# SOIL SURVEY OF
# Rice County, Minnesota

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

Issued March 1975

**Major fieldwork for this soil survey was done in the period 1942 to 1970. Soil names and descriptions were approved in 1972. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1972. This survey was made cooperatively by the Soil Conservation Service and the University of Minnesota Agricultural Experiment Station. It is part of the technical assistance furnished to the Rice Soil and Water Conservation District.**

**Copies of the soil map in this publication can be made by commercial photographers, or they can be purchased on individual order from the Cartographic Division, Soil Conservation Service, United States Department of Agriculture, Washington, D.C. 20250.**

# HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms, ranches, and woodlands; in selecting sites for roads, ponds, buildings, and other structures; and in judging the suitability of tracts of land for farming, industry, and recreation.

## Locating Soils

All the soils of Rice County are shown on the detailed map at the back of this publication. This map consists of many sheets made from aerial photographs. Each sheet is numbered to correspond with a number on the Index to Map Sheets.

On each sheet of the detailed map, soil areas are outlined and are identified by symbols. All areas marked with the same symbol are the same kind of soil. The soil symbol is inside the area if there is enough room; otherwise, it is outside and a pointer shows where the symbol belongs.

## Finding and Using Information

The "Guide to Mapping Units" can be used to find information. This guide lists all the soils of the county in alphabetic order by map symbol and gives the capability classification of each. It also shows the page where each soil is described and the page for the woodland suitability group and for the building site group in which the soil has been placed.

Individual colored maps showing the relative suitability or degree of limitation of soils for many specific purposes can be developed by using the soil map and the information in the text. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

*Farmers and those who work with farmers* can learn about use and management of the soils from the soil descriptions and from the discussions of the capability units, the building sites, and the woodland groups.

*Foresters and others* can refer to the section "Woodland and Windbreaks," where the soils of the county are grouped according to their suitability for trees.

*Game managers, sportsmen, and others* can find information about soils and wildlife in the section "Wildlife."

*Community planners and others* can read about soil properties that affect the choice of sites for dwellings, industrial buildings, and recreational areas in the sections "Use of the Soils for Community Development" and "Use of the Soils for Recreational Development."

*Engineers and builders* can find, under "Engineering Uses of the Soils," tables that contain test data, estimates of soil properties, and information about soil features that affect engineering practices.

*Scientists and others* can read about how the soils formed and how they are classified in the section "Formation and Classification of the Soils."

*Newcomers in Rice County* may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the information about the county given in the section "General Nature of the County."

*Cover:* **Recreation area in the Lester-Hayden-Le Sueur association.**

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# SOIL SURVEY OF RICE COUNTY, MINNESOTA

BY CARROLL R. CARLSON, JOSEPH F. CUMMINS, RUSSELL J. EDWARDS, GRENFALL F. HARMS, JAMES J. MURRAY, RICHARD E. ROLLING, RONALD SEVERSON, AND D. KIRK WOODWORTH, SOIL CONSERVATION SERVICE

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

RICE COUNTY is in the south-central part of Minnesota (fig. 1). Faribault, the county seat, is about 60 miles south of Minneapolis-St. Paul and about 50 miles north of the State of Iowa line. The county has a total land area of 316,800 acres. Farmland comprises 87 percent of this acreage. In 1969, approximately 80 percent of the land in farms was used for crops; these were mainly corn, soybeans, and alfalfa. Dairying and hogs are the principal livestock enterprises.

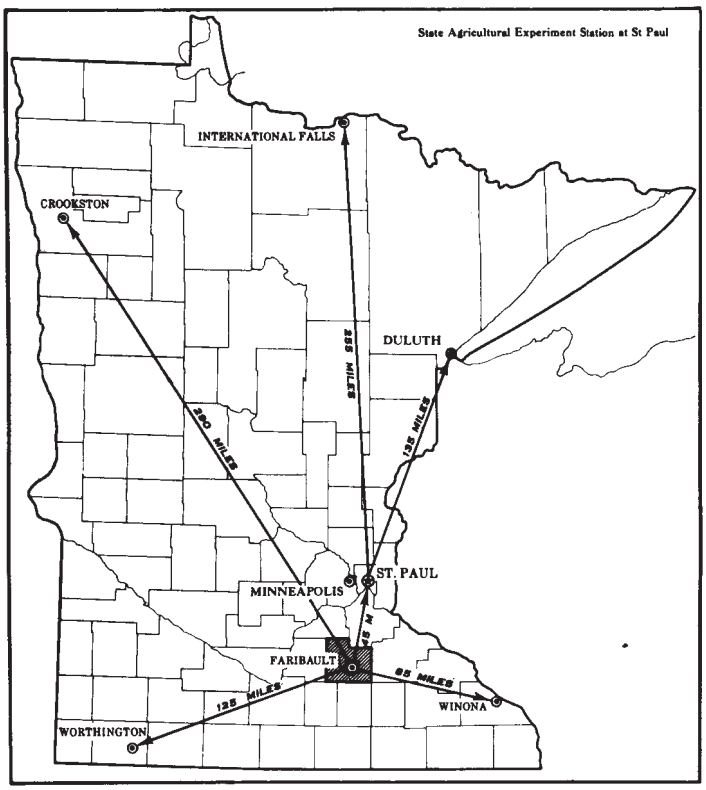


*Figure 1.*—**Location of Rice County in Minnesota.**

## How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Rice County, where they are located, and how they can be used. The soil scientists went into the county knowing they were likely to 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. Clarion and Nicollet, 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, Clarion loam, 2 to 6 percent slopes, is one of several phases within the Clarion 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 other kind that have been seen within an area that is dominantly of a recognized soil phase.

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

A soil complex consists of areas of two or more soils, so intricately mixed or so small in size that they cannot be shown 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 consists of the names of the dominant soils, joined by a hyphen. Clarion-Estherville-Storden complex, 4 to 12 percent slopes, eroded, 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. Alluvial land, frequently flooded, is a land type in this county.

While a survey is in progress, soil scientists take soil samples needed for laboratory measurements and for engineering tests. Laboratory data from the same kind 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 kind 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 effluent fail on a given kind of soil, and they relate this to the slow permeability of the soil or a 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 Rice 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, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The terms for texture used in the title for several of the associations apply to the texture of the surface layer. For example, in the title of association 1, the words "loam" and "clay loam" refer to the texture of the surface layer.

The soil associations in Rice County are discussed in the following pages. Soil associations and delineations on the general soil map in this soil survey do not fully agree with those of the general soil maps in adjacent counties published at a different date. Differences in the maps are the result of improvements in the classification of soils, particularly in the modifications or refinements in soil series concepts. Another difference is caused by the range in slope that is permitted within associations in different surveys.

### 1. *Clarion-Webster-Nicollet association*

*Nearly level to hilly, well-drained to poorly drained loams and clay loams that formed in friable glacial till on uplands*

This association consists of nearly level to hilly soils on ground moraines. Slopes are complex and generally range from 0 to 18 percent, but they are more than 18 percent in a few places around the many large sloughs and potholes that are scattered throughout the association.

This association makes up about 6 percent of the county. It is about 37 percent Clarion soils, 26 percent Webster soils, 17 percent Nicollet soils, and 20 percent minor soils.

Clarion soils are gently undulating to hilly and are well drained. They have slopes of 2 to 18 percent. The surface layer typically is very dark brown loam about 13 inches thick. The subsoil is dark yellowish-brown, brown, dark-brown, and light olive-brown loam about 21 inches thick. It is underlain by light yellowish-brown and light olive-brown, calcareous loam.

Webster soils are nearly level and poorly drained. The surface layer typically is black clay loam about 20 inches thick. The subsoil is mottled, olive-gray clay loam about 8 inches thick. It is underlain by mottled, olive-gray and grayish-brown, calcareous clay loam and loam.

Nicollet soils are nearly level to gently undulating and are moderately well drained to somewhat poorly drained. They have slopes of 1 to 3 percent. The surface layer typically is black clay loam about 19 inches thick. The subsoil is mottled, dark grayish-brown and grayish-brown clay loam about 21 inches thick. It is underlain by mottled, grayish-brown, calcareous loam.

Minor soils in this association are the Biscay, Canisteo, Estherville, Fairhaven, Glencoe, Lester, Le Sueur, Storden, and Terril soils. The wet, noncalcareous Biscay and Glencoe soils are in the swales and low concave areas. The calcareous Canisteo soils occupy rims around the

wet soils. The calcareous Storden soils and the Clarion soils are closely interminged. Terril soils are at the base of the more sloping Clarion soils.

Nearly all of this association is used for cultivated crops. Corn and soybeans are the principal crops. A few steep areas and wet, undrained areas are used for permanent pasture and as wildlife habitat. Fertility, the content of organic matter, and the available water capacity are high. The main concerns of management are controlling water erosion, improving drainage, and maintaining good tilth and fertility. The soils have a high potential for producing all cultivated crops commonly grown in the county.

### 2. *Lester-Hayden-Le Sueur association*

*Nearly level to steep, well-drained to somewhat poorly drained loams and clay loams that formed in friable glacial till on uplands*

This association consists of nearly level to steep soils on ground moraines (fig. 2). Slopes are complex and generally range from 0 to 25 percent, but they are more than 25 percent in a few places around the many large sloughs and potholes that are scattered throughout the association.

This association makes up about 38 percent of the county. It is about 31 percent Lester soils, 19 percent Hayden soils, 5 percent Le Sueur soils, and 45 percent minor soils.

Lester soils are undulating to hilly and are well drained. They have slopes of 2 to 18 percent. The surface layer typically is black loam about 5 inches thick. The subsurface layer is very dark gray loam about 3 inches thick. The subsoil is brown, dark yellowish-brown, and light olive-brown clay loam and loam about 32 inches thick. It is underlain by light olive-brown, calcareous loam.

***Figure* 2.—Typical area of the Lester-Hayden-Le Sueur association.**

Hayden soils are undulating to steep and well drained. They have slopes of 2 to 30 percent. The surface layer typically is very dark gray, very dark grayish-brown, and dark grayish-brown loam about 8 inches thick. The subsoil is dark grayish-brown, dark-brown, and yellowish-brown clay loam about 32 inches thick. It is underlain by light olive-brown, calcareous loam.

Le Sueur soils are nearly level to undulating and are moderately well drained to somewhat poorly drained. They have slopes of 1 to 3 percent. The surface layer typically is black and very dark gray clay loam about 14 inches thick. The subsoil is mottled, very dark grayish-brown, dark grayish-brown, and olive-brown clay loam about 22 inches thick. It is underlain by grayish-brown, calcareous clay loam.

Minor soils in this association are the Biscay, Canisteo, Clarion, Cordova, Dundas, Estherville, Fairhaven, Glencoe, Storden, Terril, and Webster soils. The wet, noncalcareous Biscay, Cordova, Dundas, Glencoe, and Webster soils occupy swales and low, concave areas. The rims around the wet soils are occupied by calcareous Canisteo soils. The calcareous Storden soils are closely intermingled with Lester soils. Terril soils are at the base of the more sloping Lester and Hayden soils.

Nearly all of this association is used for cultivated crops. Corn and soybeans are the principal crops. A few steep areas and wet, undrained areas are used for permanent pasture and as wildlife habitat. Fertility and the available water capacity are high. The content of organic matter is moderate to high. The main concerns of management are controlling erosion caused by water, improving drainage, and maintaining good tilth and fertility. The soils have a high potential for producing all cultivated crops commonly grown in the county.

### 3. *Kilkenny-Shields-Lerdal association*

*Nearly level to moderately steep, well-drained to somewhat poorly drained clay loams and silt loams that formed in firm, shaly glacial till on uplands*

This association consists of nearly level to moderately steep soils on ground moraines. Slopes generally range from 0 to 18 percent, but they are more than 18 percent in a few places around the many large sloughs and potholes that are scattered throughout the association.

This association makes up about 20 percent of the county. It is about 34 percent Kilkenny soils, 13 percent Shields soils, 7 percent Lerdal soils, and 46 percent minor soils.

Kilkenny soils are gently sloping to moderately steep and well drained. They have slopes of 2 to 18 percent. The surface layer typically is very dark gray clay loam about 7 inches thick. The subsurface layer is dark grayish-brown clay loam about 4 inches thick. The subsoil is olive-brown, grayish-brown, and light olive-brown clay loam about 28 inches thick. It is underlain by mottled, light olive-brown, calcareous clay loam.

Shields soils are nearly level and somewhat poorly drained. The surface layer typically is black and very dark gray silt loam about 7 inches thick. The subsurface layer is dark-gray silty clay loam about 4 inches thick. The subsoil is mottled, olive-gray, firm silty clay about 27 inches thick. It is underlain by mottled, olive-gray, calcareous clay loam.

Lerdal soils are nearly level to moderately steep and are moderately well drained to somewhat poorly drained. They have slopes of 1 to 18 percent. The surface layer typically is very dark gray silt loam about 6 inches thick. The subsoil is mottled, dark grayish-brown and grayish-brown, firm clay loam and clay about 34 inches thick. It is underlain by olive-gray, calcareous clay loam.

Minor soils in this association are the Cordova, Dundas, Erin, Glencoe, Hayden, Lester, Le Sueur, Mazaska, Rolfe, Terril, and Webster soils. The wet, noncalcareous Cordova, Dundas, Glencoe, Mazaska, Rolfe, and Webster soils are in swales and low, concave areas. Terril soils are below the more sloping Kilkenny and Lerdal soils.

This association is used mainly for cultivated crops and as woodland. Corn, soybeans, small grains, and hay are the principal crops. Some undrained areas are used for permanent pasture and as wildlife habitat. Fertility of the soils is medium to high, the content of organic matter is moderate to high, and the available water capacity is high. The main concerns of management are controlling erosion caused by water, improving drainage, and maintaining good tilth and fertility. The soils have a moderate to high potential for producing cultivated crops and trees.

### 4. *Moland-Maxcreek-Merton association*

*Nearly level to sloping, well-drained to poorly drained silt loams and silty clay loams that formed in loess and friable glacial till on uplands*

This association consists of nearly level to sloping soils on ground moraines. Slopes generally range from 0 to 12 percent, but they are more than 12 percent in a few places around the many large drainageways that are scattered throughout the association.

