to 2 percent slopes	55	11	20	50	3.0	2.5
Dickman sandy loam, 2 to 6 percent slopes	50	10	18	45	3.0	2.3
Duelm loamy coarse sand	60	12	20	50	3.0	2.1
Dundas loam	80	16	28	70	4.0	4.2
Emmert gravelly coarse sandy loam, 6 to 12 percent slopes	30	6		35	2.0	2.0
Emmert gravelly coarse sandy loam, 12 to 25 percent slopes					1.5	1.5
Emmert complex, 4 to 12 percent slopes	35	7	14	45	2.5	2.5
Emmert complex, 12 to 25 percent slopes					1.5	2.0
Glencoe loam	80	16	28			4.0
Growton fine sandy loam, 1 to 4 percent slopes	80	16	30	70	4.0	3.7
Hayden fine sandy loam, 2 to 6 percent slopes	85	17	32	75	4.3	4.2
Hayden fine sandy loam, 6 to 12 percent slopes, eroded	75	15	28	65	4.0	3.8
Hayden fine sandy loam, 12 to 24 percent slopes	65	13	26	60	3.5	3.5
Heyder fine sandy loam, 2 to 6 percent slopes	80	16	32	75	4.3	4.0
Heyder fine sandy loam, 6 to 12 percent slopes, eroded	75	15	28	65	4.0	3.6
Heyder fine sandy loam, 12 to 18 percent slopes	65	13	25	60	3.5	3.3
Heyder fine sandy loam, 18 to 30 percent slopes					3.0	2.8
Heyder complex, 4 to 12 percent slopes	65	13	25	60	4.0	3.3
Heyder complex, 12 to 25 percent slopes					3.0	2.8
Hubbard coarse sand, 0 to 2 percent slopes	50	10	18	45	2.5	2.0
Hubbard coarse sand, 2 to 6 percent slopes	45	9	16	40	2.2	1.8
Hubbard coarse sand, 6 to 12 percent slopes	40	8	12	35	1.8	1.6
Isan sandy loam	65	11	20			3.3
Isanti fine sandy loam	55	11	20			3.3
Kingsley fine sandy loam, 2 to 6 percent slopes	70	14	28	65	3.8	3.8
Kingsley fine sandy loam, 6 to 12 percent slopes, eroded	60	12	25	55	3.0	3.5
Kingsley fine sandy loam, 12 to 18 percent slopes	50	10	21	50	2.5	3.0
Kingsley fine sandy loam, 18 to 30 percent slopes					2.0	2.6
Kratka loamy fine sand	60	12	20			3.5
Lake beaches						1.3
Langola loamy sand, 0 to 6 percent slopes	55	11	20	55	3.0	2.9
Lino loamy fine sand, 0 to 4 percent slopes	60	12	20	60	3.0	2.3
Loamy wet land	75	15	25			4.0
Lupton muck		15				3.3
Markey muck		13				3.2
Meehan sand	60	12	20	50	3.0	2.1
Millerville mucky peat		15				3.0
Mora fine sandy loam, 1 to 4 percent slopes	80	16	30	75	3.8	4.0
Nessel fine sandy loam, 1 to 4 percent slopes	85	17	33	80	4.3	4.3
Nowen sandy loam	80	16	28	70	4.0	4.0
Nymore loamy coarse sand, 12 to 25 percent slopes					1.5	1.7
Nymore loamy sand, 0 to 2 percent slopes	50	10	18	45	2.5	2.2
Nymore loamy sand, 2 to 6 percent slopes	45	9	16	40	2.2	2.0
Nymore loamy sand, 6 to 12 percent slopes	40	8	12	35	1.5	1.7
Rifle mucky peat		15				3.6
Rifle muck, woody		15				3.6
Rondeau muck		13				3.0
Ronneby fine sandy loam	80	16	28	70	3.8	3.8

TABLE 5.—*Estimated average yields per acre of principal crops*—Continued

Soil	Corn for grain	Corn for silage	Soybeans	Oats	Alfalfa	Permanent bluegrass pasture
	Bu	*Tons*	*Bu*	*Bu*	*Tons*	*AUM* [1]
Sartell fine sand, 2 to 6 percent slopes	45	9	18	40	2.5	2.0
Sartell fine sand, 6 to 12 percent slopes	40	8	14	35	2.0	1.8
Sartell fine sand, 6 to 12 percent slopes, eroded					1.5	1.5
Sartell fine sand, 12 to 24 percent slopes, eroded						1.0
Seelyeville muck		15				3.0
Soderville fine sand, 0 to 4 percent slopes	60	12	20	60	3.0	3.3
Webster loam	80	16	30	70	4.0	3.8
Zimmerman fine sand, 0 to 2 percent slopes	55	11	18	45	2.5	2.5
Zimmerman fine sand, 2 to 6 percent slopes	50	10	16	40	2.2	2.2
Zimmerman fine sand, 6 to 12 percent slopes	45	9	12	35	1.8	1.9
Zimmerman fine sand, 12 to 24 percent slopes					1.5	1.6

[1] Animal-unit-month. An animal-unit-month is the amount of pasture consumed in one month by one animal unit (one cow or steer, one horse, five hogs, or seven sheep or goats.) An estimate of 4.0, for example, indicates that 1 acre will provide adequate grazing for one animal unit for 4 months without injury to the pasture.

slopes are short and irregular. Slope also makes irrigation difficult. Minimum tillage, no-till planting, and cover crops help maintain the level of organic matter, conserve moisture, and reduce erosion. This unit is best suited to permanent vegetation. Areas should be left in woods or permanent pasture.

CAPABILITY UNIT VIIIw–1

In this unit are organic soils in depressions and adjacent to lakes and streams. Some are deep. Some are shallow. The shallow soils are underlain by sand or loamy material and are covered with 1 to 3 feet of water most of the year. The natural vegetation is cattails, rushes, sedges, and other water-tolerant plants.

This unit also includes soils in the Carlos Avery Wildlife Management Area where water is impounded by dikes and water control structures. These soils are covered with 1 to 3 feet of water. The water level can be adjusted to control types and growth of aquatic plants.

These soils provide wetland habitat. Draining the marshy areas is commonly not feasible. If drained, they would require management similar to that suggested for the soils in capability unit IVw–3.

Estimated yields

In table 5 are estimated long-term average acre yields under improved management for major farm crops grown in Anoka County. These yields are based on all available data and observations of representatives of the Soil Conservation Service, the Extension Service, and the Minnesota Agricultural Experiment Station and on interviews with farmers.

No yield is listed if a crop is considered unsuited to a particular soil. A crop can be grown on such soils, but because the soils are droughty, steep, poorly drained, or susceptible to flooding, the crop is not likely to be successful.

The yield figures represent an average to be expected over a period of 10 years. They do not take into account abnormal crop seasons or past management of a particular farm. Considered in making the estimates were climate, characteristics of the soil, and careful management. Yields will continue to change with improved technology.

Woodland

Anoka County, within the northern deciduous forest region, was primarily covered with forest types of northern hardwoods and oak. Within the oak forest were a few "oak openings" and a few scattered pines.

On the sand plain is the oak forest type. The original forest was mainly bur oak, northern red oak, and pin oak in the drier areas, and quaking aspen and paper birch in the more poorly drained areas. The large areas of very poorly drained organic soils were treeless except for some tamarack and northern white cedar. The level, coarser sand plain along the Mississippi River was prairie grassland. Only a few scattered small forests, mainly oak, occurred.

The glacial till areas in the northwestern and southeastern part of the county are in the northern hardwood forest type. These areas were covered mainly with sugar maple, American elm, American basswood, northern red and white oak, green ash, butternut, ironwood, and quaking aspen.

The present woodland is in small tracts. The tree species are similar to those of the original forest types. Most of the woodland is used for homesites and recreation. Some is grazed for pasture.

The soils of Anoka County have been assigned to woodland groups to assist owners in planning the use of their soils for wood crops. Each group is made up of soils that are suited to the same kinds of trees, need approximately the same kind of management, and have about the same potential productivity. Potential productivity and species suitability is shown in table 6.