This association makes up about 4 percent of the county. It is about 30 percent Moland soils, 22 percent Maxcreek soils, 10 percent Merton soils, and 38 percent minor soils.

Moland soils are gently sloping to sloping and are well drained. Slopes are 2 to 12 percent. The surface layer typically is black and dark-brown silt loam about 14 inches thick. The subsoil is dark-brown to light olive-brown silt loam and loam about 35 inches thick. It is underlain by light olive-brown, calcareous loam.

Maxcreek soils are nearly level and poorly drained. The surface layer typically is black silty clay loam about 18 inches thick. The subsoil is mottled, olive-gray, dark grayish-brown, and olive silt loam about 18 inches thick. It is underlain by mottled, grayish-brown, calcareous loam.

Merton soils are nearly level to gently sloping and are moderately well drained. Slopes are 1 to 3 percent. The surface layer typically is black silt loam about 15 inches thick. The subsoil is mottled, dark grayish-brown and light olive-brown silt loam and loam about 19 inches thick. It is underlain by light olive-brown, calcareous loam.

Minor soils in this association are the Canisteo, Fairhaven, and Kato soils. The wet, noncalcareous Kato soils are in swales and low concave areas. The calcareous Canisteo soils occupy the rims around the wet soils.

Nearly all of this association is used for cultivated crops. Corn and soybeans are the principal crops. A few steeper areas and wet, undrained areas are used for permanent pasture and as wildlife habitat. Fertility, the content of organic matter, and the available water capacity are high.

The main concerns of management are controlling erosion caused by water, improving drainage, and maintaining good tilth and fertility. The soils have a high potential for producing all cultivated crops commonly grown in the county.

### 5. *Ostrander-Maxfield-Klinger association*

*Nearly level to steep, well-drained to poorly drained silt loams and silty clay loams that formed in loess and firm glacial till on uplands*

This association consists of nearly level to steep soils on ground moraines. Slopes generally range from 0 to 25 percent, but they are more than 25 percent in a few places around the many large drainageways that are scattered throughout the association.

This association makes up about 16 percent of the county. It is about 40 percent Ostrander soils, 27 percent Maxfield soils, 15 percent Klinger soils, and 18 percent minor soils.

Ostrander soils are gently sloping to steep and well drained. Slopes are 2 to 25 percent. The surface layer typically is black and very dark brown silt loam about 11 inches thick. The subsoil is dark brown and yellowish-brown silt loam and loam about 31 inches thick. It is underlain by yellowish-brown, firm, calcareous loam.

Maxfield soils are nearly level and poorly drained. The surface layer typically is black silty clay loam about 20 inches thick. The subsoil is mottled, dark grayish-brown and yellowish-brown silt loam and loam about 17 inches thick. It is underlain by mottled, yellowish-brown, firm, calcareous loam.

Klinger soils are nearly level to gently sloping and are moderately well drained. Slopes are 1 to 3 percent. The surface layer typically is black silt loam about 14 inches thick. The subsoil is mottled, very dark grayish-brown, brown, and yellowish-brown silt loam and loam about 33 inches thick. It is underlain by yellowish-brown, firm, calcareous loam.

Minor soils in this association are the Canisteo, Garwin, Judson, Kato, and Port Byron soils. The wet, non-calcareous Garwin and Kato soils are in swales and low, concave areas. The calcareous Canisteo soils occupy rims around the wet soils. The sloping Port Byron soils are closely intermingled with Ostrander soils. Judson soils occupy the draws below the more sloping Ostrander soils.

Nearly all of this association is used for cultivated crops. Corn and soybeans are the principal crops. A few steep areas and wet, undrained areas are used for permanent pasture and as wildlife habitat. Fertility, the the content of organic matter, and the available water capacity are high. The main concerns of management are controlling erosion caused by water, improving drainage, and maintaining good tilth and fertility. The soils have a high potential for producing all cultivated crops commonly grown in the county.

### 6. *Maxfield-Klinger association*

*Nearly level to gently sloping, poorly drained and moderately well drained silty clay loams and silt loams that formed in loess and firm glacial till on uplands*

This association consists of nearly level to gently sloping soils on ground moraines (fig. 3). Slopes generally range from 0 to 3 percent, but they are more than 3 percent in a few places around drainageways that are scattered throughout the association.

This association makes up about 1 percent of the county. It is about 49 percent Maxfield soils, 25 percent Klinger soils, and 26 percent minor soils.

Maxfield soils are nearly level and poorly drained. The surface layer typically is black silty clay loam about 20 inches thick. The subsoil is mottled, dark grayish-brown and yellowish-brown silt loam and loam about 17 inches thick. It is underlain by mottled, yellowish-brown, firm, calcareous loam.

Klinger soils are nearly level to gently sloping and are moderately well drained. They have slopes of 1 to 3 percent. The surface layer typically is black silt loam about 14 inches thick. The subsoil is mottled, very dark grayish-brown, brown, and yellowish-brown silt loam and loam about 33 inches thick. It is underlain by yellowish-brown, firm, calcareous loam.

Minor soils in this association are the Canisteo and Ostrander soils. The rims around the wet swales are occupied by calcareous Canisteo soils. The Ostrander soils are sloping.

Nearly all of this association is used for cultivated crops. Corn and soybeans are the principal crops. A few wet, undrained areas are used for permanent pasture and as wildlife habitat. Fertility, the content of organic matter, and the available water capacity are high. The main concerns of management are improving drainage and maintaining tilth and fertility. The soils have a high potential for producing all cultivated crops commonly grown in the county.

### 7. *Renova-Kasson-Skyberg association*

*Nearly level to steep, well-drained to somewhat poorly drained silt loams that formed in loess and firm glacial till on uplands*

This association consists of nearly level to steep soils on ground moraines. Slopes generally range from 0 to 25 percent, but they are more than 25 percent in a few places around the many large drainageways that are scattered throughout the association.

This association makes up about 3 percent of the county. It is about 70 percent Renova soils, 6 percent Kasson soils, 3 percent Skyberg soils, and 21 percent minor soils.

Renova soils are gently sloping to steep and are well drained. They have slopes of 2 to 25 percent. The surface layer typically is very dark gray silt loam about 3 inches thick. The subsurface layer is dark grayish-brown and grayish-brown silt loam about 7 inches thick. The subsoil is dark yellowish-brown and yellowish-brown silty clay loam and about 42 inches thick. It is underlain by yellowish-brown, firm, slightly calcareous loam.

Kasson soils are nearly level to gently sloping and are moderately well drained. They have slopes of 1 to 3 percent. The surface layer typically is very dark grayish-brown silt loam about 7 inches thick. The subsurface layer is dark grayish-brown silt loam about 3 inches thick. The subsoil is mottled, dark grayish-brown to light olive-brown silty clay loam and loam about 48 inches thick. It is underlain by olive-brown and dark yellowish-brown, firm, calcareous loam.

Skyberg soils are nearly level and somewhat poorly drained. The surface layer typically is very dark gray silt loam about 8 inches thick. The subsurface layer is mottled, dark-gray silt loam about 5 inches thick. The subsoil is

*Figure 3.*—**Typical area of the Maxfield-Klinger association.**

mottled, dark grayish-brown, grayish-brown, and yellowish-brown silty clay loam and clay loam about 35 inches thick. It is underlain by mottled, yellowish-brown, firm, calcareous loam.

Minor soils in this association are the Garwin, Judson, Kato, Maxfield, Ostrander, Port Byron, and Vlasaty soils. The wet, noncalcareous Garwin and Kato soils are in swales and low, concave areas. The sloping Ostrander soils are closely intermingled with Renova soils. Judson soils occupy the draws below the more sloping Renova soils.

This association is used mainly as woodland, but a few areas are used for cultivated crops. Undrained, wet areas are used for permanent pasture and as wildlife habitat. Fertility is medium, the content of organic matter is moderate, and the available water capacity is high. The main concerns of management are controlling erosion caused by water, improving drainage, and maintaining good tilth and fertility. The soils have a high potential for producing trees and cultivated crops.

### 8. *Colo-Estherville-Waukegan association*

*Nearly level to sloping, poorly drained to somewhat excessively drained silty clay loams, sandy loams, and silt loams that formed in alluvium on bottom lands, terraces, and outwash plains*

This association consists of nearly level to sloping soils on bottom lands, outwash plains, and stream terraces. Slopes generally range from 0 to 12 percent, but they are more than 12 percent in a few places along major streams and drainageways that are scattered throughout the association.

This association makes up about 12 percent of the county. It is about 25 percent Colo soils, 14 percent Estherville soils, 9 percent Waukegan soils, and 52 percent minor soils.

Colo soils are nearly level and poorly drained. The surface layer typically is black silty clay loam about 60 inches thick.

Estherville soils are nearly level to sloping and are somewhat excessively drained. They have slopes of 0 to 12 percent. The surface layer typically is black and very dark grayish-brown sandy loam about 10 inches thick. The subsoil is dark grayish-brown sandy loam and gravelly coarse sand about 14 inches thick. It is underlain by grayish-brown and light olive-brown, calcareous gravelly coarse sand.

Waukegan soils are nearly level to gently undulating and are well drained. They have slopes of 0 to 6 percent. The surface layer typically is black silt loam about 15 inches thick. The subsoil is brown silt loam in the upper 18 inches and brown and yellowish-brown gravelly coarse sand in the lower 19 inches. It is underlain by yellowish-brown, brown, and grayish-brown gravelly coarse sand.

Minor soils in this association are the Biscay, Canisteo, Copaston, Dickman, Dodgeville, Etter, Fairhaven, Faxon, Kato, Salida, Sogn, and Zumbro soils. The wet, noncalcareous Biscay, Faxon, Kato, and Zumbro soils are in swales and low, concave areas. The calcareous Canisteo soils are on rims around the wet soils. Salida and Etter soils are closely intermingled with Estherville and Waukegan soils. Sogn and Dodgeville soils are on rises surrounded by nearly level areas of Waukegan soils.

This association is used for cultivated crops, for permanent pasture, and as woodland. Corn and soybeans are the principal crops. A few steeper areas and wet, undrained areas are used for permanent pasture and as wildlife habitat. Fertility, the content of organic matter, and the available water capacity are high for Colo soils and are low to high for Estherville and Waukegan soils. The main concerns of management are controlling erosion caused by water, improving drainage, and maintaining good tilth and fertility. This association has a moderate potential for producing cultivated crops commonly grown in the county.

# *Descriptions of the Soils*

This section describes the soil series and mapping units in Rice 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. The profile described in the series is representative for mapping units in that series. If the profile of a given mapping unit is different 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. Color terms are for moist soil unless otherwise stated.

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

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit, woodland group, and building site group in which the mapping unit has been placed. The page for the description of each capability unit, woodland group, or building site group can be learned by referring to the "Guide to Mapping Units" at the back of this survey.

The names, descriptions, and delineations of soils in this soil survey do not fully agree or fully join with soil maps of adjoining counties published at an earlier date. Differences are brought about by better knowledge of soils, by modification and refinements in soil series concepts, and by the extent of soils within the survey area. Commonly, it is more feasible to combine small acreages of similar soils that respond to use and management in much the same way than it is to separate these soils and give them names. The soil descriptions reflect these combinations. Other differences are brought about by the predominance of different soils in taxonomic units made up by two or three series. Still another difference may be caused by the range in slope allowed within the mapping unit for each survey.

The acreage and proportionate extent of each mapping unit in Rice County are shown in table 1. Many of the terms used in describing soils can be found in the Glossary, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*11*).[1]

## Alluvial Land

Alluvial land consists of well drained or moderately well drained soil material that has been recently deposited by streams. It is nearly level and occupies areas adjacent to major streams and their tributaries. The surface layer is dominantly loam, but in some places it is loamy sand or sandy loam of varying thickness. The subsoil is stratified, and its texture ranges from sand to silty clay loam or clay loam. Remnant meander channels are in some areas. Reaction is neutral. Permeability is moderate to moderately rapid in most places, and available water capacity is variable. The content of organic matter is high, and natural fertility is medium.

**Alluvial land** (Ad) is on the higher bottom lands along the major rivers and their principal tributaries, and it is subject to occasional flooding and scouring. This land is

[1] Italic numbers in parentheses refer to Literature Cited, p. 116.