Each woodland group is identified by a three-part symbol, for example, 2o1, 2o4, or 3w1. The first number in the symbol indicates potential productivity of the soils, which is based on field determinations of average site index of an indicator forest type or species. The numeral 1 means very high, 2 high, 3

TABLE 6.—*Potential productivity and species suitability by woodland groups*

[Woodland group 5w1 is not suited to trees]

Woodland group	Potential productivity		Species to be favored—	
	Important wood crops (species)	Average site index[1]	In existing stands	For planting
2o1	Quaking aspen	75	Red pine, eastern white pine, American basswood, northern red oak, quaking aspen.	Red pine, white spruce, eastern white pine, northern red oak, black walnut.
	Red pine	60		
	Eastern white pine	55		
	Jack pine	64		
	American basswood	65		
	Northern red oak	70		
	Sugar maple	57		
	Paper birch	53		
2o2	Red pine	60	Red pine, eastern white pine, jack pine, quaking aspen, northern red oak, white oak.	Red pine, white spruce, jack pine, northern red oak, white oak, silver maple, eastern white pine.
	Eastern white pine	57		
	Jack pine	67		
	Quaking aspen	77		
	Northern red oak	60		
	White oak	60		
	Eastern white pine	55		
2o3	Northern red oak	70	Northern red oak, black walnut, cottonwood, white oak, silver maple.	Northern red oak, black walnut, silver maple, eastern white pine.
	Eastern cottonwood	90		
	Black walnut	60		
	Silver maple	70		
	American elm	55		
2o4	Quaking aspen	76	Eastern white pine, northern red oak, American basswood.	Eastern white pine, northern red oak, American basswood.
	Eastern white pine	57		
	Northern red oak	70		
	American basswood	62		
	Sugar maple	57		
2r1	Northern red oak	65	White oak, northern red oak, American basswood, eastern white pine.	White oak, northern red oak, eastern white pine, American basswood.
	White oak	60		
	American basswood	60		
	Eastern white pine	55		
3s1	Red pine	56	Red pine, eastern white pine.	Red pine, white spruce.
	Eastern white pine	54		
	Jack pine	60		
	Bur oak	40		
3s2	Red pine	52	Red pine, eastern white pine, bur oak.	Red pine, jack pine.
	Eastern white pine	51		
	Jack pine	53		
	Bur oak	35		
3w1	Green ash	51	Quaking aspen, black ash, eastern cottonwood.	White spruce, eastern cottonwood, black ash.
	Quaking aspen	74		
	Black ash	51		
	American elm	55		
	Eastern cottonwood	86		

[1] A lower site index can occur on south- and west-facing slopes.

moderately high, 4 moderate, and 5 low. Site index is the height, in feet, that the dominant trees of a given species, on a specified kind of soil, reach in a natural, unmanaged stand in a stated number of years. For the merchantable hardwoods and softwoods in this county, the site index is the height reached in 50 years, except for cottonwood, for which the index is the height reached in 30 years.

Site indexes are grouped into site quality classes, upon which the approximate expected yields per acre in cords are based. On basis of research studies (*4*), site index can be converted into approximate expected growth and yield per acre in cords. See table 7.

The second part of the symbol identifying a woodland group is a small letter. This letter indicates an important soil property that imposes a slight to severe hazard or limitation in management. A letter *c* means that the main limitation is the kind or amount of clay in the upper part of the soil; *o* indicates few limitations that restrict use of the soil for trees; *r* means that the main limitation is steep slope; *s* means that the soil is sandy and dry, has little or no difference in

TABLE 7.—*Annual yields in cords per acre for stated kinds of trees and site indexes*

[The symbol > means more than; symbol < means less than]

Yields in cords per acre per year [1]	Site indexes for—		
	Red pine, white spruce	Eastern white pine, northern red oak [2]	Jack pine, quaking aspen
>0.7	>60	>65	>70
0.6–0.7	55	60	65
0.5–0.6	50	55	60
<0.5	<45	<50	<55

[1] Trees greater than 6 inches in diameter at breast height having a minimum top diameter of 4 inches.

[2] Northern red oak yields by site index can also be used for the American basswood, American elm, black walnut, bur oak, and white oak. Limited research data available on those species.

texture between the surface layer and subsoil, has low available water capacity, and generally has a low supply of plant nutrients; and *w* means that water in or on the soil, either seasonally or year round, is the chief limitation.

The third part of the symbol, a number, subdivides a group on the basis of species adaptability to soil condition.

To facilitate management, the soils of Anoka County have been assigned to nine woodland groups, which are described on the following pages. The hazards of windthrow and erosion, the limitation to use of equipment, the hazard of seedling mortality, and the risk of competition from undesirable plants are considered for each group. They are expressed as *slight, moderate,* or *severe.*

Windthrow hazard measures the effect of soils on root development and the ability of the soil to hold trees firmly. The hazard is *slight* if roots extend to more than 20 inches and the tree withstands most wind; *moderate,* if roots extend from 10 to 20 inches and some trees are blown down during periods of excessive soil wetness and strong wind; *severe,* if roots extend to 10 inches or less and trees do not stand alone in strong wind.

Erosion hazard refers to the potential hazard of soil losses in woodland. The hazard is *slight* if expected soil loss is small; *moderate* if some soil loss is expected and care is needed during logging and construction; and *severe* if special methods are necessary for preventing excessive soil loss. Only the steep soils in Anoka County are subject to severe erosion.

Equipment limitations are based on soil characteristics that restrict or prohibit the use of equipment commonly used in tending and harvesting the trees. In Anoka County the soil characteristics having the most limiting effect are drainage, depth to the water table, slope, and texture of the surface layer. *Slight* indicates no restriction in the kind of equipment or in the time of year it is used; *moderate* means that use of equipment is restricted less than 3 months of the year; and *severe* means that special equipment is needed and its use is restricted more than 3 months of the year.

Seedling mortality refers to the expected degree of mortality of planted seedlings as influenced by kinds of soil when plant competition is not a limiting factor. Considered are depth to the water table, hazard of flooding, drainage, soil depth and structure, and degree of erosion. Normal rainfall, good planting stock, and proper planting are assumed. A rating of *slight* indicates an expected loss of less than 25 percent of the planted seedlings; *moderate,* a loss of 25 to 50 percent of the seedlings; and *severe,* a loss of more than 50 percent. Special preparation of the site is needed before planting for soils rated severe and for most soils rated moderate.

Plant competition is based on the degree to which unwanted plants invade openings in the tree canopy. Considered are available water capacity, fertility, drainage, and degree of erosion. A rating of *slight* means that competition from other plants is no problem; *moderate,* that plant competition delays development of fully stocked stands of desirable trees; and *severe,* that plant competition prevents establishment of a desirable stand unless intensive site preparation and cultivation are used to control undesirable plants.

Table 8 shows, by woodland groups, a planting guide for trees and shrubs that can be grown in Anoka County for wildlife, windbreaks or shelterbelts, and beautification.

Species suitability is by the letters A, B, and C. The letter A means *preferred.* The planting is easy to establish, is sturdy, is best for intended use, and does not become a weed. The letter B means *suitable.* Planting grows well, but may lack one or more characteristics necessary for preferred rating. The letter C means *generally unsuitable.* The planting is short lived, scraggly, unsightly, and subject to disease and insects.

In the paragraphs that follow are descriptions of the woodland groups recognized in Anoka County.

WOODLAND GROUP 2o1

This group consists of well drained to moderately well drained, moderately coarse textured to medium textured soils that have a moderately coarse textured to moderately fine textured subsoil. Most of these soils have medium to high natural fertility and moderate to high available water capacity. Slopes are 0 to 2 percent.

Seedling mortality is slight, plant competition is severe, equipment limitations are slight, and the hazard of erosion is slight.

TABLE 8.—*Tree and shrub planting guide*

[For windbreaks, wildlife, and beautification. *A* means preferred, *B* suitable, and *C* generally unsuitable. Group 5w1 is not listed because the soils are too wet for planting]

Tree and shrub species	Suitability and height at 20 years of specified plantings by woodland groups																	
	2o1		2o2		2o3		2o4		[1]2r1		3s1		[1]3s2		3w1		4s1	
	Feet		*Feet*		*Feet*		*Feet*		*Feet*		*Feet*		*Feet*		*Feet*		*Feet*	
Coniferous trees:																		
Eastern redcedar	B	19	A	19	B	19	B	10	A	15–19	A	15	A	12–18	B	10	A	12–18
Northern white cedar	A	20	A	18	A	20	A	15	A	10–20	A	15	A	0–11	A	15	A	0–11
Jack pine	A	28	A	24	A	28	C	25	A	10–20	A	20	A	15–25	C	25	A	15–25
Red pine [2]	A	28	A	24	A	28	C	25	A	10–20	A	20	A	15–25	C	25	A	15–25
Eastern white pine	A	28	A	24	A	28	C	25	A	10–20	A	20	A	15–25	C	25	A	15–25
Blue spruce	A	22	A	22	A	22	A	8	A	15–22	B	18	B	0–22	A	22	B	0–22
White spruce	A	22	A	22	A	22	A	8	A	15–22	B	18	B	0–22	A	22	B	0–22
Deciduous trees:																		
Green ash	A	35	A	28	A	35	A	30	A	20–35	C	20	C	0–28	A	30	C	0–28
Black ash	C	--	C	--	C	--	A	30	C	--	C	--	C	--	A	30	C	--
American basswood	A	28	B	18	B	25	B	30	B	20–35	C	20	C	0–28	B	32	C	0–28
Paper birch	B	25	A	30	B	20	C	15	B	20–30	C	18	C	0–25	C	15	C	0–25
American elm	B	36	B	28	C	36	B	32	B	20–35	C	20	C	0–28	B	32	C	0–28
Siberian elm	C	43	C	35	C	43	B	40	C	30–45	C	28	C	--	B	40	C	--
Hackberry	A	34	A	25	A	35	B	20	A	20–35	A	18	B	0–25	B	12	A	0–25
Silver maple	B	30	B	45	A	45	B	35	C	20–45	C	30	C	0–45	B	35	C	0–45
Sugar maple	A	33	B	24	B	30	C	20	C	15–30	C	20	C	--	C	20	C	--
Northern red oak	A	35	A	30	B	30	C	20	A	15–30	A	20	A	15–25	C	--	A	15–25
White oak	A	35	B	25	B	30	B	30	B	15–30	B	20	B	15–25	C	--	A	15–25
Bur oak	B	30	A	25	B	30	C	25	A	15–30	A	18	A	15–25	C	--	A	15–25
Black walnut	A	25	B	30	B	20	C	--	C	--	C	--	C	--	C	--	C	--
Golden willow	C	34	C	30	B	34	A	35	C	5–30	C	--	C	--	A	35	C	--
Laurel willow	C	34	C	30	B	34	A	35	C	5–30	C	--	C	--	A	35	C	--
Small trees and shrubs:																		
Siberian peashrub	C	9	B	12	C	10	C	12	B	8–10	A	12	A	10–12	C	12	A	10–12
Siberian crabapple	A	15	A	15	A	15	C	--	A	10–20	A	12	A	10–15	C	--	A	10–15
Amur honeysuckle	A	9	A	11	A	15	A	10	A	5–5	A	10	A	5–10	A	10	A	5–10
Tartarian honeysuckle	A	9	A	11	A	15	A	10	A	5–15	A	10	A	5–10	A	10	A	5–10
Late lilac	A	10	A	12	A	12	A	12	A	8–15	C	8	C	0–10	A	12	C	0–10
Amur maple	A	18	B	16	A	25	A	16	C	10–20	C	12	C	--	A	16	C	0–12
American plum	B	14	B	10	A	20	C	--	A	10–20	A	12	A	0–10	C	--	C	0–10
Redosier dogwood	A	8	A	12	A	15	A	15	A	5–10	C	--	C	--	A	15	C	0–12
Russian-olive	C	20	B	25	B	30	B	24	B	25–35	A	15	A	10–20	B	24	A	15–25
Purple willow	B	16	B	12	A	20	A	14	B	5–20	C	9	C	--	A	14	C	--
Silver buffaloberry	C	10	B	15	C	10	C	10	B	10–15	A	12	B	0–10	C	--	A	10–15

[1] First number is for south slopes, second number is for north slopes, dashed line indicates unsatisfactory growth or no growth.

[2] Many are grown specifically for Christmas tree production.

WOODLAND GROUP 2o2

This group consists of somewhat excessively drained to moderately well drained soils. Most of these soils are moderately coarse textured. Some are coarse textured and are underlain by moderately fine textured material. Most of these soils have medium natural fertility and low to high available water capacity. Slopes are 0 to 18 percent.

Seedling mortality is slight for most soils, but moderate for those that have a coarse textured surface layer. Plant competition is moderate, equipment limitations are slight, and the hazard of erosion is slight.

WOODLAND GROUP 2o3

The one soil in this group, Becker very fine sandy loam, is well drained and moderately well drained. This soil is in drainageways and on flood plains. It is subject to occasional flooding of short duration. It has medium natural fertility and moderate available water capacity. Slopes are 0 to 3 percent.

Seedling mortality is slight, plant competition is severe, equipment limitations are slight, and the hazard of erosion is slight.

WOODLAND GROUP 2o4

The one soil in this group, Ronneby fine sandy loam, is somewhat poorly drained. It has medium natural fertility and moderate available water capacity. The seasonal high water table is between 2 and 4 feet. Slopes are 0 to 2 percent.

Seedling mortality is slight, plant competition is severe, equipment limitations are slight, and the hazard of erosion is slight.

WOODLAND GROUP 2r1

This group consists of well-drained, moderately coarse textured soils that have a coarse textured to moderately fine textured subsoil. These soils have medium natural fertility and moderate to high available water capacity. Slopes are 12 to 30 percent.

Seedling mortality is slight to moderate, plant competition is moderate to severe, equipment limitations are moderate to severe, and the hazard of erosion is moderate to severe.

WOODLAND GROUP 3s1

This group consists mostly of somewhat poorly drained to excessively drained, moderately coarse textured soils that are shallow to deep over sand or sand and gravel. Also in this group are soils that have a moderately coarse textured or medium textured subsoil. Most of these soils have low natural fertility and low available water capacity. Slopes are 0 to 12 percent.

Seedling mortality is moderate to severe, plant competition is slight, equipment limitations are slight, and the hazard of erosion is slight.

WOODLAND GROUP 3s2

This group consists of somewhat excessively drained to excessively drained, moderately coarse textured and coarse textured soils underlain by sand or sand and gravel. Most of these soils have low natural fertility and low available water capacity. Slopes are 12 to 25 percent.

Seedling mortality is severe, plant competition is slight, equipment limitations are moderate to severe, and the hazard of erosion is moderate to severe.

WOODLAND GROUP 3w1

This group consists mostly of poorly drained, moderately coarse textured and medium textured soils that have a moderately coarse textured to fine textured subsoil. Also in this group are coarse textured soils underlain by moderately coarse textured material. Most of these soils have low to high natural fertility and moderate to high available water capacity. The water table, at a depth of 1 to 4 feet during wet periods, is the controlling factor for woodland suitability. Slopes are 0 to 2 percent.

Seedling mortality is moderate, plant competition is severe, equipment limitations are moderate, and the hazard of erosion is slight.

WOODLAND GROUP 5w1

This group consists of very poorly drained depressional mineral soils, organic soils, alluvial soils, and marsh areas. Soil characteristics are variable. Marsh areas are covered with 1 to 3 feet of water, and the alluvial soils are subject to frequent flooding. The rest are subject to occasional flooding or ponding for short periods and have a water table at or near the surface.

This group is unsuited or very poorly suited to trees and shrubs. Seedling mortality, plant competition, and equipment limitations are severe.

Wildlife[3]

Anoka County is in the transitional area of most major wildlife species. The number of animals of any one species is not so high as in more favored parts of the habitat range for the species.

The chief species of wildlife in the county are gray squirrel, fox squirrel, muskrat, mink, and white-tailed deer, and several species of waterfowl, pheasants, and grouse. Their numbers are related to land use.

Scattered about the parts of Anoka County under rapid urban development are undeveloped soil areas where limitations for urban use are severe. These areas produce and shelter large numbers of waterfowl and pheasants. This wildlife is often protected from hunting because incorporated villages and cities have hunting restrictions.

The Carlos Avery Game Management Area, managed by the Minnesota Department of Natural Resources, is on the Rifle-Isanti soil association (see the General Soil Map at the back of this survey). This area supports large numbers of waterfowl, furbearers, and big game species, and is an important stopover area for migrating birds. It is heavily used by Twin City and local residents for observing wildlife and for hunting.

The Cedar Creek Natural History Area, operated by the University of Minnesota, is in the north-central part of the county. It is a nationally known study area of the range and habitat for many kinds of wildlife.

The Lino-Lakes Chain, Coon, Linwood, and Martin Lakes provide good fishing. There are also a large number of waterfowl lakes, as well as many potential areas for wetland development.

The production of wildlife species depends largely on the amount and distribution of food, cover, and water. If any of these elements is missing, inadequate, or inaccessible, the wildlife is scarce or absent.

Soils directly affect the kind and amount of vegetation that is used as food and cover. They also affect the development of water impoundments. In this way soils indirectly influence the kinds of wildlife that can live in an area.

If the soils are suitable, habitat for wildlife can be created or improved by planting suitable vegetation, by managing the existing plant cover, by fostering the natural establishment of desirable plants, or by a combination of these measures.

In table 9, soils are rated by soil associations, according to their potential for supporting the main kinds of wildlife habitat in the survey area. The ratings are based on the ability of the soils to produce plants and other elements that make up the wildlife habitat. Table 9 can be used in—

1. Planning the use of parks, refuges, nature study areas, and other recreational developments for wildlife.
2. Selecting soils that are suitable for creating, improving, or maintaining specific kinds of wildlife habitat.
3. Determining the intensity of management needed for individual elements of wildlife habitat.

[3] ALLEN VAUGHN, State conservation biologist, helped prepare this section.

TABLE 9.—*Wildlife habitat*

Soil association [1]	Potential for habitat elements							Potential as habitat for wildlife		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood plants	Coniferous plants	Wetland plants	Shallow water trees	Openland	Woodland	Wetland
1. Hubbard-Nymore	Poor	Poor	Fair	Poor	Fair	Very poor.	Very poor.	Poor	Fair	Very poor.
2. Zimmerman-Isanti-Lino.	Poor	Poor	Fair	Poor	Fair	Fair	Fair	Poor	Fair	Fair.
3. Heyder-Kingsley-Hayden.	Fair	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
4. Emmert-Kingsley	Fair to poor.	Fair	Fair to good.	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
5. Nessel-Dundas-Webster.	Good	Fair	Good	Fair	Fair	Good	Good	Good	Fair	Good.
6. Rifle-Isanti	Poor	Poor	Poor	Poor	Poor	Good	Good	Poor	Poor	Good.

[1] See general soil map for general location of soil association in the county.

4. Eliminating sites that would be difficult or impractical to manage for specific kinds of wildlife.
5. Determining areas that are suitable for acquisition for use by wildlife.