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

| Soil | Acres | Percent | Soil | Acres | Percent |
|---|---|---|---|---|---|
| Alluvial land | 3,009 | 1.0 | Klinger silt loam, 1 to 3 percent slopes | 8,692 | 2.7 |
| Alluvial land, frequently flooded | 4,001 | 1.3 | Lake beaches | 2,956 | .9 |
| Biscay loam | 519 | .2 | Lerdal silt loam, 1 to 6 percent slopes | 2,274 | .7 |
| Biscay loam, seepy variant | 336 | .1 | Lerdal clay loam, 6 to 12 percent slopes, eroded | 1,136 | .4 |
| Boone fine sand, 2 to 12 percent slopes | 314 | .1 | Lerdal clay loam, 12 to 18 percent slopes, eroded | 909 | .3 |
| Boone fine sand, 12 to 25 percent slopes | 555 | .2 | Lester loam, 2 to 6 percent slopes | 25,564 | 8.2 |
| Boone fine sand, 25 to 40 percent slopes | 432 | .1 | Lester loam, 6 to 12 percent slopes | 1,516 | .5 |
| Canisteo clay loam | 4,155 | 1.3 | Lester loam, 6 to 12 percent slopes, eroded | 8,152 | 2.6 |
| Canisteo clay loam, depressional | 2,502 | .8 | Lester loam, 12 to 18 percent slopes, eroded | 2,425 | .8 |
| Caron muck | 8,984 | 2.8 | Lester loam, 18 to 25 percent slopes | 303 | .1 |
| Clarion loam, 2 to 6 percent slopes | 8,233 | 2.6 | Le Sueur clay loam, 1 to 3 percent slopes | 7,041 | 2.2 |
| Clarion loam, 6 to 12 percent slopes | 1,364 | .4 | Marsh | 1,365 | .4 |
| Clarion-Estherville-Storden complex, 4 to 12 percent slopes, eroded | 476 | .2 | Maxcreek silty clay loam | 2,169 | .7 |
| Clarion-Storden loams, 6 to 12 percent slopes | 1,364 | .4 | Maxcreek silty clay loam, swales | 701 | .2 |
| Clarion-Storden loams, 12 to 18 percent slopes | 455 | .1 | Maxfield silty clay loam | 12,117 | 3.9 |
| Clarion-Storden loams, 18 to 25 percent slopes | 454 | .1 | Maxfield silty clay loam, swales | 3,565 | 1.1 |
| Colo silty clay loam | 9,933 | 3.1 | Mazaska silty clay loam | 5,842 | 1.8 |
| Copaston sandy clay loam, 0 to 2 percent slopes | 350 | .1 | Merton silt loam, 1 to 3 percent slopes | 1,378 | .4 |
| Cordova clay loam | 9,122 | 2.9 | Moland silt loam, 2 to 6 percent slopes | 3,041 | 1.0 |
| Dickman sandy loam, 0 to 2 percent slopes | 295 | .1 | Moland silt loam, 6 to 12 percent slopes | 348 | .1 |
| Dickman sandy loam, 2 to 6 percent slopes | 717 | .2 | Moland silt loam, 12 to 18 percent slopes, eroded | 354 | .1 |
| Dickman sandy loam, 6 to 12 percent slopes | 271 | .1 | Muskego muck | 1,749 | .6 |
| Dickman sandy loam, benches, 0 to 2 percent slopes | 681 | .2 | Nicollet clay loam, 1 to 3 percent slopes | 3,411 | 1.1 |
| Dickman sandy loam, benches, 2 to 6 percent slopes | 769 | .2 | Ostrander loam, 12 to 18 percent slopes, eroded | 1,567 | .5 |
| Dodgeville silt loam, 2 to 6 percent slopes | 161 | (1) | Ostrander loam, 18 to 30 percent slopes, eroded | 945 | .3 |
| Dodgeville silt loam, 6 to 12 percent slopes | 314 | .1 | Ostrander silt loam, 2 to 6 percent slopes | 12,018 | 3.8 |
| Dodgeville silt loam, 12 to 18 percent slopes | 230 | .1 | Ostrander silt loam, 6 to 12 percent slopes, eroded | 5,472 | 1.7 |
| Dodgeville silt loam, 18 to 25 percent slopes | 245 | .1 | Ostrander silt loam, bedrock substratum, 0 to to 2 percent slopes | 321 | .1 |
| Dundas silt loam | 3,148 | 1.0 | Palms muck | 4,577 | 1.4 |
| Erin silt loam, 2 to 6 percent slopes | 1,970 | .6 | Port Byron silt loam, 0 to 2 percent slopes | 170 | (1) |
| Erin silt loam, 6 to 12 percent slopes, eroded | 5,769 | 1.8 | Port Byron silt loam, 2 to 6 percent slopes | 852 | .3 |
| Erin silt loam, 12 to 18 percent slopes, eroded | 2,576 | .8 | Port Byron silt loam, 6 to 12 percent slopes | 1,088 | .3 |
| Erin silt loam, 18 to 30 percent slopes | 2,121 | .7 | Port Byron silt loam, 12 to 18 percent slopes | 312 | .1 |
| Estherville sandy loam, 0 to 2 percent slopes | 2,269 | .7 | Port Byron-Bold silt loams, 6 to 12 percent slopes | 237 | .1 |
| Estherville sandy loam, 2 to 6 percent slopes | 1,936 | .6 | Port Byron-Bold silt loams, 12 to 18 percent slopes | 324 | .1 |
| Estherville sandy loam, 6 to 12 percent slopes | 1,037 | .3 | Renova silt loam, 2 to 6 percent slopes | 4,534 | 1.4 |
| Etter fine sandy loam, 2 to 6 percent slopes | 268 | .1 | Renova silt loam, 6 to 12 percent slopes | 1,835 | .6 |
| Etter fine sandy loam, 6 to 15 percent slopes | 361 | .1 | Renova silt loam, 12 to 18 percent slopes, eroded | 832 | .3 |
| Fairhaven silt loam, 0 to 2 percent slopes | 1,476 | .5 | Renova silt loam, 18 to 30 percent slopes | 615 | .2 |
| Fairhaven silt loam, 2 to 6 percent slopes | 926 | .3 | Rolfe silty clay loam | 1,286 | .4 |
| Fairhaven silt loam, loamy subsoil variant, 0 to 2 percent slopes | 976 | .3 | Rough broken land | 1,156 | .4 |
| Fairhaven silt loam, loamy subsoil variant, 2 to 6 percent slopes | 591 | .2 | Salida gravelly sandy loam, 4 to 12 percent slopes | 966 | .3 |
| Faxon clay loam | 186 | .1 | Salida gravelly sandy loam, 12 to 30 percent slopes | 1,620 | .5 |
| Garwin silty clay loam | 656 | .2 | Shields silt loam | 8,166 | 2.6 |
| Glencoe clay loam | 11,603 | 3.7 | Skyberg silt loam | 309 | .1 |
| Hayden loam, 2 to 6 percent slopes | 3,020 | 1.0 | Sogn stony loam, 18 to 35 percent slopes | 689 | .2 |
| Hayden loam, 6 to 12 percent slopes | 10,522 | 3.3 | Terril loam, 1 to 6 percent slopes | 1,152 | .4 |
| Hayden loam, 12 to 18 percent slopes | 5,052 | 1.6 | Terril loam, 6 to 12 percent slopes | 1,191 | .4 |
| Hayden loam, 18 to 30 percent slopes | 4,243 | 1.3 | Vlasaty silt loam, 1 to 4 percent slopes | 532 | .2 |
| Judson silt loam, 4 to 12 percent slopes | 2,180 | .7 | Waukegan silt loam, 0 to 2 percent slopes | 2,958 | .9 |
| Kasson silt loam, 1 to 3 percent slopes | 617 | .2 | Waukegan silt loam, 2 to 6 percent slopes | 443 | .1 |
| Kato silty clay loam | 1,724 | .5 | Webster clay loam | 15,964 | 5.0 |
| Kilkenny clay loam, 2 to 6 percent slopes | 15,619 | 5.0 | Zumbro sandy loam | 344 | .1 |
| Kilkenny clay loam, 6 to 12 percent slopes, eroded | 4,851 | 1.5 | | | |
| Kilkenny clay loam, 12 to 18 percent slopes, eroded | 1,212 | .4 | | | |
| Kilkenny clay loam, 18 to 25 percent slopes | 167 | (1) | Total | 316,800 | 100.0 |

[1] Less than 0.05 percent.

used principally for corn and soybeans. Variation in texture of the flood deposits causes wide difference in plant growth during periods of drought. Capability unit IIw–3; woodland group 6; building site group 13.

**Alluvial land, frequently flooded** (Af) is adjacent to the major rivers and their principal tributaries. It is subject to frequent flooding, scouring, and stream cutting. Because of the hazard of flooding, this land is used principally as undeveloped pasture. Capability unit VIw–1; woodland group 8; building site group 13.

## Biscay Series

The Biscay series consists of nearly level, poorly drained, loamy soils that formed in 24 to 40 inches of loamy sediment over coarse sand and fine gravel. These soils are on broad outwash plains and valley trains. The native vegetation was principally water-tolerant prairie grasses.

In a representative profile the surface layer is black loam about 15 inches thick. The subsoil is mottled, very dark grayish-brown and dark grayish-brown, friable loam about 10 inches thick. The underlying material is grayish-brown, loose sandy loam and gravelly coarse sand.

Permeability is moderate in the upper part of the profile and rapid in the underlying material. Runoff is slow to ponded. Available water capacity is moderate. The water table is at a depth of 0 to 3 feet. The organic-matter content is high, and natural fertility is medium.

Undrained, these soils are poorly suited to crops. Where the soils are adequately drained, they are well suited to most crops and, in large areas, are used for corn and soybeans.

Representative profile of Biscay loam, in Morristown Township, 800 feet west and 1,000 feet south of center of sec. 22, T. 109 N., R. 22 W.

Ap—0 to 8 inches, black (N 2/0) loam; massive (cloddy); friable; neutral; abrupt, wavy boundary.

A3—8 to 15 inches, black (10YR 2/1) loam, very dark brown (10YR 2/2) crushed; weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

B21g—15 to 20 inches, very dark grayish-brown (10YR 3/2) grading to dark grayish-brown (2.5Y 4/2) loam; few, fine, distinct, light olive-brown (2.5Y 5/4) mottles and few, fine, faint, strong-brown (7.5YR 5/6, 5/8) mottles; weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

B22g—20 to 25 inches, dark grayish-brown (2.5Y 4/2) loam; many, fine, distinct, yellowish-brown (10YR 5/6) mottles and few, fine, faint, strong-brown (7.5YR 5/6) mottles; weak, fine, subangular blocky structure; friable; neutral; abrupt, wavy boundary.

IIC1g—25 to 33 inches, grayish-brown (2.5Y 5/2) sandy loam; many, fine, distinct, light olive-brown (2.5Y 5/4) mottles; massive; loose; slightly effervescent in spots; mildly alkaline; clear, wavy boundary.

IIC2g—33 to 64 inches, grayish-brown (2.5Y 5/2) gravelly coarse sand; many, fine, distinct, light olive-brown (2.5Y 5/4) and light brownish-gray (2.5Y 6/2) mottles; single grained; loose; strongly effervescent; mildly alkaline.

The thickness of the solum and the depth to the coarse-textured IIC horizon range from 24 to 40 inches. The Ap and A3 horizons range from 8 to 16 inches in combined thickness. These horizons commonly are neutral but range from slightly acid to mildly alkaline. The A3 horizon ranges from 3 to 7 inches in thickness. It commonly is neutral but in places is mildly alkaline. The B horizon ranges from 10 to 24 inches in thickness. It commonly is loam, but in places it ranges to sandy clay loam or sandy loam in the lower part. IIC horizon in some profiles is fine sand and sand that has some coarse gravel. It is commonly mildly alkaline but is neutral in the upper part in some profiles in depressions.

Biscay soils are more poorly drained than the associated Estherville soils and have lower chroma in the B horizon. They contain more sand and less silt than the similar Kato soils. These Biscay soils are nearly level, but the similar Biscay, seepy variant, soils are sloping.

**Biscay loam** (0 to 2 percent slopes) (Bc).—This soil is in tracts 3 to 100 acres in size mostly on broad outwash plains but also in small upland draws. Included with it in mapping are areas of soils that have a calcareous surface layer and areas of soils that have loamy till at a depth of 60 to 72 inches.

This soil is wet. The depth to the water table ranges from 0 to 3 feet in undrained areas. Improved drainage is needed for most crops presently grown. Tile drains and open ditches effectively remove excess water. Maintaining good tilth and fertility are minor management needs. Capability unit IIw-2; woodland group 7; building site group 9.

## Biscay Series, Seepy Variant

The Biscay series, seepy variant, consists of gently sloping to moderately steep, poorly drained, loamy soils that formed in 26 to 40 inches of loamy sediment over coarse sand and fine gravel. These soils are on terrace escarpments at the base of uplands. The native vegetation was principally water-tolerant prairie grasses.

In a representative profile the surface layer is black loam about 17 inches thick. The subsoil is mottled, dark grayish-brown and grayish-brown, friable loam about 11 inches thick. The underlying material is light olive-brown, loose sandy loam, sand, and gravel.

Permeability is moderate in the upper part of the profile and rapid in the underlying material. Runoff is slow. Available water capacity is moderate. The water table is at a depth of 0 to 3 feet. The organic-matter content is high, and natural fertility is medium.

Undrained, these soils are poorly suited to crops. Where the soils are adequately drained, they are suited to most crops and, in a few areas, are used for corn and soybeans.

Representative profile of Biscay loam, seepy variant, in Bridgewater Township, 660 feet north and 430 feet west of southeast corner of sec. 32, T. 111 N., R. 20 W.

A1—0 to 10 inches, black (N 2/0) loam; weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

A3—10 to 17 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

B21g—17 to 22 inches, dark grayish-brown (2.5Y 4/2) loam; few, fine, faint, strong-brown (7.5YR 5/6) mottles and few, fine, distinct, light olive-brown (2.5Y 5/6) mottles; weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

B22g—22 to 28 inches, grayish-brown (2.5Y 5/2) loam; few, fine, distinct, light olive-brown (2.5Y 5/6) mottles; weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

IIC1g—28 to 35 inches, light olive-brown (2.5Y 5/4) sandy loam; few pebbles; few, fine, distinct, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/6) mottles; single grained; loose; slightly effervescent; mildly alkaline; clear, wavy boundary.

IIC2g—35 to 68 inches, light olive-brown (2.5Y 5/4) sand and gravel; few, fine, distinct, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/6) mottles; single grained; loose; strongly effervescent; mildly alkaline.

Thickness of the solum and depth to the coarse-textured IIC horizon range from 26 to 40 inches. The Ap and A1 horizons range from 8 to 18 inches in combined thickness. Reaction commonly is neutral, but it ranges from slightly acid to mildly alkaline. The A3 horizon ranges from 3 to 10 inches in thickness. Reaction commonly is neutral, but it is mildly alkaline in places. The B horizon ranges from 10 to 24 inches in thickness. This horizon has distinct, light olive-brown mottles in some profiles. Texture commonly is loam but ranges to sandy clay loam or sandy loam. The IIC horizon is sandy loam, sand, and gravel. In some profiles it is fine sand and sand. Reaction is commonly mildly alkaline, but it is neutral in the upper part of the horizon in some places.

Biscay, seepy variant, soils are more poorly drained than the associated Estherville soils and have lower chroma in the B horizon. They contain more sand and less silt than the similar Kato soils. Biscay, seepy variant, soils are sloping, whereas the normal Biscay soils are nearly level.