A rating of *good* means that the element of wildlife habitat or the kind of habitat is easily created, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected if the soil is used for the designated purpose. A rating of *fair* means that the element of habitat or the kind of habitat can be created, improved, or maintained in most places. Moderate intensity of management and fairly frequent attention are required for satisfactory results. A rating of *poor* means that limitations are severe for the designated element of wildlife habitat or kind of wildlife. Habitat can be created, improved, or maintained in most places, but management is difficult and requires intensive effort. A rating of *very poor* means that restrictions are very severe on the use of soil for the element of wildlife habitat or the kind of wildlife, and that unsatisfactory results can be expected. Wildlife habitat is impossible or impractical to create, improve, or maintain on soils having a rating of *very poor*.

Elements of wildlife habitat.—Table 9 shows the suitability of each soil association for various kinds of plants and other elements that make up wildlife habitat.

Grain and seed crops are seed-producing annuals used by wildlife. Examples are corn, sorghum, wheat, oats, barley, millet, buckwheat, soybeans, and sunflowers. The major soil properties that affect grain and seed crops are effective rooting depth, texture of the surface layer, available water capacity, wetness, slope, and the hazard of flooding.

Grasses and legumes are domestic perennial grasses and herbaceous legumes that are planted for wildlife food and cover. Examples are wheatgrass, green needle grass, reed canarygrass, switchgrass, bromegrass, timothy, clover, alfalfa, trefoil, and crownvetch. The major soil properties that affect grasses and legumes are effective rooting depth, texture of the surface layer, available water capacity, wetness, slope, and the hazard of flooding.

Wild herbaceous plants are native or naturally established herbaceous legumes, grasses, and forbs (including weeds) that provide food and cover for wildlife. Examples are bluestem, indiangrass, goldenrod, beggarweed, barnyard grass, marsh elder, wheatgrass, sweetclover, trefoil, and grama. The major soil properties that affect wild herbaceous plants are thickness of soil, texture of the surface layer, available water capacity, wetness, and the hazard of flooding.

Hardwood plants are nonconiferous trees and associated woody understory plants that provide cover for wildlife or that produce nuts or other fruit, buds, catkins, twigs, bark, or foliage that wildlife eat. They commonly grow naturally, but may be planted. Examples of native hardwood plants are oak, cherry, aspen, apple, hawthorn, dogwood, plum, sumac, hazelnut, blackberry, grape, viburnum, blueberry, birch, and maple. Examples of commercially available fruit-bearing shrubs that are valuable for wildlife are cherry, crabapple, and honeysuckle. The major soil properties that affect hardwood trees and shrubs are effective rooting depth, available water capacity, and wetness.

Coniferous plants are cone-bearing trees, shrubs, or groundcover that furnish cover or supply food in the form of browse, seeds, or fruit-like cones. They commonly grow naturally, but may be planted or transplanted. Examples of coniferous plants are pine, spruces, fir, cedar, and juniper. Most coniferous species are available commercially. The major soil properties affecting coniferous plants are effective rooting depth, available water capacity, and wetness.

Wetland plants are annual and perennial wild herbaceous plants that grow on moist or wet sites, not including submerged or floating aquatics. They produce food or cover used extensively by wildlife that use wetland as habitat. Examples of wetland plants are smartweed, wild millet, rushes, sedges, reeds, wildrice, cordgrass, and cattail. The major soil properties

that affect wetland plants are wetness, soil reaction, and slope.

Shallow water areas useful to wildlife are areas where water at the surface is less than 5 feet deep. They may be natural wet areas or they may be created by dams or levees or by water-control devices in marshes or streams. Examples are muskrat marshes, waterfowl feeding areas, wildlife watering developments, wildlife ponds, and beaver ponds. The major soil properties that affect shallow water areas are wetness, slope, and permeability.

Kinds of wildlife habitat.—Table 9 also shows the suitability of the soil associations for providing habitat for various kinds of wildlife.

Openland wildlife are birds and mammals that inhabit croplands, pastures, meadows, and areas overgrown with grasses, herbs, shrubs, and vines. Examples are pheasant, meadowlark, field sparrow, killdeer, cottontail rabbit, red fox, and woodchuck. The major elements of habitat are grains and seedcrops, grasses and legumes, and wild herbaceous plants.

Woodland wildlife are such birds and mammals as ruffed grouse, woodcock, thrushes, vireos, woodpeckers, squirrel, raccoon, and white-tailed deer. The major elements of habitat are hardwood trees and coniferous trees, grasses and legumes, and wild herbaceous plants.

Wetland wildlife are birds and mammals that inhabit swampy, marshy, or open-water areas. Examples are ducks, geese, herons, shorebirds, rails, kingfishers, muskrat, mink, and beaver. The major elements of habitat are wetland plants and shallow water areas.

Ratings in table 9 are based on the overall suitability of the soils in the soil associations. Individual areas, therefore, may be better suited or more poorly suited than the rating indicates.

Formation and Classification of Soils

This section tells how the factors of soil formation have affected the formation of the soils in Anoka County. It also explains the system of soil classification currently used and classifies the soils according to that system.

Factors of Soil Formation

Soil is produced through soil-forming processes acting on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material, (2) the climate under which the soil material has accumulated and existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, or lay of the land, and (5) the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. It may be much or little, but some time is always required for differentiation of soil horizons. Usually, a long time is required for the formation of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Parent material

The most extensive sources of parent material in Anoka County are glacial till, glacial outwash, and organic deposits. Smaller areas consist of glacial lake sediments and aluvium. The differences in glacial deposits account for many of the differences in soils.

Glacial till.—About one-fifth of the soils in Anoka County formed in glacial till, which is nonsorted drift of sand, silt, and clay. These soils are loamy in texture. Stones and pebbles are common throughout the soil. Hayden, Heyder, and Kingsley soils formed in glacial till.

Outwash.—About half the soils in Anoka County formed in glacial outwash, which is the coarser part of till that has been reworked and redeposited by moving water. There are two main areas of outwash deposits. The larger is the central part of the county where the outwash sediment consists of well sorted fine sand. Sartell and Zimmerman soils, for example, formed in this material. The other outwash area consists of stratified coarse sand, sand, and some gravelly sand which occurs mainly along the Mississippi and Rum Rivers. Hubbard and Nymore soils are the main soils formed in this material.

Organic soil material.—About one-fourth of the soils in the county formed in organic soil material in waterlogged depressions. They are in scattered areas throughout the county. The largest areas are on the Rifle-Isanti association, in the eastern part of the county. This material consists largely of aquatic and semi-aquatic plant remains at various stages of decomposition in a saturated environment. It is 30 percent or more organic matter if the mineral fraction is 50 percent or more clay and 20 percent or more organic matter if no clay is present. The amount of organic matter is proportional if the percentage of clay is less than 50. Rifle and Seelyeville soils are the main soils formed in this material. The material deposited in some bogs is precipitated aquatic, biological, or chemical material. It is called limnic material. It qualifies as either organic or mineral. Millerville soils, for example, have liminic material in the lower layers.

Glacial lake sediments.—This material consists of water sorted sediments laid down in small glacial lakes. It ranges in texture from very fine sand and silt to clay. It occurs as small scattered areas in the western part of the county. Brickton and Dalbo soils formed in this material.

Alluvium.—These deposits occur in areas adjacent to rivers, streams, and creeks throughout the county. They are recent, and the soils show little development. The texture of these deposits ranges widely. Alluvial land, frequently flooded, is an alluvial soil.

Climate

Climate is an important factor in determining the kind of vegetation, animals, bacteria, and other organisms that persist in the soil. It determines the intensity of physical and chemical activities in the soil, mainly through the effects of precipitation and temperature. The effects of climate and vegetation vary according to the relief, permeability, and the length of time the parent material has been in place.

Anoka County has a subhumid, continental climate, hot summers and cold winters. The climate is essentially uniform throughout the county. It is described in detail under the heading "Environmental Factors Affecting Soil Use."

Plant and animal life

Plants, animals, bacteria, and other organisms are active in the soil forming process. They aid in the breakdown of parent material and the formation of organic matter and also in the decomposition of organic matter. Vegetation affects soil formation by leaving residue on the soil and by transferring plant nutrients from the subsoil to the surface horizon. The kinds of plants and animals that live on and in the soil are determined by the climate, parent material, relief, and the age of the soil.

Formation of Anoka County soils has been influenced by forest and prairie. The surface layer of soils formed under forest is thinner and lighter in color than the surface layer of soils formed under prairie. In forest soils the movement of clay and organic material downward into the subsoil is greater than in prairie soils. Loamy soils formed under forest vegetation have a light-colored subsurface layer just below the surface layer. Hayden soils are examples of forested soils. Hubbard soils, which have thick, dark-colored surface layers, are examples of soils formed under prairie.

Relief

Relief, or surface configuration of the land, is an important factor in the formation of soils. It affects the distribution of water, erosion, and movement of parent material, soil moisture, and soil temperature. Sloping land is usually more dry than a flat or concave surface because water runs off, and there is less leaching. A depressional area collects water and commonly has very slow internal water movement and a high water table. Sloping soils are usually well drained and have good aeration and bright internal colors because of oxidation. Heyder soils are examples. Poorly drained soils in depressions have a thicker and darker surface layer because the content of organic matter is higher. The subsoil has a dull grayish color and varying degrees of mottling. Isanti soils are examples of soils formed in a low-lying, poorly drained position.

Soil profiles are most strongly developed and have greater depth in gently sloping areas where internal drainage is good. The degree of profile development is largely a function of the amount of water passing through the soil.

Relief affects the temperature of the soil by its exposure to the sun. South-facing slopes are warmer, and vegetation commonly is more sparse.

Soils saturated with water in depressions are slower to warm up in spring because more heat is required to heat a cubic foot of waterlogged soil than a cubic foot of dry soil. Cool temperatures and poor oxidation of poorly drained soils retard the microorganism population. Organic soils form in low, flat positions of the landscape in Anoka County where drainage is very poor. Markey and Rifle soils are examples.

Time

Soil characteristics are also determined by the length of time involved in the soil forming process. Age of the soil is characterized by changes in the morphology or appearance of the profile. Soluble materials are first leached out. Organic matter then begins to accumulate and initiates horizon development.

Soils in Anoka County are young, geologically speaking, because the last glacial period ended some 12,000 years ago. A young soil has more natural plant nutrients and commonly is more fertile than an older mature soil. A young soil has many properties of the parent material since soil forming processes have not had time to greatly alter this fresh material.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First through classification, and then through use of soil maps, we can apply our knowledge of soils to specific fields and other tracts of land.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and apply knowledge about soils in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. The broad categories facilitate study and comparison in large areas, such as countries and continents.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey (*7*) in 1965. Because this system is under continual study, readers interested in developments of the current system should search the latest literature available (*5*).

The current system of classification has six categories. Beginning with the broadest, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped. In table 10, the soil series of Anoka County are classified in three categories of the current system. Categories of the current system are briefly defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are the Entisols and Histosols, which occur in many different climates. Each order is

TABLE 10.—*Classification of soils*

Series	Family	Subgroup	Order
Alluvial land	Sandy and loamy		Entisols.
Anoka	Coarse-loamy, mixed	Eutric Glossoboralfs	Alfisols.
Becker	Coarse-loamy, mixed, mesic	Typic Hapludolls	Mollisols.
Blomford	Sandy over loamy, mixed, nonacid, frigid	Mollic Haplaquents	Entisols.
Braham	Sandy over loamy, mixed, frigid	Arenic Eutrochrepts	Inceptisols.
Brickton	Fine, mixed, frigid	Mollic Ochraqualfs	Alfisols.
Cathro	Loamy, euic	Terric Borosaprists	Histosols.
Chetek	Coarse-loamy, mixed	Eutric Glossoboralfs	Alfisols.
Cut and fill land	Sandy and loamy		Entisols.
Dalbo	Fine, mixed	Aquic Eutroboralfs	Alfisols.
Dickman	Sandy, mixed, mesic	Typic Hapludolls	Mollisols.
Duelm	Sandy, mixed	Aquic Haploborolls	Mollisols.
Dundas [1]	Fine-loamy, mixed, mesic	Udollic Ochraqualfs	Alfisols.
Emmert [2]	Sandy-skeletal, mixed, frigid	Typic Udorthents	Entisols.
Glencoe [3]	Fine-loamy, mixed, mesic	Cumulic Haplaquolls	Mollisols.
Growton	Coarse-loamy, mixed	Aquic Eutroboralfs	Alfisols.
Hayden	Fine-loamy, mixed, mesic	Typic Hapludalfs	Alfisols.
Heyder	Coarse-loamy, mixed	Typic Eutroboralfs	Alfisols.
Hubbard	Sandy, mixed	Udorthentic Haploborolls	Mollisols.
Isan	Sandy, mixed, frigid	Typic Haplaquolls	Mollisols.
Isanti	Sandy, mixed, frigid	Typic Haplaquolls	Mollisols.
Kingsley	Coarse-loamy, mixed, mesic	Mollic Hapludalfs	Alfisols.
Kratka [4]	Sandy over loamy, mixed, frigid	Typic Haplaquolls	Mollisols.
Lake beaches	Sandy		Entisols.
Langola	Sandy, mixed	Udorthentic Haploborolls	Mollisols.
Lino	Mixed, frigid	Aquic Udipsamments	Entisols.
Loamy wet land	Loamy		Mollisols.
Lupton [5]	Euic	Typic Borosaprists	Histosols.
Markey	Sandy or sandy-skeletal, euic	Terric Borosaprists	Histosols.
Marsh			
Meehan	Mixed, frigid	Aquic Udipsamments	Entisols.
Millerville	Coprogenous, euic	Limnic Borohemists	Histosols.
Mora	Coarse-loamy, mixed	Aquic Fragiboralfs	Alfisols.
Nessel	Fine-loamy, mixed, mesic	Glossaquic Hapludalfs	Alfisols.
Nowen	Coarse-loamy, mixed, frigid	Mollic Ochraqualfs	Alfisols.
Nymore	Mixed, frigid	Typic Udipsamments	Entisols.
Rifle	Euic	Typic Borohemists	Histosols.
Rondeau	Marly, euic	Limnic Borosaprists	Histosols.
Ronneby	Coarse-loamy, mixed, frigid	Aeric Fragiaqualfs	Alfisols.
Sartell	Mixed, frigid	Typic Udipsamments	Entisols.
Seelyeville	Euic	Typic Borosaprists	Histosols.
Soderville	Sandy, mixed	Aquic Glossoboralfs	Alfisols.
Webster [3]	Fine-loamy, mixed, mesic	Typic Haplaquolls	Mollisols.
Zimmerman	Mixed, frigid	Alfic Udipsamments	Entisols.

[1] This soil is a taxadjunct to the series because the upper 30 inches is dominantly 2 chroma and the B horizon has more sand and less clay.

[2] This soil is a taxadjunct to the series because carbonatic gravel is within a depth of 40 inches.

[3] This soil is a taxadjunct to the series because it has a higher sand content than is defined as the range for the series.

[4] This soil is a taxadjunct to the series because soil temperature is higher.

[5] This soil is a taxadjunct to the series because bog iron occurs in the upper tier and the soil is more acid than is defined as the range for series.

identified by a word of three or four syllables ending in *sol* (Moll-i-sol).

SUBORDER. Each order is divided into suborders that are based primarily on those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging, or soil differences resulting from the climate or vegetation. The names of suborders have two syllables. The last syllable indicates the order. An example is *Aquoll* (*Aqa*, meaning water or wet, and *oll*, from *Mollisol*).

GREAT GROUP. Each suborder is divided into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated; those that have pans that interfere with growth of roots, movement of water, or both; and thick, dark-colored surface horizons. The features used are the self-mulching properties of clay, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), dark-red and dark-brown colors associated with basic rocks, and the like. The names of great groups have three or four syllables; a prefix is added to the name of the suborder. An example is *Haplaquoll* (*Hapl*, meaning simple horizons, *aqu*, for wetness or water, and *oll*, from Mollisols).

SUBGROUP. Each great group is divided into sub-

groups, one representing the central (typic) segment of the group, and others called intergrades that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is *Typic Haplaquoll* (a typical Haplaquoll).

FAMILY. Soil families are established within a subgroup primarily on the basis of properties important to the growth of plants or on the behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence. A family name consists of a series of adjectives preceding the subgroup name. The adjectives are the class names for texture, mineralogy, and so on, that are used as family differentiae. An example is the fine-loamy, mixed, mesic family of Typic Haplaquolls.

SERIES. The series is a collection of soil individuals essentially uniform in differentiating characteristics and in arrangement of horizons. If genetic horizons are thin or absent, it is a collection of soil individuals that, within defined depth limits, are uniform in all soil properties diagnostic for the series. Some soil properties that affect series classification are the content and kind of clay minerals, permeability, reaction, color, and structure.

Environmental Factors Affecting Soil Use

Settlement of Anoka County began in 1844. The county was organized in 1857. Except for the southeastern tip of the county, boundaries were the same as they are today.

The first settlers found much of the upland fairly well timbered. Oak was dominant. In the north-central part of the county there was some merchantable pine. Some of the organic soils supported a large growth of tamarack. By 1860, several farms were established. They raised small grain, corn, potatoes, and livestock. The early settlers cut most of the pine for lumber and the red oak and tamarack for railway crossties and cordwood. In 1864, the first railroad was built through the county. The railroad and other improvements in transportation facilities greatly stimulated farming.

In 1879, about 9 percent of Anoka County was farmed. This percentage rose steadily until the 1930's when it was about 75 percent. It has decreased steadily since then, and in 1972, only about 30 percent of the county was cropped.

Anoka County is part of the Twin Cities metropolitan area. Since 1950, the county has undergone rapid urban development.