**Biscay loam, seepy variant** (4 to 18 percent slopes) (Bk).—This soil is in tracts 3 to 20 acres in size on toe slopes and in small upland draws. Included with it in mapping are some areas of soils that have a calcareous surface layer and some that have loamy till at a depth of 60 to 72 inches.

This soil is wet. Runoff is slow. Depth to the water table ranges from 0 to 3 feet in the undrained areas. Improved drainage is needed if the soil is to be used for most crops grown locally. Tile drainage is used to remove excess water. Maintaining good tilth and fertility are minor management needs. Capability unit Vlw–2; woodland group 7; building site group 9.

## Bold Series

The Bold series consists of sloping to moderately steep, well-drained, silty soils that formed in calcareous loess. These soils have convex slopes and are on uplands. They are closely associated with the Port Byron soils. The native vegetation was a sparse growth of tall prairie grass and deciduous trees.

In a representative profile the surface layer is calcareous, dark grayish-brown silt loam about 8 inches thick. The underlying material is calcareous, yellowish-brown, very friable silt loam.

Permeability is moderate. Infiltration commonly is slowed because of puddling on the surface. Runoff is medium to rapid. The water table is below a depth of 10 feet. The available water capacity is very high. Organic-matter content is moderate, and natural fertility is medium.

Most areas of these soils are in crops. Erosion is a hazard. Special fertility programs are beneficial to most crops because of the high content of lime in the soil.

Representative profile of Bold silt loam, in an area of Port Byron-Bold silt loams, 12 to 18 percent slopes, in Northfield Township, 1,200 feet east and 40 feet north of center of sec. 22, T. 111 N., R. 19 W.

Ap—0 to 8 inches, dark grayish-brown (10YR 4/2) silt loam; few inclusions of yellowish brown (10YR 5/4); massive (cloddy); very friable; violently effervescent; mildly alkaline; abrupt, smooth boundary.

C1—8 to 11 inches, yellowish-brown (10YR 5/4) silt loam; few dark grayish-brown (10YR 4/2) worm casts; weak, very fine, granular structure; very friable; violently effervescent; mildly alkaline; clear, wavy boundary.

C2—11 to 60 inches, yellowish-brown (10YR 5/4) silt loam; few inclusions of light yellowish brown (10YR 6/4); massive; very friable; violently effervescent; mildly alkaline.

The Ap and A1 horizons are dark brown or dark grayish brown. The C1 horizon commonly is yellowish brown but ranges to light olive brown or olive brown.

The Bold soils lack a B horizon, whereas the associated Port Byron soils have a B horizon. They have free carbonates in all horizons, but free carbonates are leached to a depth of more than 24 inches in the Port Byron soils.

In Rice County the Bold soils are mapped only in complexes with the Port Byron soils. Descriptions of these complexes are given under the heading "Port Byron Series."

## Boone Series

The Boone series consists of gently sloping to very steep, excessively drained, sandy soils that have sandstone bedrock at a depth of 20 to 40 inches. These soils formed in sandstone sediment in which the sand is commonly fine sand. They occupy side slopes and circular sandhills, 5 to 15 acres in size, in glaciated areas on uplands. The native vegetation was oak and hazel brush.

In a representative profile the surface layer is dark-gray fine sand about 2 inches thick. The subsurface layer is dark grayish-brown fine sand about 3 inches thick. The subsoil is grayish-brown, light-gray, and very pale brown, loose fine sand about 25 inches thick. The underlying material is very pale brown, weakly cemented sandstone.

Permeability is very rapid. Runoff is slow to rapid, depending on slope. The water table is below a depth of 10 feet. The available water capacity is very low. The content of organic matter and natural fertility are low.

The very low available water capacity, low fertility, and hazard of soil blowing are major limitations to crop growth. The soils are better suited to permanent vegetation, particularly coniferous forest, than to most other plants.

Representative profile of Boone fine sand, 2 to 12 percent slopes, in Bridgewater Township, 1,000 feet south and 900 feet east of northwest corner of sec. 23, T. 111 N., R. 20 W.

A1—0 to 2 inches, dark-gray (10YR 4/1) fine sand, gray (10YR 5/1) dry; single grained; loose; strongly acid; abrupt, smooth boundary.

A2—2 to 5 inches, dark grayish-brown (10YR 4/2) fine sand, gray (10YR 5/1) dry; few dark-brown (7.5YR 3/2) root channels; single grained; loose; strongly acid; clear, wavy boundary.

B2—5 to 12 inches, grayish-brown (10YR 5/2) fine sand, light brownish gray (10YR 6/2) dry; few black root channel fillings; few inclusions of light yellowish brown (10YR 6/4); single grained; loose; strongly acid; clear, wavy boundary.

B3—12 to 30 inches, light-gray (10YR 7/2) and very pale brown (10YR 7/4) fine sand; few dark-brown (7.5YR 3/2) krotovinas; single grained; loose; medium acid; clear, wavy boundary.

R—30 inches, very pale brown (10YR 7/3) weakly cemented sandstone; few inclusions of light brown (7.5YR 6/4); sand is mostly fine in size; neutral.

Depth to weakly cemented sandstone ranges from 20 to 40 inches. The A1 horizon is dark gray or dark grayish brown in color and ranges from 2 to 4 inches in thickness. The A2 horizon is dark grayish brown to gray when dry and ranges from 1 to 4 inches in thickness. The B horizon ranges from 12 to 34 inches in thickness. The B3 horizon contains some fragments of weakly cemented sandstone in some profiles. The R horizon is weakly cemented to hard sandstone. Reaction is slightly acid or neutral.

The Boone soils are coarser in texture than the similar Etter soils.

**Boone fine sand, 2 to 12 percent slopes** (BoC).—This soil is in areas 3 to 20 acres in size on hilltops, side slopes, and crests of circular-shaped hills. It has the profile described as representative of the series.

Included with this soil in mapping are a few areas of eroded soils in which the surface layer consists mostly of subsoil material. The upper layers of this soil have commonly been disturbed by burrowing rodents.

This is a droughty soil. Runoff is slow, and there is a moderate hazard of water erosion and soil blowing. This soil is better suited to permanent vegetation, preferably

conifers, than to most other plants. Some areas have been used as a source of sand. Capability unit VIs–1; woodland group 4; building site group 2.

**Boone fine sand, 12 to 25 percent slopes** (BoD).—This soil is in areas 4 to 20 acres in size on sidehills and circular-shaped hills. Included with it in mapping are a few areas of eroded soils. The surface layer in these areas consists mostly of subsoil material. The upper layers of this soil have commonly been disturbed by burrowing rodents (fig. 4).

*Figure 4.*—**Typical area of Boone fine sand.**

This is a droughty soil. Runoff is medium, and there is a moderate hazard of water erosion and soil blowing. This soil is better suited to permanent vegetation, preferably conifers, than to most other plants. Capability unit VIIs–1; woodland group 5; building site group 2.

**Boone fine sand, 25 to 40 percent slopes** (BoF).—This soil is in areas 4 to 16 acres in size on sidehills of circular mesas. It has a profile similar to the one described as representative of the series, but its layers are somewhat thinner. The upper layers have commonly been disturbed by burrowing rodents.

Included with this soil in mapping are areas of eroded soils, and in these the surface layer consists mostly of subsoil material. Also included, at the base of some slopes, is a soil that has a thickened surface layer.

This Boone soil is droughty. Runoff is rapid, and the hazard of erosion is severe. Many of these areas have been converted to permanent vegetation, mainly conifers. Capability unit VIIs–1; woodland group 5; building site group 2.

## Canisteo Series

The Canisteo series consists of nearly level, poorly drained and very poorly drained, calcareous soils that formed in loamy glacial drift. These soils occupy broad upland tracts, shallow draws and rims of depressions, and drainageways. The native vegetation was water-tolerant prairie grasses.

In a representative profile the surface layer is black and very dark gray, calcareous clay loam about 19 inches thick. The subsoil is dark grayish-brown, dark-gray, and olive-gray, calcareous, friable clay loam about 11 inches thick. The underlying material is mottled, olive-gray and olive, calcareous, friable clay loam.

Permeability is moderate. Runoff is slow to ponded. The water table is at a depth of 0 to 3 feet, or near tile depth. The available water capacity is high. The content of organic matter and natural fertility are high.

Undrained, these soils are moderately well suited to poorly suited to crops. Where the soils are adequately drained, they are well suited to crops and, in most areas, are used for that purpose. Special fertility treatments are beneficial to most crops because of the high concentration of lime carbonates in the soil.

Representative profile of Canisteo clay loam, in Walcott Township, 300 feet east and 400 feet north of southwest corner of sec. 18, T. 109 N., R. 20 W.

Ap—0 to 9 inches, black (N 2/0) clay loam, gray (10YR 5/1) dry; weak, very fine, subangular blocky structure; friable; about 2 percent coarse fragments; violently effervescent; mildly alkaline; abrupt, smooth boundary.

A1—9 to 13 inches, black (N 2/0) clay loam, gray (10YR 5/1) dry; weak, very fine, subangular blocky structure; friable; violently effervescent; about 2 percent coarse fragments; mildly alkaline; clear, wavy boundary.

A3—13 to 19 inches, very dark gray (10YR 3/1) clay loam; few tongues of black (N 2/0); common, fine, distinct, olive-brown (2.5Y 4/4) mottles; weak, fine, subangular blocky structure; friable; about 2 percent coarse fragments; violently effervescent; mildly alkaline; clear, wavy boundary.

B21g—19 to 24 inches, dark grayish-brown (2.5Y 4/2) and dark-gray (10YR 4/1) clay loam; few tongues of very dark gray (10YR 3/1) and olive gray (5Y 5/2); few, fine, distinct, strong-brown (7.5YR 5/8) mottles; weak, fine, subangular blocky structure; friable; about 2 percent coarse fragments; strongly effervescent; mildly alkaline; clear, wavy boundary.

B22g—24 to 30 inches, olive-gray (5Y 5/2) clay loam; weak, fine, subangular blocky structure; friable; about 2 percent coarse fragments; strongly effervescent; mildly alkaline; clear, wavy boundary.

Cg—30 to 60 inches, olive-gray (5Y 5/2) and olive (5Y 5/3) clay loam; common, fine, distinct, light olive-brown (2.5Y 5/6) mottles; massive; friable; about 2 percent coarse fragments; strongly effervescent; mildly alkaline.

The solum ranges from 20 to 36 inches in thickness. The Ap and A1 horizons range from 10 to 20 inches in combined thickness. The A3 horizon ranges from 4 to 8 inches in thickness. The A horizon ranges from loam to clay loam or silty clay loam. Soils that have a silty clay loam A horizon are mainly in the eastern part of the county. The calcium carbonate equivalent in this horizon ranges from 5 to 15 percent. The B horizon typically is loam or clay loam. However, in some places the upper part of the B horizon is silt loam or silty clay loam, the middle part is loam, and the lower part is sand that contains some gravel, loamy sand, sandy loam, sandy clay loam, or loam. Layers of material that are coarser in texture than loam are less than 6 inches thick. Reaction commonly is mildly alkaline, but the lower part of this horizon in some profiles is neutral. Calcium carbonate equivalent in the B horizon ranges from

0 to 15 percent but most commonly is 10 to 15 percent. The C horizon is loam or clay loam. It is massive or has weak, subangular blocky structure. Calcium carbonate equivalent in this horizon is 10 to 25 percent.

The Canisteo soils have free lime in the A horizon, but the associated Maxcreek and Webster soils lack free lime in that horizon.

**Canisteo clay loam** (0 to 2 percent slopes) (Ca).—This soil is in 10- to-100 acre tracts. It has the profile described as representative of the series. Included with it are small tracts of Webster and Maxcreek soils.

This soil is wet. Depth to the water table commonly ranges from 0 to 3 feet in undrained areas. Improved drainage is needed for most crops presently grown. Tile drainage effectively removes excess water. This soil has a high concentration of lime carbonates. Concentrations generally are greatest on the rims of depressions and at lower positions in the broad, nearly level tracts. The content of lime carbonate exceeds 15 percent on a few rims and rises. Most areas of this soil have been drained and are used mostly for crops. Capability unit IIw-1; woodland group 7; building site group 10.

**Canisteo clay loam, depressional** (0 to 2 percent slopes) (Cd).—This soil is in depressions 3 to 5 acres in size and in long, winding, drainageways of low-gradient 5 to 30 acres in size. It has a profile similar to that described as representative of the series, but there is a thin layer of muck on the surface in some places.

Included with this soil in mapping are small areas of Glencoe soils, mostly in the center of the depressions.

This soil is very wet. Depth to the water table ranges from 0 to 3 feet in undrained areas. Improved drainage is needed for most crops presently grown. This soil has a high concentration of lime carbonates. Accumulations generally are lower in the depressions than in adjacent rims, and a higher percentage of carbonates are remnants of snail shells. This soil is used mostly for crops. Capability unit IIIw–1; woodland group 8; building site group 12.

## Caron Series

The Caron series consists of nearly level, very poorly drained, muck soils that formed mostly in moderately decomposed reeds and sedges and limnic material. These soils are in bogs that formerly were lakes.

In a representative profile the surface layer is black muck (sapric material) about 9 inches thick. The next layer is very dark grayish-brown mucky peat (hemic material) about 37 inches thick. Below this is lake sediment of very dark brown, calcareous, limnic material about 38 inches thick. The underlying material is olive-gray, calcareous silty clay loam.

Permeability is moderately rapid. Runoff is slow to ponded. The water table is at a depth of 0 to 3 feet, or near tile depth. Available water capacity is very high. The content of organic matter is very high, and natural fertility is low.

Some areas of these soils are in crops. Undrained, the soils are poorly suited to most crops. Where the soils are adequately drained, they are suited to early maturing crops. Frost hazard and soil blowing are the major limitations to the use of these soils.

Representative profile of Caron muck, in Webster Township, 840 feet north and 700 feet west of center of sec. 25, T. 112 N., R. 21 W.