Geology

Anoka County was covered by a number of glacial movements (*3, 10*). The material deposited by earlier glaciers is buried under the more recent glacial deposits of the Wisconsin glaciation. Only deposits from the last two major ice movements, however, are recognized in the county. Both entered the county from the northeast. The Superior lobe brought in reddish-brown sandy loam till from the Lake Superior basin. This red till contains red felsite, pink sandstone, gabbro, and basalt, all of which are rock types from the Lake Superior region. This reddish till is mainly in the northwest and southeast corners of the county. The main soils on this till are Kingsley, Mora, and Ronneby soils. Emmert soils are on the water-sorted gravel and coarse sands, which occur with the till.

The Des Moines lobe deposited a light olive-brown calcareous sandy loam or loam till from the Manitoba area of Canada. This till, commonly called "gray" till, contains granite and carbonate siliceous shale and effervesces with hydrochloric acid. The main soils on this till are Hayden and Heyder soils.

During the southward movement of the Des Moines lobe a broad bulge, known as the Grantsburg sublobe, developed west and northwest of the Twin Cities. It extended in a northwesterly direction along the inside of the St. Croix Moraine, deposited by the previous advance of the Superior lobe, and into Wisconsin, blocking the Mississippi watershed and causing it to outlet into the St. Croix River Valley.

As the Grantsburg sublobe wasted, the Mississippi River gradually migrated westward and southward to its present course, depositing the fine sand which covers a large part of the county, the Anoka Sand Plain. These fine sandy deposits were left by the meltwaters as the diverted glacial Mississippi River followed the retreating Grantsburg sublobe. The major soils in these fine sandy deposits are Sartell and Zimmerman soils.

The Grantsburg sublobe filled several old drainageways left by the Superior lobe. These old glacial channels are conspicuous by the alignment of lakes in the Rice Creek watershed toward the eastern part of the county and the Martin, Linwood, Coon, and Ham Lake chain.

Eventually, the Mississippi River established a final course. This channel is more direct and is steeper than the older meandering route. It formed a valley train that deposited coarser sands at the southwestern edge of the sand plain. The main soil in this area is the Hubbard soil.

Because the Grantsburg sublobe was the last to move across the county, the gray till can be seen over the red till in many deep excavations and cuts along new road construction areas.

Relief and Drainage

Glacial drift, mainly outwash sands and glacial till, covers all of Anoka County. The gently rolling to steep glacial till areas at the northwest corner, the southeast corner, and the southern tip of the county have the highest elevations. The highest elevation in the county, about 1,110 feet above sea level, is at the northwest corner. The lowest point, about 800 feet, is along the Mississippi River as it leaves the county in the Fridley area. The glacial drift commonly is 100 to 250 feet thick and is underlain by limestone and sandstone bedrock.

TABLE 11.—*Temperature and precipitation data*

[All data from Cambridge, Minnesota, for the period 1941–70 unless otherwise specified]

Month	Temperature				Precipitation				
					Normal monthly total	Based on data 1932–70		Based on data 1940–71	
						One year in 10 will have—			
	Normal daily maximum	Normal daily minimum	Extreme maximum	Extreme minimum		Less than—	More than—	Days with snow cover of 1 inch or more	Average depth of snow on days with snow cover
	°F	°F	°F	°F	*Inches*	*Inches*	*Inches*	*Number*	*Inches*
January	19.5	−0.6	40	−25	0.69	0.20	1.59	27	10.4
February	24.4	3.2	43	−20	.71	.10	1.54	25	11.3
March	36.4	16.6	57	− 8	1.37	.35	2.32	20	10.2
April	54.3	32.5	77	18	2.32	.98	3.61	3	2.4
May	66.9	43.3	86	28	3.62	1.04	6.38	----------	----------
June	76.2	54.8	91	38	4.77	1.42	7.60	----------	----------
July	81.3	58.4	93	46	3.74	1.49	6.04	----------	----------
August	76.7	56.6	92	43	3.91	1.55	6.35	----------	----------
September	68.8	46.7	86	30	3.15	.63	5.43	----------	----------
October	58.8	37.1	78	20	1.93	.41	4.72	(1)	2.0
November	38.7	21.8	59	0	1.30	.39	2.64	9	3.9
December	25.0	7.5	44	−16	.89	.16	1.87	23	6.9
Year	52.5	31.5	[2]95	[3]−27	28.47	21.45	38.31	107	9.0

[1] Less than 0.5 day.

[2] Average annual maximum; alltime highest temperature 109° F on July 14, 1936.

[3] Average annual minimum; alltime lowest temperature −42° F on January 23, 1935.

The Anoka Sand Plain, which covers most of the county, is nearly level and has numerous iceblock depressions and old glacial drainageways. At present, these depressions are lakes or bogs. Inactive sand dunes are easily observed in Bunker Prairie Park and the Cedar Creek Natural History Area. The average elevation of the sand plain is about 870 feet above sea level near the Mississippi River to about 900 feet in the central part of the county.

Most of the county is drained by the Rum River, Coon Creek, and the Rice Creek Watershed, all of which drain into the Mississippi River. The northeastern part of the county is in the Sunrise River Watershed, which drains easterly to the St. Croix River.

Water

Anoka County has an ample supply of surface and subsurface water for recreational, domestic, and commercial uses.

There are 138 lakes in the county, 70 of which are more than 50 acres in size. Forty-five are fishing lakes. Coon, George, Ham, Linwood, and Martin Lakes provide good fishing and are also used for swimming and boating. Many of the more shallow lakes provide habitat and limited hunting of waterfowl.

About 60 miles mostly along the Mississippi and Run Rivers is suitable for canoeing. The pool above Coon Rapids Dam is suitable for larger power boats.

Subsurface water for domestic use is available at a depth of 15 to 40 feet in the sandy outwash areas. Much of this water is secured by hand-driven sandpoints. Water in the glacial till areas is deeper, and drilled wells are required. Large wells for community, irrigation, and commercial use are usually drilled down several hundred feet into the aquifers in the sedimentary bedrock. This water is plentiful and of good quality. Most deep wells that penetrate into the bedrock aquifers are under artesian pressure, and the water rises to or near the surface. Some of the shallower wells in the glacial drift in the eastern part of the county are also affected by artesian pressure.

The cities of Minneapolis and St. Paul use surface water from the Mississippi River in Fridley. St. Paul also uses surface water from the Rice Creek Watershed at Centerville Lake. All surface water is filtered, purified, and softened.

Climate[4]

Anoka County, near the center of the great land area of the North American continent, has no sharply marked differences in topography. Consequently, the climate is fairly uniform. Summers are warm. Southerly winds bring warm moist air from the Gulf of Mexico; thus, summer is the season of greatest precipitation. Winters are in sharp contrast. Solar heating is less effective. The days are short, the sun is low on the horizon, and the land cools rapidly. Prevailing

[4] By EARL L. KUEHNAST, State climatologist, National Weather Service, U.S. Department of Commerce.

TABLE 12.—*Probabilities of last freezing temperature in spring and first in fall*

[All data from Cambridge, Minnesota [1]]

Probability	Dates for given probabilities and temperature				
	16° F or lower	20° F or lower	24° F or lower	28° F or lower	32° F or lower
Spring:					
1 year in 10 later than	April 17	April 28	May 4	May 14	May 25
2 years in 10 later than	April 11	April 21	April 29	May 8	May 20
5 years in 10 later than	March 30	April 9	April 20	April 29	May 12
Fall:					
1 year in 10 earlier than	October 22	October 12	October 3	September 23	September 12
2 years in 10 earlier than	October 27	October 18	October 9	September 29	September 17
5 years in 10 earlier than	November 7	October 29	October 20	October 9	September 27

[1] As published in the University of Minnesota's Agricultural Experiment Station Technical Bulletin 243, March 1963, *Climate of Minnesota Part I*, by Baker and Strub.

northerly winds cause additional cooling. Because the air masses are dry, winter is the season of least precipitation.

About 75 percent of the annual precipitation, almost 21.5 inches, falls during the period April through September. Measurable precipitation of 0.01 inch occurs on about 110 days per year, 4 of which have 1 inch or more. Rainfall intensity of about 1½ inches an hour can be expected to recur once in 3 years.

Table 11 lists for each month the highest and lowest precipitation expected 1 year in 10. Annual amounts have ranged from a low of 18.80 inches in 1933 to a high of 40.70 inches in 1968. The highest in any month was 10.93 inches in June 1944. The county has an average of about 36 thunderstorms each year, some accompanied by hail and damaging winds. Twelve tornadoes were reported between 1916 and 1971.

Drought occurs whenever the supply of water for crops, either rainfall or soil moisture, becomes inadequate. Each day there is inadequate moisture in the root zone is defined as a drought day. Six severe droughts occurred during the period 1931 to 1970 in east-central Minnesota; 1934 was the worst, and other severe drought years were 1933, 1936, 1937, 1940, and 1961.

The mean temperature during December, January, and February is 13.3° F. One of the colder winters was that of 1935–1936 when the mean temperature was 5.3°. In almost all winters a reading of 20° below zero or lower occurs on an average of 5 to 6 days.

The first measurable snowfall occurs about the middle of October 1 year in 10, and the last about the middle of April or later 3 years in 10. Annual snowfall averages 43.2 inches, but since 1932 has ranged from 5.4 inches in 1958–1959 to 81.6 in 1950–1951. Information on snow cover and average depth is given in table 11.