Oa—0 to 9 inches, black (10YR 2/1, broken face and rubbed) sapric material; about 20 percent fibers, 10 percent rubbed; weak, fine, subangular blocky structure; herbaceous fibers; about 45 percent mineral material; slightly acid; abrupt, smooth boundary.

Oe—9 to 46 inches, very dark grayish-brown (10YR 3/2, broken face) hemic material, very dark brown (10YR 2/2, rubbed); about 75 percent fibers, 30 percent rubbed; weak, fine, platy structure; herbaceous fibers; about 15 percent mineral material; slightly acid; gradual, wavy boundary.

Lco1—46 to 60 inches, very dark brown (10YR 2/2, broken face) coprogenous earth, black (10YR 2/1, rubbed); about 20 percent fibers, 10 percent rubbed; weak, fine, subangular blocky structure; about 45 percent mineral material; neutral; gradual, wavy boundary.

Lco2—60 to 84 inches, very dark brown (10YR 2/2, broken face) coprogenous earth, black (10YR 2/1, rubbed); about 10 percent fibers, less than 5 percent rubbed; massive; about 65 percent mineral material; neutral; clear, wavy boundary.

IIC—84 to 96 inches, olive-gray (5Y 4/2) silty clay loam; massive; mildly alkaline.

The depth to coprogenous earth ranges from 16 to 51 inches. The Oa horizon ranges from 0 to 12 inches in thickness. The Oe horizon ranges from 16 to 51 inches in thickness and is very dark grayish brown, very dark gray, or very dark brown. The Oa and Oe horizons are slightly acid or neutral. The Lco horizon ranges from 30 to 50 inches or more in thickness. It is neutral or mildly alkaline and very dark brown, very dark grayish brown, or dark grayish brown. The underlying material is silty clay loam, sandy clay loam, clay loam, or loam; it begins at a depth ranging from 51 inches to 10 feet or more.

Caron soils are associated with Palms soils and are similar to the Muskego soils. They have a IIC horizon at a depth of more than 51 inches, whereas the Palms soils have a IIC horizon at a depth of 16 to 50 inches. Caron soils have a layer of hemic material, which is lacking or very thin in the Muskego soils.

**Caron muck** (0 to 2 percent slopes) (Ck).—This soil is in small depressions and in several bogs that are more than 200 acres in size. Included with it in mapping are a few moderately steep, sidehill seeps in the major river valleys. In these areas the muck layer is more than 51 inches thick and generally is underlain by clay loam, silty clay loam, or sandy loam below a depth of 51 inches. The edges of the larger bogs commonly have narrow, discontinuous strips of soils that have sandy or gravelly underlying material. Also included are a few small sandy islands and sand bars and small areas where the underlying material is at a depth of less than 51 inches. This is caused by the irregularity of the upper surface of the underlying material. In a few areas the surface layer is calcareous.

Some areas of this soil are in crops, some are in pasture, and several of the larger bogs are in their natural state. The largest areas of Caron muck are in the western part of the county. Drainage and fertility maintenance are the major management needs. Dikes are needed in some places to control flooding. Capability unit IIIw–2; woodland group 8; building site group 12.

## Clarion Series

The Clarion series consists of gently undulating to steep, well-drained soils that formed in loamy glacial till. These soils are on knolls and hillsides on uplands. The native vegetation was tall prairie grass and a few thin stands of oak or brush.

In a representative profile the surface layer is very dark brown loam about 13 inches thick. The subsoil, about 21 inches thick, is brown and dark yellowish-brown, friable

loam in the upper 15 inches and light olive-brown, friable loam in the lower part. The underlying material is calcareous, light yellowish-brown and light olive-brown, friable loam.

Permeability is moderate. Runoff is medium to rapid, depending on slope. The water table is at a depth below 10 feet. The available water capacity is high. The organic-matter content generally is high, but it is lower in the eroded soils. Natural fertility is high.

Most areas of these soils are in crops and are well suited to this use. A few areas are wooded or in permanent pasture. The hazard of erosion is the major limitation to the use of these soils.

Representative profile of Clarion loam, 2 to 6 percent slopes, in Warsaw Township, 1,000 feet east and 120 feet south of northwest corner of sec. 26, T. 109 N., R. 21 W.

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

A1—9 to 13 inches, very dark brown (10YR 2/2) loam; weak, fine, subangular blocky structure; friable; about 2 percent coarse fragments; slightly acid; clear, wavy boundary.

B1—13 to 19 inches, brown (10YR 4/3) loam; weak, fine, subangular blocky structure; friable; about 2 percent coarse fragments; dark-brown (10YR 3/3) coatings on faces of peds; slightly acid; clear, wavy boundary.

B2—19 to 28 inches, dark yellowish-brown (10YR 4/4) loam; weak, fine, subangular blocky structure; friable; about 2 percent coarse fragments; slightly acid; clear, wavy boundary.

B3—28 to 34 inches, light olive-brown (2.5Y 5/4) loam; weak, fine, subangular blocky structure; friable; about 2 percent coarse fragments; neutral; abrupt, smooth boundary.

C—34 to 60 inches, light olive-brown (2.5Y 5/4) and light yellowish-brown (2.5Y 6/4) loam; massive; friable; few, gray (10YR 6/1), feathered segregations of lime; about 2 percent coarse fragments; mildly alkaline; strongly effervescent.

The solum ranges from 25 to 40 inches in thickness. The Ap and A1 horizons generally are black, very dark brown, or very dark gray and are loam or clay loam. In a few places, however, these horizons are sandy loam. They range from 7 to 13 inches in thickness and are slightly acid or medium acid. The B2 horizon is dark-brown, brown, or dark yellowish-brown loam or light clay loam. The B horizon ranges from 15 to 30 inches in thickness and has weak or moderate, fine and medium, subangular blocky structure. The B1 and B2 horizons are slightly acid or medium acid, and the B3 horizon generally is neutral. The C horizon is grayish brown, light olive brown, or yellowish brown.

The Clarion soils have a thicker A1 horizon and less clay in the B horizon than the similar Lester soils. They have more sand and less silt in the A horizon and in the upper part of the B horizon than the similar Moland soils. They have a B horizon which is absent in the associated Storden soils. Free carbonates are leached to a depth of 2 feet or more in the Clarion soils, but Storden soils have free carbonates throughout the profile.

**Clarion loam, 2 to 6 percent slopes** (ClB).—This soil is in areas 5 to 20 acres in size on knolls and rises. Slopes are convex and concave and are 75 to 150 feet long. The soil is associated with Nicollet and Webster soils and, in some places, is above more sloping Clarion soils. This soil has the profile described as representative of the series. Its layers are thinner where slopes are convex than they are in other places.

Included with this soil in mapping are small areas of Nicollet soils and areas of Webster and Glencoe soils in narrow draws and small depressions. Some of the draws and depressions are identified on the soil map by a symbol for drainageway or depression. A symbol for gravel identifies a small gravelly area.

Runoff is medium, but the hazard of erosion is only slight. This soil is used mostly for crops and is well suited to this use. Capability unit IIe–1; woodland group 1; building site group 5.

**Clarion loam, 6 to 12 percent slopes** (ClC).—This soil is on irregularly shaped knolls that range from 5 to 30 acres in size and have concave and convex slopes. It also is in irregularly shaped areas of 5 to 15 acres on hillsides. Slopes are 75 to 150 feet long. This soil has a profile similar to the one described as representative of the series, but its layers are thinner. They are thinnest where slopes are convex. In places the original dark-colored surface layer has been mixed with part of the brownish subsoil through erosion and deep tillage, and in a few areas the present surface layer is mostly brownish material from the subsoil. This layer is less friable and contains less organic matter than the original surface layer.

Included with this soil in mapping are some areas of soils that have a sandy loam surface layer and a few areas of soils that have slopes of more than 12 percent. Also included, at the base of some slopes, are areas of a soil that has a thicker surface layer than this Clarion soil. Also included are areas of Webster and Glencoe soils in narrow downslope drainageways and small depressions and areas of Storden soils. Small pockets of gravel are identified on the soil map by a special symbol.

Runoff is medium. The hazard of erosion is moderate. Most of the acreage of this soil is used for crops. Capability unit IIIe–1; woodland group 1; building site group 5.

**Clarion-Estherville-Storden complex, 4 to 12 percent slopes, eroded** (CnC2).—The gently undulating to rolling soils of this complex are in small, scattered tracts throughout the county, but they are mainly near drainageways and near the edge of glacial outwash areas. The complex is about 40 percent Clarion loam, 30 percent Estherville sandy loam, and 30 percent Storden loam. Each of these soils has a profile similar to the one described as representative of its series. In the Clarion soil, however, erosion and deep tillage have caused a mixing of part of the brownish subsoil into the dark-colored surface layer. The present surface layer is lighter colored, lower in organic-matter content, and less friable than the original surface layer.

Included in mapping are small areas of Salida soils that are identified on the soil map by the gravel symbol.

Soils in this complex are farmed in fields with other soils. Runoff is medium, and the hazard of erosion is moderate. Temperature variations are much greater on south- and west-facing slopes than on east- and north-facing slopes. Droughtiness of the Estherville soil and the high content of lime carbonates in the Storden soil are special concerns in management. Capability unit IIIe–4; Clarion and Storden soils in woodland group 1, Estherville soil in woodland group 4; building site group 4.

**Clarion-Storden loams, 6 to 12 percent slopes** (CsC).—These soils are in irregularly shaped areas of 5 to 30 acres on knolls. Slopes are concave and convex (fig. 5). The complex is about 70 percent Clarion loam and 30 percent lighter colored Storden loam. Each of these soils has a profile similar to that described as representative of its series. In some areas of the Clarion soil, however, erosion and deep tillage have caused a mixing of part

*Figure 5.*—**Light-colored, calcareous Storden soils on knolls. The dark-colored areas are Clarion soils**

of the brownish subsoil into the dark-colored surface layer. In these areas the present surface layer is less friable and contains less organic matter than the original surface layer.

Included in mapping are a few areas of soils that have slopes of less than 6 percent or more than 12 percent. Also included, at the base of some slopes, are areas of a soil that has a thickened surface layer. Small gravel areas are marked on the soil map by a symbol for gravel.

Runoff is medium, and the hazard of erosion is moderate. Temperature variations are greater on south- and west-facing slopes than on north- and east-facing slopes. Applications of special fertilizers are beneficial on the calcareous Storden soil. Most of this complex is used for crops. Capability unit IIIe–1; woodland group 1; building site group 5.

**Clarion-Storden loams, 12 to 18 percent slopes** (CsD).—These soils are in irregularly shaped areas, 5 to 30 acres in size, on knolls and hillsides. Slopes are 75 to 150 feet long. The complex is about 65 percent Clarion loam and 35 percent lighter colored Storden loam. The Storden soil has convex slopes. Each of the soils in this unit has a profile similar to the one described as representative of its series, but in some areas of the Clarion soil, erosion and deep tillage have caused a mixing of part of the brownish subsoil into the dark-colored surface layer. In these areas the present surface layer is less friable and contains less organic matter than the original surface layer.

Included in mapping are a few areas of soils that have slopes of less than 12 percent or more than 18 percent. Also included, at the base of many slopes, are areas of a soil that has a thickened surface layer. Small gravel areas are marked on the soil map by a symbol for gravel.

Runoff is rapid, and the hazard of erosion is severe. Temperature variations are much greater on south- and west-facing slopes than on the north- and east-facing slopes. Applications of special fertilizers are beneficial on the calcareous Storden soil. Most of this complex is used for crops. Capability unit IVe–1; woodland group 1; building site group 5.

**Clarion-Storden loams, 18 to 25 percent slopes** (CsE).—These soils are in irregularly shaped areas, 5 to 30 acres in size, on knolls and hillsides. Slopes are 75 to 150 feet long. The complex is about 60 percent Clarion loam and 40 percent Storden loam. Each of these soils has a profile similar to the one described as representative of its series, but the soil layers are thinner.

Included in mapping are areas of soils that have slopes of less than 18 percent or more than 25 percent, and, at the base of many slopes, areas of a soil that has a thickened surface layer. Also included are a few areas of eroded soils.

This complex is used for permanent pasture. Runoff is rapid, and the hazard of erosion is severe. Applications of special fertilizers are beneficial on the calcareous Storden soil. Capability unit VIe–1; woodland group 1; building site group 5.

## Colo Series

The Colo series consists of nearly level, poorly drained, silty soils that formed in alluvial deposits. These soils are on bottom lands adjacent to major streams and their tributaries. The native vegetation was water-tolerant prairie grasses.

In a representative profile the surface layer is black silty clay loam about 60 inches thick.

Permeability is moderately slow. Runoff is slow to ponded. Depth to the water table commonly ranges from 2 to 5 feet. The available water capacity is high. Organic-matter content and natural fertility are high.

Many areas of these soils are in crops, but some are in permanent grass pasture. If these soils are properly drained and protected against flooding, they are well suited to most crops, especially corn and soybeans. Wetness and the hazard of flooding are the major limitations.

Representative profile of Colo silty clay loam, in Richland Township, 1,130 feet east and 1,200 feet south of northwest corner of sec. 12, T. 109 N., R. 19 W.

Ap—0 to 8 inches, black (N 2/0) silty clay loam; massive (cloddy); friable; few, fine, distinct, dark-brown (7.5Y 3/4) mottles; neutral; abrupt, smooth boundary.

A11—8 to 16 inches, black (N 2/0) silty clay loam; common, fine, distinct, dark-brown (7.5YR 3/4) mottles; weak, fine, granular structure; friable; neutral; clear, wavy boundary.

A12—16 to 23 inches, black (N 2/0) silty clay loam; weak, very fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

A13—23 to 39 inches, black (10YR 2/1) silty clay loam; moderate, very fine and fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

A14—39 to 60 inches, black (5Y 2/1) silty clay loam; moderate, very fine and fine, subangular blocky structure; friable; neutral.

The A horizon ranges from 36 to 60 inches in total thickness. Its texture is silt loam or silty clay loam in the upper part. In some profiles, free lime occurs at a depth below 45 inches.

Colo soils contain more silt and less sand than the similar Glencoe soils. They contain more clay and less sand than the associated Zumbro soils.

**Colo silty clay loam** (0 to 2 percent slopes) (Ct).—This soil is on bottom lands adjacent to smaller streams. Meander channels are few. This soil is occasionally flooded.

Included with this soil in mapping are small areas of alluvial land. Also included are some areas where the

surface layer is calcareous; these are identified on the soil map by a symbol.

This soil is wet. Depth to the water table commonly ranges from 2 to 5 feet and is controlled by streamflow. Flooding occurs mainly during spring snowmelt and occasionally during periods of high or extended rainfall in June and early in July. Some areas are tiled. Tile functions satisfactorily except when streams are at or near floodflow. This soil is mostly in crops. Capability unit IIw-1; woodland group 7; building site group 12.

## Copaston Series

The Copaston series consists of nearly level, well-drained, loamy soils that formed in 12 to 20 inches of loamy sediment over bedrock. These soils are on broad flats within the glacial outwash plains. The native vegetation was mixed prairie grasses and deciduous trees.

In a representative profile the surface layer is friable, very dark brown sandy clay loam and very dark grayish-brown fine sandy loam about 11 inches thick. The subsoil is dark-brown, friable sandy loam about 7 inches thick. Below this is limestone bedrock.

Permeability is moderate. Runoff is slow to medium. The water table is below a depth of 10 feet. Available water capacity is low to moderate. Organic-matter content is moderate, and natural fertility is medium.

Some areas of these soils are in crops, and some remain in trees or permanent pasture. Crop growth is limited by lack of available water in some years.

Representative profile of Copaston sandy clay loam, 0 to 2 percent slopes, in Bridgewater Township, 980 feet east and 900 feet south of center of sec. 2, T. 111 N., R. 20 W.

A1—0 to 7 inches, very dark brown (10YR 2/2) sandy clay loam; weak, very fine and fine, subangular blocky structure; friable; about 5 percent coarse fragments; neutral; clear, smooth boundary.

A3—7 to 11 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; weak, very fine and fine, subangular blocky structure; friable; about 5 percent coarse fragments; medium acid; clear, wavy boundary.

B2—11 to 18 inches, dark-brown (10YR 3/3) sandy loam; weak, fine, subangular blocky structure; friable; about 10 percent coarse fragments; slightly acid; abrupt, wavy boundary.

R—18 inches +, limestone bedrock.

Depth to the R horizon ranges from 12 to 20 inches. The Ap and A1 horizons are very dark brown, very dark grayish brown, or black; their dry colors are very dark gray and dark grayish brown to grayish brown. The Ap and A1 horizons range from 4 to 10 inches in combined thickness. Reaction is neutral to medium acid. The A3 horizon is very dark grayish brown or dark brown and is 2 to 6 inches thick. Reaction is slightly acid or medium acid. The B2 horizon is 5 to 10 inches thick. A few thin clay films are on faces of peds in this horizon in some places. Reaction is slightly acid or medium acid. In some profiles there is a B3 horizon as much as 10 inches thick. The R horizon typically is limestone but is sandstone bedrock in some places.

The Copaston soils have more sand and less clay in their solum and are deeper to bedrock than the associated Sogn soils. They have more sand and less silt in the A and B horizons than the similar Dodgeville soils, and they also are shallower to bedrock.

**Copaston sandy clay loam, 0 to 2 percent slopes** (CvA).—This soil is on broad flats of glacial outwash plains. Included with it in some areas are soils that consist of sandy material. In these the subsoil is lighter in color than it is in this Copaston soil. Also included are small areas where slopes are more than 2 percent, and a few outcrops of bedrock are in some areas.

This soil is moderately droughty. Runoff is slow to medium. Soil blowing is a hazard. This soil is mostly in permanent pasture and crops. Capability unit IIIs-1; woodland group 3; building site group 3.

## Cordova Series

The Cordova series consists of nearly level, poorly drained, loamy soils that formed in glacial till. These soils occupy broad, winding, nearly level tracts that intermingle with more sloping soils. The native vegetation was water-tolerant prairie grasses and deciduous trees.

In a representative profile the surface layer is black clay loam about 13 inches thick. The subsoil is friable to firm clay loam about 23 inches thick. The upper part of the subsoil is dark olive gray, and the middle and lower parts are olive gray with yellowish-brown mottles. The underlying material is mottled, olive-gray, friable loam.

Permeability is moderately slow, and runoff is slow. The water table is at a depth of 0 to 3 feet, or near the tile depth. Available water capacity, organic-matter content, and natural fertility all are high.

Most areas of these soils are used for crops. Undrained, these soils are only moderately well suited to poorly suited to most crops. If adequately drained, they are suited to most crops. Controlling the water table and maintaining good tilth and a high level of fertility are the major management needs.

Representative profile of Cordova clay loam, in Webster Township, 1,300 feet south and 60 feet west of center of sec. 24, T. 112 N., R. 21 W.

A1—0 to 11 inches, black (10YR 2/1) clay loam; weak, fine, granular structure; friable; about 1 percent coarse fragments; medium acid; abrupt, wavy boundary.

A3–11 to 13 inches, black (10YR 2/1) clay loam; moderate, fine, subangular blocky structure; friable; about 1 percent coarse fragments; common, thin, dark-gray (10YR 4/1), porous coatings on faces of peds; medium acid; abrupt, wavy boundary.

B1tg—13 to 18 inches, dark olive-gray (5Y 3/2) clay loam; moderate, fine, angular blocky structure; friable; about 1 percent coarse fragments; many, thick, black (10YR 2/1) clay films on faces of peds; medium acid; clear, wavy boundary.

B21tg—18 to 26 inches, olive-gray (5Y 4/2) clay loam; common, fine, distinct, yellowish-brown (10YR 5/8) mottles; moderate, medium, subangular blocky structure; firm; about 1 percent coarse fragments; many, thin, very dark gray (10YR 3/1) clay films on faces of peds; medium acid; clear, wavy boundary.

B22tg—26 to 36 inches, olive-gray (5Y 5/2) clay loam; common, fine, distinct, yellowish-brown (10YR 5/8) mottles; weak, medium, prismatic structure parting to moderate, medium, subangular blocky; firm; about 1 percent coarse fragments; common, thin, very dark gray (10YR 3/1) clay films on faces of peds; medium acid; clear, wavy boundary.

Cg—36 to 60 inches, olive-gray (5Y 5/2) loam; common, medium, distinct, yellowish-brown (10YR 5/8) mottles; massive; friable; about 2 percent coarse fragments; few black (10YR 2/1) fillings in root channels; mildly alkaline; strongly effervescent.

Thickness of the solum and depth to free carbonates range from 24 to 45 inches. The A horizon ranges from 11 to 20 inches in thickness. The Ap horizon and the A1 horizon are silty clay loam or clay loam. Structure is weak or moderate, fine, granular or subangular blocky. Reaction commonly is medium acid but ranges to neutral. The black or very dark gray A3 horizon

is not in all profiles. It commonly is medium acid but ranges to neutral. The B horizon ranges from 10 to 25 inches in thickness. The B1 and B21 horizons are silty clay loam or clay loam, and the B22 horizon is loam or clay loam. Reaction is medium acid or slightly acid in the B horizon. The C horizon is clay loam or loam, and consistence is friable or firm.

Cordova soils have a thinner A horizon than the associated Glencoe soils. They have more clay in the B horizon than the similar Webster soils.

**Cordova clay loam** (0 to 2 percent slopes) (Cy).—This soil occupies 5- to 80-acre tracts that are broad and occur within areas of the Hayden, Lester, Le Sueur, Dundas, and Glencoe soils. In a few places, this soil is associated with Kilkenny, Lerdal, Shields, and Mazaska soils.

Included with this soil in mapping are a few small areas of Glencoe and Dundas soils. Also, included are areas of Canisteo soils on the rims of drainageways.

This soil is wet. Depth to the water table commonly ranges from 0 to 3 feet in undrained areas. Runoff is slow. Improved drainage is needed for most crops presently grown. A properly designed and installed drainage system effectively removes excess water. Most areas of this soil are in crops. Capability unit IIw–1; woodland group 7; building site group 10.

## Dickman Series

The Dickman series consists of nearly level to sloping, somewhat excessively drained soils that formed in loamy material and in the underlying sandy sediment in which the sand is commonly medium and fine sand. These soils are on broad outwash flats and small, rounded hills in the glaciated uplands. Slopes are uniform. The native vegetation was mostly tall prairie grass.

In a representative profile the surface layer is very dark brown sandy loam about 19 inches thick. The subsoil is about 26 inches thick. The upper 8 inches of the subsoil is dark yellowish-brown to yellowish-brown, loose loamy sand. The lower part is yellowish-brown and light yellowish-brown, loose sand. The underlying material is yellowish-brown and light yellowish-brown, loose sand.

Permeability is rapid. Runoff is slow to medium. The water table is below a depth of 10 feet. The available water capacity is moderate to low. Organic-matter content is moderate to low, and natural fertility is medium to low.

These soils are used mostly for crops. Where they are closely intermingled with Salida soils, however, they are commonly in permanent vegetation. The moderate to low available water capacity and risk of soil blowing are the major limitations.

Representative profile of Dickman sandy loam, 2 to 6 percent slopes, in Northfield Township, 500 feet south and 75 feet east of northwest corner of sec. 32, T. 112 N., R. 19 W.

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

A3—10 to 19 inches, very dark brown (10YR 2/2) and very dark grayish-brown (10YR 3/2) sandy loam; weak, medium, subangular blocky structure; very friable; medium acid; abrupt, wavy boundary.

B2—19 to 27 inches, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/4) loamy sand; weak, fine, granular structure; loose; medium acid; gradual, wavy boundary.

IIB22—27 to 38 inches, yellowish-brown (10YR 5/4) and light yellowish-brown (10YR 6/4) sand; single grained; loose; medium acid; gradual, wavy boundary.

IIB23—38 to 45 inches, yellowish-brown (10YR 5/4) sand; few inclusions of dark yellowish brown (10YR 4/4); single grained; loose; medium acid; gradual, wavy boundary.

IIC—45 to 60 inches, yellowish-brown (10YR 5/4) and light yellowish-brown (10YR 6/4) sand and fine sand; single grained; loose; neutral.

The solum ranges from 30 to 50 inches in thickness. The A horizon ranges from very dark brown and very dark grayish brown to very dark gray in color, from sandy loam or fine sandy loam to loam in texture, and from 10 to 20 inches in thickness. Reaction is slightly acid or medium acid. The upper part of the B horizon is loamy sand, sandy loam, or fine sandy loam. The lower part of the IIB horizon is sand, fine sand, loamy sand, or loamy fine sand. The B2 horizon is 8 to 30 inches thick. Reaction is slightly acid or medium acid. The C horizon ranges from medium acid to neutral. Lime commonly is leached to a depth below 60 inches.

Dickman soils have less clay and more sand in the B2 horizon than the associated Fairhaven soils. The IIC horizon of the Dickman soils is sandy, whereas that of the similar Estherville soils is gravelly coarse sand.

**Dickman sandy loam, 0 to 2 percent slopes** (DcA).—This soil is on the tops of hills and ridges above more sloping Dickman soils. Included with it in mapping are some areas of soils that have loamy till material that begins below a depth of 5 feet. In these included areas, the subsoil is grayer than it is in this Dickman soil. Also included are small areas of soils that slope more than 2 percent.

Runoff is slow. Soil blowing is a hazard. Most areas are in crops. Capability unit IIIs-1; woodland group 4; building site group 2.

**Dickman sandy loam, 2 to 6 percent slopes** (DcB).—This soil occupies tracts of 3 to 20 acres. It is on short side slopes below nearly level Dickman sandy loam and on low ridges, hills, and side slopes adjacent to drainageways. Slopes typically are 60 to 125 feet long. This soil has the profile described as representative of the series.

Included with this soil in mapping are some areas of soils that have loamy till material or loamy strata beginning at a depth below 5 feet, and some eroded areas in which part of the subsoil has been mixed with the darker surface layer. Also included are small areas of soils that have slopes of less than 2 percent or more than 6 percent.

This soil is moderately droughty. Runoff is slow to medium. Soil blowing and water erosion are slight hazards. Most areas are used for crops. Capability unit IIIe-4; woodland group 4; building site group 2.

**Dickman sandy loam, 6 to 12 percent slopes** (DcC).—This soil is in tracts of 3 to 15 acres below less sloping Dickman soils and on slopes facing the larger drainageways. Slopes range from 60 to 100 feet in length.

Included with this soil in mapping are a few small tracts of soils that have a loam surface layer and small tracts of Estherville sandy loam. Included also are a few areas where loamy till or bands begin at a depth below 5 feet, a few small areas where slopes are as much as 25 percent, and some areas of eroded soils that now have a surface layer that is mostly brownish subsoil material.

This soil is moderately droughty. Runoff is medium. Soil blowing and water erosion are moderate hazards. South- and west-facing slopes have much wider fluctuations in soil temperature than east- and north-facing slopes. This soil is used mostly for crops. Capability unit IVe-4; woodland group 4; building site group 2.

**Dickman sandy loam, benches, 0 to 2 percent slopes** (DkA).—This soil is in tracts that range from 10 to 200

acres in size. It is on stream terraces and broad outwash flats. It has a profile similar to the one described as representative of the series, but it has coarser sand and more gravel in the underlying material.

Included with this soil in mapping are a few small areas of Biscay soils. These soils occupy drainageways of the poorly developed drainage net in broader areas.

This soil is droughty. Runoff is slow. Soil blowing is a severe hazard in unprotected fields in spring. Capability unit IIIs-1; woodland group 4; building site group 2.

**Dickman sandy loam, benches, 2 to 6 percent slopes** (DkB).—This soil occupies tracts of 10 to 50 acres. In the larger tracts it is associated with the Biscay soils on broad outwash flats. The smaller tracts are on short side slopes below nearly level Dickman soils. This soil has a profile similar to the one decsribed as representative of the series, but it has coarser sand and fewer pebbles in the underlying material.

Included with this soil in mapping are a few areas of eroded soils that have part of the subsoil mixed with the surface layer. These included soils are lower in content of organic matter than this soil.