The mean temperature during June, July, and August is 67.6°. The daily maximum is in the lower 80's, and the daily minimum is in the lower 60's. A temperature of 100° or more occurs about once every 5 years and of 90° or more about 14 times a year. The wide range of temperature to be expected is shown in table 11.

The freeze-free period is long enough that the staple crops of the county reach maturity without much danger from frost. The probability (*2*) of certain temperatures occurring in spring and fall is shown in table 12. For example, 5 years out of 10, or 50 percent of the time, a temperature of 32° or lower can be expected later than May 12 and earlier than September 27.

Long term records of humidity, cloudiness, and winds are not available for Anoka County, but are available at the First Order National Weather Service Airport Stations. The following information is based on records at the Minneapolis-St. Paul Airport. The average windspeed and prevailing direction is 9.4 m.p.h. from the northwest in winter and 8.6 m.p.h. from the southeast in summer. Noontime humidity averages 56 percent in summer and 68 percent in winter. On the average, 98 days are clear, 102 partly cloudy, and 165 cloudy.

Natural Vegetation

Anoka County is in the northern deciduous forest region. The forest types were mainly northern hardwoods and oak. Within the oak forest were "oak openings" and scattered areas of pine. Grassland areas and scattered small wooded areas occurred on the Hubbard-Nymore association, especially on Hubbard soils. Small "oak openings," or savannas, were associated with Nymore soils and in some places with Sartell soils. Organic soil areas having poor drainage outlets were treeless. Other areas having better drainage were covered with stands of tamarack, white cedar, and black ash. Glacial till soils were covered with northern hardwood forest types, such as sugar maple, elm, basswood, red and white oak, ash, butternut, ironwood, and aspen.

The woodland that has not been cleared for crops is similar to what existed before settlement. It occurs as scattered small tracts and has been logged two or three times. Wooded areas are now very much in demand for homesites. Abandoned fields in the sandy soil areas commonly support a variety of prairie grasses, such as little and big bluestem. Trees encroach into these open fields after 10 to 30 years. Natural

reforestation is faster on abandoned cropland in the till soil areas because moisture conditions are better.

Transportation Facilities

The Burlington Northern Railroad provides good freight service to the major business centers in the county. U.S. Highway 10 is parallel to the Misssissippi River from Spring Lake Park to the western edge of the county. Minnesota Highway 65 extends from north to south through the center of the county, and Minnesota Highway 47 from north to south through the western part of the county. Interstate Highways 35E and 35W extend through the southeastern part of the county. Most of the county roads are blacktopped. The Federal, State, and county road systems provide easy access to the Twin Cities' trade market and job market for those who are within commuting distance. Anoka County is serviced by the Anoka County Airport in the City of Blaine and the Minneapolis-St. Paul International Airport about 20 miles south of the county.

Trends in Soil Use

The trend in Anoka County is one of urbanization. The population is increasing at a rate of about 5 to 8 percent per year.

The percent of land in farms in Anoka County has decreased from 77 percent in 1940 to about 31 percent in 1970. During the same period, the number of farms decreased from 1,627 to 615. The population of the county during this period increased from 22,443 to 153,562. The projected population for the year 1980 is 195,000.

As the county becomes more densely populated and urbanized, some land is used for purposes to which it is not suited. Land, water, and vegetation are often the smallest cost in urban development and frequently are given the least consideration.

Community development that uses soil survey information can be carefully planned around basic soil, water, and vegetative resources. Such planning often makes the difference between an attractive, esthetically pleasing community and one that is not.

As the population of Anoka County increases it will become more important that all densely populated areas change from onsite sewage disposal systems to a central sewage system and adequate treatment facilities. This change is essential if both the surface and the glacial drift water sources and eventually the deeper aquifers are to remain uncontaminated. Contaminated water is not only a hazard to public health but also reduces recreational enjoyment of surface waters.

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Glossary

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

	Inches
Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	More than 9

Blowout. A shallow depression from which all or most of the soil material has been removed by wind. A blowout has a flat or irregular floor formed by a resistant layer or by an accumulation of pebbles or cobbles. In some blowouts the water table is exposed.

Bog iron. A spongy variety of hydrated oxide of iron or limonite.

Calcareous soil. A soil containing enough calcium carbonate (commonly with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid. A soil having measurable amounts of calcium carbonate or magnesium carbonate.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Coarse fragments. Mineral or rock particles up to 3 inches (2 millimeters to 7.5 centimeters) in diameter.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard; little affected by moistening.

Coprogenous. Designating the influence of animal excrement, as of the earthworm, in forming soil, especially humus.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained.—Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained.—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained.—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically for long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained.—Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained.—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depths. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients, as for example in "hillpeats" and "climatic moors."

Dune. A mound or ridge of loose sand piled up by the wind.

Erosion. The wearing away of the land surface by running water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature, for example, fire, that exposes a bare surface.

Esker (geology). A narrow, winding ridge of stratified gravelly and sandy drift deposited by a stream flowing in a tunnel beneath a glacier.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat). The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Fragipan. A loamy, brittle subsurface horizon low in porosity and content of organic matter and low or moderate in clay but high in silt or very fine sand. A fragipan appears cemented and restricts roots. When dry, it is hard or very hard and has a higher bulk density than the horizon or horizons above. When moist, it tends to rupture suddenly under pressure rather than to deform slowly.

Glacial drift (geology). Pulverized and other rock material transported by glacial ice and then deposited. Also the assorted and unassorted material deposited by streams flowing from glaciers.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.5 centimeters) in diameter. An individual piece is a pebble.

Hemic soil material (mucky peat). Organic soil material intermediate in degree of decomposition between the less decomposed fibric and the more decomposed sapric material.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. The major horizons of mineral soil are as follows:

O horizon.—An organic layer, fresh and decaying plant residue, at the surface of a mineral soil.

A horizon.—The mineral horizon, formed or forming at or near the surface, in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon most of which was originally part of a B horizon.

A2 horizon.—A mineral horizon, mainly a residual concentration of sand and silt high in content of resistant minerals as a result of the loss of silicate clay, iron, aluminum, or a combination of these.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or a combination of these; (2) by prismatic or blocky structure; (3) by redder or browner colors than those in the A horizon; or (4) by a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the A or B horizon. The material of a C horizon may be either like or unlike that from which the solum is presumed to have formed. If the material is known to differ from that in the solum the Roman numeral II precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock commonly underlies a C horizon, but can be directly below an A or a B horizon.

Hummocky. Refers to a landscape of hillocks, separated by low sags, having sharply rounded tops and steep sides. Hummocky relief resembles rolling or undulating relief, but the tops of ridges are narrower and the sides are shorter and less even.

Ice-block depression. A depression formed by the melting of a large, detached block of stagnant ice that was wholly or partly buried in glacial drift.

Kame (geology). An irregular, short ridge or hill or stratified glacial drift.

Lacustrine deposit (geology). Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Leaching. The removal of soluble material from soil or other material by percolating water.

Limnic material. Organic and inorganic material either deposited in water through the action of aquatic organisms, such as algae or diatoms, or derived from submerged and floating aquatic plants modified by aquatic animals.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is greater than that of organic soil.

Moraine (geology). An accumulation of earth, stones, and other debris deposited by a glacier. Types are terminal, lateral, medial, and ground.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: *abundance*—few, common, and many; *size*—fine, medium, and coarse; and *contrast*—faint, distinct, and prominent. The size measurements are of the diameter along the greatest dimension. Fine indicates less than 5 millimeters (around 0.2 inch); medium, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and coarse, more than 15 millimeters (about 0.6 inch).

Muck. Dark colored, finely divided, well decomposed organic soil material mixed with mineral soil material. The content of organic matter is more than 20 percent.

Munsell notation. A designation of color by degrees of the three single variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

Organic matter. A general term for plant and animal material, in or on the soil, in all stages of decomposition. Readily decomposed organic matter is often distinguished from the more stable forms that are past the stage of rapid decomposition.

Organic soil. A general term applied to a soil or to a soil horizon that consists primarily of organic matter, such as peat soils, muck soils, and peaty soil layers.

Outwash plain. A land form of mainly sandy or coarse textured material of glaciofluvial origin. An outwash plain is commonly smooth; where pitted, it is generally low in relief.

Parent material. The great variety of unconsolidated organic and mineral material in which soil forms. Consolidated bedrock is not yet parent material by this concept.

Peat. Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture.

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Permeability. The quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves through the soil. Terms describing permeability are very slow (less than 0.06 inch), slow (0.06 to 0.20 inch), moderately slow (0.2 to 0.6 inch), moderate (0.6 to 2.0 inches), moderately rapid (2.0 to 6.0 inches), rapid (6.0 to 20 inches), and very rapid (more than 20 inches).

Pressure ridge. A ridge produced by horizontal pressure associated with movement of glacial ice.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

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

Relief. The elevations or inequalities of a land surface, considered collectively.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sapric soil material (muck). The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body at the earth's surface that is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in mature soil consists of the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristics of the soil are largely confined to the solum.

Stratified. Arranged in strata, or layers. The term refers to geologic material. Layers in soils that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata.

Structure, soil. The arrangement of primary soil particles into compound particles of aggregates that are separated from adjoining aggregates. The principal forms of soil structure are—platy (laminated), prismatic (vertical axis of aggregates longer than horizontal, columnar (prisms with rounded tops), blocky (angular or subangular), and granular. Structureless soils are either single grained (each grain by itself, as in dune sand) or massive (the particles adhering without any regular cleavage, as in many hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use or management.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are sand, loamy sand, sandy loam, loam, silt, silt loam, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Till plain. An extensive flat to undulating area underlain by glacial till.

Tilth, soil. The condition of the soil, especially the soil structure, as related to the growth of plants. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Valley train. A long, narrow body of outwash confined within a valley.

Variant, soil. A soil having properties sufficiently different from those of other known soils to justify a new series name, but the limited geographic soil area does not justify creation of a new series.

Water table. The upper limit of the soil or underlying rock material that is wholly saturated with water.

Water table, apparent. A thick zone of free water in the soil. An apparent water table is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil.

Water table, artesian. A water table under hydrostatic head, generally beneath an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole.

Water table, perched. A water table standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

Map symbol	Mapping unit	Page	Community development group	Recreation group	Capability unit		Woodland group
			Number	Number	Symbol	Page	Number
Af	Alluvial land, mixed, frequently flooded	10	8	6	VIw-1	76	5w1
AnA	Anoka loamy fine sand, 0 to 2 percent slopes	11	1	4	IIIs-2	74	3s1
AnB	Anoka loamy fine sand, 2 to 6 percent slopes	12	1	4	IIIs-2	74	3s1
AnC	Anoka loamy fine sand, 6 to 12 percent slopes	12	1	4	IVe-2	75	3s1
Ba	Becker very fine sandy loam	12	8	5	IIw-1	73	2o3
Bm	Blomford loamy fine sand	13	5	3	IIIw-1	74	3w1
BtB	Braham loamy fine sand, 2 to 6 percent slopes	14	2	4	IIIs-2	74	2o2
BtC	Braham loamy fine sand, 6 to 18 percent slopes	14	2	4	IVe-2	75	2o2
Bx	Brickton silt loam	15	5	6	IIIw-2	74	3w1
Cb	Cathro muck	16	6	6	IIIw-3	74	5w1
CkB	Chetek sandy loam, 2 to 6 percent slopes	16	1	1	IIIe-1	73	3s1
CkC	Chetek sandy loam, 6 to 12 percent slopes	16	1	1	IVe-2	75	3s1
Cu	Cut and fill land	17	--	--	------	--	---
DlA	Dalbo silt loam, 1 to 5 percent slopes	17	3	2	IIe-2	73	2o1
DnA	Dickman sandy loam, 0 to 2 percent slopes	18	1	1	IIIs-1	74	3s1
DnB	Dickman sandy loam, 2 to 6 percent slopes	18	1	1	IIIe-1	73	3s1
Dp	Duelm loamy coarse sand	19	4	4	IVw-1	75	3s1
Du	Dundas loam	19	5	3	IIIw-2	74	3w1
EmC	Emmert gravelly coarse sandy loam, 6 to 12 percent slopes	20	1	4	VIs-1	76	3s1
EmD	Emmert gravelly coarse sandy loam, 12 to 25 percent slopes	20	1	4	VIIs-1	76	3s2
EpC	Emmert complex, 4 to 12 percent slopes	20	1	4	VIs-1	76	3s1
EpD	Emmert complex, 12 to 25 percent slopes	21	1	4	VIIs-1	76	3s2
Gc	Glencoe loam	21	6	6	IIIw-4	74	5w1
GrA	Growton fine sandy loam, 1 to 4 percent slopes	22	2	1	IIe-1	73	2o2
HdB	Hayden fine sandy loam, 2 to 6 percent slopes	23	2	1	IIe-1	73	2o1
HdC2	Hayden fine sandy loam, 6 to 12 percent slopes, eroded	23	2	1	IIIe-1	73	2o1
HdD	Hayden fine sandy loam, 12 to 24 percent slopes	23	2	1	IVe-1	75	2r1
HeB	Heyder fine sandy loam, 2 to 6 percent slopes	24	2	1	IIe-1	73	2o2
HeC2	Heyder fine sandy loam, 6 to 12 percent slopes, eroded	24	2	1	IIIe-1	73	2o2
HeD	Heyder fine sandy loam, 12 to 18 percent slopes	24	2	1	IVe-1	75	2r1
HeE	Heyder fine sandy loam, 18 to 30 percent slopes	24	2	1	VIe-1	76	2r1
HlC	Heyder complex, 4 to 12 percent slopes	24	2	1	IIIe-1	73	2o2
HlD	Heyder complex, 12 to 25 percent slopes	24	2	1	IVe-1	75	2r1
HuA	Hubbard coarse sand, 0 to 2 percent slopes	25	1	4	IVs-1	76	3s1
HuB	Hubbard coarse sand, 2 to 6 percent slopes	25	1	4	IVs-1	76	3s1
HuC	Hubbard coarse sand, 6 to 12 percent slopes	25	1	4	VIs-1	76	3s1
Is	Isan sandy loam	26	6	6	IVw-2	75	5w1
Iw	Isanti fine sandy loam	26	6	6	IVw-2	75	5w1
KmB	Kingsley fine sandy loam, 2 to 6 percent slopes	27	3	1	IIe-1	73	2o2
KmC2	Kingsley fine sandy loam, 6 to 12 percent slopes, eroded	27	3	1	IIIe-1	73	2o2
KmD	Kingsley fine sandy loam, 12 to 18 percent slopes	27	3	1	IVe-1	75	2r1
KmE	Kingsley fine sandy loam, 18 to 30 percent slopes	27	3	1	VIe-1	76	2r1
Kr	Kratka loamy fine sand	28	6	6	IVw-2	75	5w1
Lb	Lake beaches	28	6	6	IVw-2	75	5w1
LgB	Langola loamy sand, 0 to 6 percent slopes	29	3	4	IIIs-2	74	2o2
LnA	Lino loamy fine sand, 0 to 4 percent slopes	29	4	4	IVw-1	75	3s1
Lw	Loamy wet land	30	6	6	IIIw-4	74	5w1

Map symbol	Mapping unit	Page	Community development group	Recreation group	Capability unit		Woodland group
			Number	Number	Symbol	Page	Number
Lx	Lupton muck	30	7	6	IIIw-3	74	5w1
Ma	Markey muck	31	6	6	IVw-3	75	5w1
Mc	Marsh	31	7	6	VIIIw-1	78	5w1
Me	Meehan sand	32	4	4	IVw-1	75	3s1
Mk	Millerville mucky peat	32	7	6	IVw-3	75	5w1
MoA	Mora fine sandy loam, 1 to 4 percent slopes	33	3	2	IIe-2	73	2o2
NeA	Nessel fine sandy loam, 1 to 4 percent slopes	34	2	1	IIe-1	73	2o1
No	Nowen sandy loam	35	5	3	IIw-2	73	3w1
NrD	Nymore loamy coarse sand, 12 to 25 percent slopes	35	1	4	VIIs-1	76	3s2
NyA	Nymore loamy sand, 0 to 2 percent slopes	35	1	4	IVs-1	76	3s1
NyB	Nymore loamy sand, 2 to 6 percent slopes	36	1	4	IVs-1	76	3s1
NyC	Nymore loamy sand, 6 to 12 percent slopes	36	1	1	VIs-1	76	3s1
Rf	Rifle mucky peat	36	7	6	IIIw-3	74	5w1
Rg	Rifle muck, woody	36	7	6	IIIw-3	74	5w1
Rh	Rifle soils, ponded	37	7	6	VIIIw-1	78	5w1
Ru	Rondeau muck	38	7	6	IVw-3	75	5w1
Ry	Ronneby fine sandy loam	39	5	3	IIw-3	73	2o4
SbB	Sartell fine sand, 2 to 6 percent slopes	39	1	4	IVs-1	76	3s1
SbC	Sartell fine sand, 6 to 12 percent slopes	39	1	4	VIs-1	76	3s1
SbC2	Sartell fine sand, 6 to 12 percent slopes, eroded	39	1	4	VIs-1	76	3s1
SbD2	Sartell fine sand, 12 to 24 percent slopes, eroded	39	1	4	VIIs-1	76	3s2
Se	Seelyeville muck	40	7	6	IIIw-3	74	5w1
SoA	Soderville fine sand, 0 to 4 percent slopes	41	4	4	IVw-1	75	3s1
Wb	Webster loam	41	5	6	IIw-2	73	3w1
ZmA	Zimmerman fine sand, 0 to 2 percent slopes	42	1	4	IVs-1	76	3s1
ZmB	Zimmerman fine sand, 2 to 6 percent slopes	43	1	4	IVs-1	76	3s1
ZmC	Zimmerman fine sand, 6 to 12 percent slopes	43	1	4	VIs-1	76	3s1
ZmD	Zimmerman fine sand, 12 to 24 percent slopes	43	1	4	VIIs-1	76	3s2

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