This soil is droughty. Runoff is slow to medium. Soil blowing is severe in unprotected fields in spring. Erosion caused by water is a slight hazard. This soil is used mostly for crops. Capability unit IIIe–4; woodland group 4; building site group 2.

## Dodgeville Series

The Dodgeville series consists of undulating to steep, well-drained, silty soils that formed in 20 to 40 inches of silty sediment over bedrock. These soils are on broad tops and steeper side slopes of buttes or mesas. Slopes are both uniform and complex. The native vegetation was prairie grass and a few thin stands of oak or brush.

In a representative profile the surface layer is black silt loam about 10 inches thick. The upper part of the subsoil is dark yellowish-brown and yellowish-brown, friable silt loam about 10 inches thick. The lower part is brown to yellowish-brown, friable silt loam to loam about 8 inches thick. The underlying material is limestone bedrock.

Permeability is moderate. Runoff is medium to rapid. The water table is below a depth of 10 feet. The available water capacity is moderate. Organic-matter content is high, and natural fertility is medium.

Some areas of Dodgeville soils are in crops, and some remain in trees. These soils are well suited to most crops, though crop growth is limited by lack of available water in some years. Controlling erosion in the more sloping areas is the major management need.

Representative profile of Dodgeville silt loam, 2 to 6 percent slopes, in Northfield Township, 400 feet west and 500 feet north of southeast corner of sec. 36, T. 112 N., R. 19 W.

A1—0 to 10 inches, black (10YR 2/1) silt loam; weak, fine, granular structure; friable; slightly acid; clear, wavy boundary.

B21—10 to 15 inches, dark yellowish-brown (10YR 4/4) silt loam; weak, fine and medium, subangular blocky structure; friable; medium acid; clear, wavy boundary.

B22—15 to 20 inches, yellowish-brown (10YR 5/4) silt loam; weak, fine and medium, subangular blocky structure; friable; few bleached sand and silt grains on faces of peds; medium acid; abrupt, smooth boundary.

B23—20 to 25 inches, yellowish-brown (10YR 5/4) silt loam; weak, coarse, prismatic structure; friable; medium acid; clear, wavy boundary.

B3—25 to 28 inches, brown (10YR 5/3) loam; few, fine, faint, brown (7.5YR 4/4) mottles; weak, medium and coarse, subangular blocky structure; friable; slightly acid; abrupt, smooth boundary.

R—28 inches, limestone bedrock.

Depth to bedrock ranges from 24 to 40 inches. The Ap and A1 horizons are very dark brown, very dark gray, or black, and they range from 8 to 14 inches in combined thickness. Reaction in these horizons is neutral to medium acid. An A3 horizon that is very dark grayish brown or dark brown and 2 to 6 inches thick is in some profiles. Its reaction is slightly acid or medium acid. The B2 horizon is 12 to 20 inches thick. A few thin clay films are on faces of peds in the B22 horizon of some profiles. Reaction is slightly acid or medium acid in the B2 horizon. The B3 horizon is 2 to 8 inches thick. The R horizon typically is limestone, but in a few profiles it is sandstone.

The Dodgeville soils of Rice County are outside the defined range of the Dodgeville series because they lack a horizon that formed in clayey residuum immediately above the bedrock. This difference however, does not appreciably affect their usefulness or behavior.

Dodgeville soils have a thicker dark-colored A horizon than the associated Sogn soils and are deeper to bedrock. They have more silt and less sand in the A and B horizons than the similar Copaston soils.

**Dodgeville silt loam, 2 to 6 percent slopes** (DoB).—This soil is in areas that are 5 to 30 acres in size. It is on the tops of buttes or mesas, where it is associated with Sogn, Etter, and Boone soils. It has the profile described as representative of the series.

Included with this soil in mapping are a few areas of soils that have a surface layer and subsoil of loam that is high in content of silt.

This soil is moderately droughty. Runoff is medium. Soil blowing and water erosion are slight hazards. This soil is used for crops. Capability unit IIIe–4; woodland group 3; building site group 3.

**Dodgeville silt loam, 6 to 12 percent slopes** (DoC).—This soil is in areas of 5 to 30 acres on the tops of buttes or mesas. It is associated with Sogn, Etter, and Boone soils. The profile of this soil is similar to the one described as representative of the series, but the layers are thinner.

Included with this soil in mapping are a few areas of soils that have a surface layer and subsoil of loam, which is high in content of silt.

This soil is moderately droughty. Runoff is medium. The hazard of water erosion is slight, and that of soil blowing is moderate. This soil is used mostly for crops and permanent pasture. Capability unit IVe–4; woodland group 3; building site group 3.

**Dodgeville silt loam, 12 to 18 percent slopes** (DoD).—This soil is in small, irregular tracts of 5 to 30 acres on buttes or mesas. It has a profile similar to the one described as representative of the series, but the layers are thinner.

Included with this soil in mapping are a few areas of eroded soils in which part of the subsoil is mixed with the surface layer. As a result, this surface layer is lower in content of organic matter and less friable than is typical.

This soil is moderately droughty. Runoff is rapid, and erosion caused by water is a severe hazard. Most areas of this soil are used for permanent pasture. Capability unit VIe–2; woodland group 3; building site group 3.

**Dodgeville silt loam, 18 to 25 percent slopes** (DoE).—This soil is in small, irregular areas of 5 to 30 acres on buttes or mesas. It has a profile similar to the one de-

scribed as representative of the series, but the layers are thinner.

Included with this soil in mapping are a few areas of eroded soils in which part of the subsoil is mixed with the surface layer. As a result, the surface layer is lower in content of organic matter and less friable than is typical.

This soil is moderately droughty. Runoff is rapid, and erosion caused by water is a severe hazard. Most areas of this soil are used for permanent pasture. Capability unit VIIe-1; woodland group 3; building site group 3.

## Dundas Series

The Dundas series consists of nearly level, somewhat poorly drained, loamy soils that formed in calcareous glacial till. These soils are on gentle rises and in shallow draws of uplands within the original forested areas of the county. The native vegetation was deciduous trees.

In a representative profile the surface layer is very dark gray silt loam about 9 inches thick. This layer has a distinctive gray color when dry. The subsurface layer is dark-gray loam about 6 inches thick. The subsoil is loam or clay loam about 25 inches thick. Its colors range from dark grayish brown in the upper part to olive in the lower part. The underlying material is calcareous, mottled, grayish-brown loam.

Permeability is moderately slow. Runoff is slow to medium. Depth to the water table commonly ranges from 2 to 5 feet. Available water capacity is high. Organic-matter content is moderate, and natural fertility is medium.

Most areas of Dundas soils are in crops, but a few areas remain in trees or wooded pasture. Dundas soils are suited to most crops. Proper management includes controlling the water table and maintaining good tilth and fertility.

Representative profile of Dundas silt loam, in Bridgewater Township, 200 feet south and 1,700 feet west of northeast corner of sec. 7, T. 111 N., R. 20 W.

Ap—0 to 7 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) dry; weak, fine and medium, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A1—7 to 9 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) dry; weak, fine, granular structure; friable; slightly acid; abrupt, wavy boundary.

A2—9 to 15 inches, dark-gray (10YR 4/1) loam; dark grayish-brown (10YR 4/2) coatings on faces of peds; light gray (10YR 6/1) dry and rubbed; moderate, fine and medium, subangular blocky structure that tends to be platy; friable; strongly acid; clear, wavy boundary.

B1tg—15 to 20 inches, dark grayish-brown (2.5Y 4/2) loam; common, fine and medium, distinct, light olive-brown (2.5Y 5/4) mottles; moderate, fine and medium, subangular blocky structure; friable; about 4 percent coarse fragments; common, medium and thick, porous, gray (10YR 6/1 dry) coatings on faces of peds; few thin clay films on faces of peds; strongly acid; clear, wavy boundary.

B21tg—20 to 26 inches, grayish-brown (2.5Y 5/2) clay loam; common, fine, distinct, light olive-brown (2.5Y 5/4) mottles; moderate, fine and medium, subangular blocky structure; firm; about 4 percent coarse fragments; few, thin, porous, gray (10YR 6/1 dry) coatings on faces of peds; few, thin, grayish-brown (2.5Y 5/2) clay films on faces of peds; strongly acid; clear, wavy boundary.

B22t—26 to 31 inches, olive (5Y 5/3) clay loam; many, medium, faint, olive-gray (5Y 5/2) mottles and many, fine, distinct, yellowish-brown (10YR 5/8) mottles; strong, medium and coarse, prismatic structure parting to moderate, medium and coarse, angular blocky; firm; about 4 percent coarse fragments; thin to thick, continuous, very dark gray (10YR 3/1) and dark-gray (10YR 4/1) clay films on faces of peds; common, black (10YR 2/1), clayey fillings in old root channels; few, thin, porous coatings on faces of peds; few dark stains and concretions; medium acid; clear, wavy boundary.

B3—31 to 40 inches, olive (5Y 5/4) clay loam; many, medium, faint, olive-gray (5Y 5/2) mottles and many, medium, distinct, yellowish-brown (10YR 5/8) mottles; moderate, coarse, prismatic structure; firm; about 4 percent coarse fragments; medium and thick, continuous, very dark gray (10YR 3/1) and dark-gray (10YR 4/1) clay films on faces of peds; common, black (10YR 2/1), clayey fillings in old root channels; few dark stains and concretions; medium acid; clear, wavy boundary.

Cg—40 to 64 inches, grayish-brown (2.5Y 5/2) loam; many, medium, faint, light olive-brown (2.5Y 5/4) mottles and common, fine, distinct, olive-yellow (2.5Y 6/8) mottles; massive with a few oblique partings; friable; about 4 percent coarse fragments; few, black (10Y 2/1), clayey fillings in old root channels in upper part; few, soft, grayish, limy segregations; few dark stains; mildly alkaline; violently effervescent.

The solum ranges from 30 to 50 inches in thickness. The Ap and A1 horizons are silt loam or loam and range from 7 to 9 inches in combined thickness. Structure is weak, fine, granular or subangular blocky in the A1 horizon. The Ap and A1 horizons range from neutral to medium acid. The A2 horizon is silt loam, loam, or silty clay loam and is 2 to 8 inches thick. Reaction is slightly acid to medium acid. The B horizon is 20 to 40 inches thick and commonly is clay loam, but the upper and lower parts in some profiles are loam. In some profiles this horizon is very strongly acid.

Dundas soils are lower in clay and shale content than the similar Shields soils. They have more sand in the upper part of the B horizon than the similar Klinger soils.

**Dundas silt loam** (0 to 2 percent slopes) (Du).—This soil is in winding, shallow upland draws, 3 to 8 acres in size, and on flats and gentle rises 3 to 15 acres in size. It is closely associated with the Hayden, Lester, and Le Sueur soils. Included with it in mapping are small areas of Webster and Le Sueur soils.

Wetness is a limitation affecting the use of this soil. Depth to the water table commonly ranges from 2 to 5 feet. The soil can be properly tilled only within a narrow range of moisture content. The increase in clay and density in the lower part of the subsoil slows the movement of water. Tile drainage effectively removes excess water if the system is specifically designed for this soil. This soil is used mostly for crops, but a few areas are in trees or wooded pasture. Capability unit IIIw–3; woodland group 2; building site group 11.

## Erin Series

The Erin series consists of gently undulating to rolling, well-drained, loamy soils that formed in a mantle of shaly clay loam till 3 to 10 feet thick. These soils occupy convex positions on knolls and side slopes of hills. Slopes are both uniform and complex, generally are 75 to 200 feet long, and range from 3 to 12 percent. The native vegetation was deciduous trees.

In a representative profile the surface layer is very dark gray, friable silt loam about 7 inches thick. The subsurface layer is dark grayish-brown and dark-gray silt loam about 4 inches thick. The subsoil is dark grayish-brown to light olive-brown, firm clay and clay loam about 49 inches thick. The underlying material is calcareous, olive-brown and light olive-brown, firm clay loam.

Permeability is moderately slow. Runoff is medium to rapid. The water table is below a depth of 10 feet. The available water capacity is high. Organic-matter content is moderate, and natural fertility is medium.

Some areas of the Erin soils are wooded, but many are cultivated. If properly managed, these soils are suited to most crops. Maintaining good tilth and controlling erosion are the principal management needs.

Representative profile of Erin silt loam, 6 to 12 percent slopes, eroded, in Shieldsville Township, 300 feet north and 400 feet east of center of sec. 17, T. 110 N., R. 22 W.

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

A21—7 to 9 inches, dark grayish-brown (10YR 4/2) silt loam; weak to moderate, medium, platy structure; very friable; medium acid; abrupt, smooth boundary.

A22—9 to 11 inches, dark-gray (10YR 4/1) silt loam; weak, fine and medium, subangular blocky structure; friable; strongly acid; clear, wavy boundary.

B&A—11 to 20 inches, dark grayish-brown (10YR 4/2) clay loam; moderate to strong, fine and medium, subangular blocky structure; firm; about 2 percent coarse fragments; thick, light brownish-gray (10YR 6/2 dry), porous coatings on ped faces; common, fine, rounded shale particles; strongly acid; clear, smooth boundary.

B21t—20 to 31 inches, olive-brown (2.5Y 4/4) clay; few, fine, distinct, red mottles; strong, medium, prismatic structure parting to strong, fine to medium, angular and subangular blocky; very firm; about 2 percent coarse fragments; thick, continuous, very dark gray (10YR 3/1) to very dark grayish-brown (10YR 3/2) clay films on ped faces; common, fine, rounded shale particles; few, fine, soft, dark-colored masses; very strongly acid; gradual, wavy boundary.

B22t—31 to 40 inches, light olive-brown (2.5Y 5/4) clay loam; few, fine, prominent, reddish mottles; strong, coarse, prismatic structure parting to strong, medium, angular blocky; firm; about 4 percent coarse fragments; thick, continuous, very dark grayish-brown (10YR 3/2) clay films on ped faces; common, fine, rounded shale particles; extremely acid; gradual, wavy boundary.

B23t—40 to 50 inches, light olive-brown (2.5Y 5/4) clay loam; common, medium, distinct, light brownish-gray (2.5Y 6/2) mottles and few, fine, prominent, reddish mottles; strong, coarse, prismatic structure parting to strong, medium, angular blocky; firm; about 4 percent coarse fragments; thick, continuous, very dark brown (10YR 2/2) to dark grayish-brown (10YR 4/2) clay films on ped faces; common, fine, rounded shale particles; many, fine, root-channel fillings of black, clayey, organic material; strongly acid; gradual, wavy boundary.

B3t—50 to 60 inches, light olive-brown (2.5Y 5/4) clay loam; common, medium, distinct, light brownish-gray (2.5Y 6/2) mottles and few, fine, prominent, reddish mottles; massive with a tendency to vertical cleavage; firm; about 4 percent coarse fragments; medium, patchy, very dark brown (10YR 2/2) to dark grayish-brown (10YR 4/2) clay films on vertical ped faces; common fine shale fragments; few concretions of iron and manganese oxide; common root-channel fillings of black, clayey, organic material; neutral; clear, wavy boundary.

C—60 to 65 inches, olive-brown (2.5Y 4/4) and light olive-brown (2.5Y 5/4) clay loam; common, fine, distinct, light olive-brown (2.5Y 5/6) mottles and few, fine, prominent, reddish mottles; massive with a tendency to vertical cleavage; firm; about 4 percent coarse fragments; common fine shale fragments; mildly alkaline; calcareous.

Thickness of the solum and depth to free carbonates range from 40 to 70 inches. The A1 or Ap horizon is silt loam, clay loam, or loam. The A1 horizon ranges from 1 to 7 inches in thickness. Its structure is weak, fine, granular or subangular blocky in undisturbed areas and is weak or moderate, medium, subangular blocky in some places in cultivated areas. Reaction is slightly acid to medium acid. The A2 horizon is silt loam, loam, clay loam, or silty clay loam and is 3 to 10 inches thick. Its structure in many profiles is weak and moderate, thin and medium, platy. Part of this horizon is incorporated into the Ap horizon in some profiles. Reaction is slightly acid to strongly acid. The B&A horizon is clay loam, silty clay loam, or loam and is strongly acid or medium acid. The B2 horizon is clay loam, silty clay loam, silty clay, or clay and ranges from 30 to 60 inches in combined thickness. It is strongly acid to extremely acid. The B3 horizon is neutral to medium acid.

Erin soils have more clay in their B2 horizon than the similar Hayden soils. They have brighter colors in the B horizon than the associated Lerdal soils.

**Erin silt loam, 2 to 6 percent slopes** (ErB).—This soil is on irregularly shaped knolls that are 5 to 80 acres in size. Slopes are 80 to 150 feet long. This soil is upslope from more sloping Erin soils. It has a profile similar to the one described as representative of the series, but the layers are thinner where slopes are convex.

Included with this soil in mapping are small areas of Shields, Lerdal, and Mazaska soils having concave slopes. Small gravelly areas are identified on the soil map by a symbol for gravel. A few areas of eroded soils are also included.

Runoff is medium. The hazard of erosion is moderate. Good tilth is hard to maintain without special management. This soil is suited to the crops grown in the county. Capability unit IIe–3; woodland group 2; building site group 7.

**Erin silt loam, 6 to 12 percent slopes, eroded** (ErC2).—This soil is on irregularly shaped knolls and hillsides that are 5 to 20 acres in size. Slopes are 80 to 150 feet long. This soil has the profile described as representative of the series. Erosion, deep tillage, and tree removal in cultivated areas have mixed the original surface layer with part of the subsoil. The resulting surface layer is lower in organic matter content and less friable than the original one. The soil layers are thinnest on convex hillsides.

Included with this soil in mapping are a few areas of soils that have slopes of less than 6 percent or more than 12 percent and small gravelly areas that are identified on the soil map by a symbol for gravel. A few small areas of Storden soils also are included where slopes are convex, and a few included areas are uneroded.

Runoff is medium. The hazard of erosion is severe. Good tilth is hard to maintain without special management practices. This soil is used for cultivated crops, trees, or wooded pasture. Capability unit IIIe–3; woodland group 2; building site group 7.

**Erin silt loam, 12 to 18 percent slopes, eroded** (ErD2).—Some of this soil is on a few irregularly shaped knolls, 5 to 20 acres in size, but most of the acreage is on sidehills 5 to 20 acres in size. These hillsides are crossed by many, shallow, downslope draws and by a few deep ravines. Slopes are 80 to 120 feet long. This soil has a profile similar to the one described as representative of the series, but erosion, deep tillage, and tree removal have mixed part of the subsoil with the original surface layer. As a result, the present surface layer contains less organic matter and is less friable than the original one. Soil layers are thinnest where slopes are convex.

Included with this soil in mapping are areas of soils having slopes of less than 12 percent or more than 18 percent and areas of Shields, Lerdal, or Cordova soils in shallow downslope draws. Small gravelly areas are

identified on the soil map by the gravel symbol. A few small areas of convex Storden soils and a few uneroded areas are also included.

Runoff is rapid. The hazard of erosion is severe. South- and west-facing slopes have much greater variations in temperature than those facing east and north. This soil is used for crops, trees, or wooded pasture. Capability unit IVe–3; woodland group 2; building site group 7.

**Erin silt loam, 18 to 30 percent slopes** (ErE).—Some areas of this soil are on a few irregularly shaped knolls that range from 5 to 20 acres in size, but most of the acreage is on sidehills, 5 to 20 acres in size, that are commonly crossed by shallow, downslope draws and deep ravines. Slopes are 80 to 150 feet long. This soil has a profile similar to the one described as representative of the series, but the layers are thinner.

Included with this soil in mapping, because of limited acreage, are some areas of soils that have a surface layer of sandy loam and a few areas where slopes are less than 18 percent or more than 30 percent. Inclusions of Shields, Lerdal, or Cordova soils are in the shallow downslope draws. Small gravelly areas are identified on the soil map by the gravel symbol. A few areas of Storden soils that have convex slopes and a few areas of eroded soils are also included.

Runoff is rapid, and the hazard of erosion is very severe. South- and west-facing slopes have much greater variations in soil temperature than those facing east and north. This soil is used as woodland or for permanent pasture. Capability unit VIe–1; woodland group 2; building site group 7.

## Estherville Series

The Estherville series consists of nearly level to sloping, somewhat excessively drained soils that formed in loamy alluvial deposits and the underlying stratified sand and gravel. These soils are on broad flats, narrow ridges, and short slopes on the glacial outwash plains and stream terraces. They also are on small hills within the rolling uplands. Slopes are uniform, except where the soils are in a complex with other soils. The native vegetation was tall prairie grass and a few thin stands of oak or brush.

In a representative profile the surface layer is black and very dark grayish-brown sandy loam about 10 inches thick. The subsoil is about 14 inches thick and is dark yellowish-brown, very friable sandy loam in the upper part and dark yellowish-brown to brown gravelly coarse sand in the lower part. The underlying material is grayish-brown and light olive-brown gravelly coarse sand.

Permeability is moderately rapid in the upper part of the profile and rapid below a depth of about 16 inches. Runoff is slow to rapid, depending on slope. The water table is below a depth of 10 feet. Available water capacity is low, organic-matter content is moderate, and natural fertility is low to medium.

Most areas of these soils are in crops. However, the soils are not well suited to most row crops, because of low available water capacity, limited rooting zone, and the hazard of soil blowing.

Representative profile of Estherville sandy loam, 0 to 2 percent slopes, in Wells Township, 820 feet west and 900 feet south of the northeast corner of sec. 25, T. 110 N., R. 21 W.

A1—0 to 6 inches, black (10YR 2/1) sandy loam, very dark brown (10YR 2/2) rubbed; weak, fine, granular structure; very friable; slightly acid; clear, wavy boundary.

A3—6 to 10 inches, very dark grayish-brown (10YR 3/2) sandy loam; weak, fine and medium, subangular blocky structure; very friable; slightly acid; clear, wavy boundary.

B2—10 to 16 inches, dark yellowish-brown (10YR 3/4) sandy loam, dark yellowish brown (10YR 4/4) rubbed; weak, fine and medium, subangular blocky structure; very friable; medium acid; abrupt, smooth boundary.

IIB31—16 to 20 inches, dark yellowish-brown (10YR 3/4) gravelly coarse sand; single grained; loose; about 25 percent gravel; medium acid; clear, wavy boundary.

IIB32—20 to 24 inches, dark-brown to brown (10YR 4/3) and dark yellowish-brown (10YR 3/4) gravelly coarse sand; single grained; loose; about 15 percent gravel; slightly acid; clear, wavy boundary.

IIC1—24 to 31 inches, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) gravelly coarse sand; single grained; loose; about 5 percent gravel; slightly acid; clear, wavy boundary.

IIC2—31 to 38 inches, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) gravelly coarse sand; single grained; loose; about 15 percent gravel; slightly effervescent; moderately alkaline; abrupt, smooth boundary.

IIC3—38 to 68 inches, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) gravelly coarse sand; single grained; about 35 percent gravel; slightly effervescent; moderately alkaline.

Thickness of the solum and depth to sand and gravel range from 15 to 30 inches. The Ap and A1 horizons are sandy loam or light loam 6 to 10 inches thick. Reaction in these horizons is slightly acid or medium acid. The A3 horizon is 3 to 9 inches thick. Its reaction is slightly acid or medium acid. The B2 horizon is dark yellowish-brown or dark-brown sandy loam or loam about 4 to 11 inches thick. Reaction in this horizon is also slightly acid or medium acid. The IIC horizon is gravelly coarse sand, gravel, sandy gravel, coarse sand, or stratified coarse sand and gravel. The upper few inches of this horizon is leached of lime in some profiles.

Estherville soils have more coarse sand in the A and B horizons than the similar Dickman soils. Also, the IIC horizon of Estherville soils has coarser sand along with gravel, whereas the Dickman soils lack coarse sand and gravel in that horizon. Estherville soils have a finer textured B horizon than the associated Salida soils.

**Estherville sandy loam, 0 to 2 percent slopes** (EsA).—This soil is in tracts that range from 3 to 200 acres in size. The smaller tracts commonly are scattered among areas of loamy soils on uplands. The larger tracts are on broad flats along the major rivers and their tributaries. This soil has the profile described as representative of the series.

Included with this soil in mapping are small areas where slopes are more than 2 percent and a few areas of Dickman soils. Included also are Biscay soils in a few drainageways that cross the broader areas.

This soil is droughty. Runoff is slow. Soil blowing is a hazard, especially on the larger tracts in spring. Most of this soil is used for crops. Capability unit IIIs–1; woodland group 4; building site group 2.

**Estherville sandy loam, 2 to 6 percent slopes** (EsB).—This soil is in tracts that range from 3 to 30 acres in size. The smaller tracts are on gentle, convex mounds and ridges in the uplands or on short side slopes below the nearly level Estherville soil. The larger tracts occur as broad, gently undulating terraces or benches and are adjacent to major rivers and their tributaries.

Included with this soil in mapping are areas where slopes are less than 2 percent or more than 6 percent, a few small areas of Biscay soils in shallow drainageways, and a few areas of Salida soils on small, convex knobs at

the upper part of short, sharp slopes. Also included are a few areas of eroded soils that have subsoil material mixed with the original surface layer.

This soil is droughty. Runoff is slow to medium. There is a slight hazard of water erosion and soil blowing. Most of this soil is used for crops. Capability unit IIIe–4; woodland group 4; building site group 2.

**Estherville sandy loam, 6 to 12 percent slopes** (EsC).—This soil is on sharp side slopes below less sloping Estherville soils and on hills within areas of loamy soils on uplands. Areas of this soil range from 3 to 30 acres in size. Slopes range from 50 to 125 feet in length.

Included with this soil in mapping are a few areas where slopes are less than 6 percent and more than 12 percent, a few small areas of Salida and Dickman soils, and a few areas of eroded soils that have part of the subsoil mixed with the original surface layer. These latter areas have more gravel in the surface layer.

This soil is droughty. Runoff is medium. There is a moderate hazard of water erosion and soil-blowing. South- and west-facing slopes have soil temperatures that fluctuate much more widely than those of slopes facing east or north. Most areas of this soil are used for crops. Capability unit IVe-4; woodland group 4; building site group 2.

## Etter Series

The Etter series consists of gently sloping to moderately steep, well-drained, loamy soils that formed over sandstone. These soils are in areas that range from 5 to 40 acres in size on toe slopes in the uplands. Slopes are uniform. The native vegetation was deciduous trees and tall prairie grass.

In a representative profile the surface layer is very dark grayish-brown and dark-brown fine sandy loam about 12 inches thick. The subsoil is dark yellowish-brown and yellowish-brown, friable loam and loamy fine sand about 20 inches thick. The underlying material is yellowish-brown, brownish-yellow, and light-gray, loose, soft sandstone.

Permeability is moderate. Runoff is medium to rapid. The water table is below a depth of 10 feet. Available water capacity is moderate, organic-matter content is high, and natural fertility is medium.

Some areas of these soils are in crops and some are wooded. The hazards of water erosion and soil blowing, the moderate available water capacity, and the medium level of fertility are major limitations to crop growth.

Representative profile of Etter fine sandy loam, 6 to 15 percent slopes, in Northfield Township, 1,360 feet north and 320 feet west of southeast corner of sec. 31, T. 112 N., R. 19 W.

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; few dark-brown (10YR 3/3) channels; weak, fine, granular structure; friable; about 1 percent coarse fragments; slightly acid; abrupt, smooth boundary.

A1—8 to 12 inches, dark-brown (10YR 3/3) fine sandy loam; few dark yellowish-brown (10YR 3/4) channels; weak, fine, granular structure; friable; about 1 percent coarse fragments; medium acid; abrupt, smooth boundary.

B21—12 to 18 inches, dark yellowish-brown (10YR 3/4) loam, dark brown or brown (10YR 4/3) rubbed; weak, fine and very fine, subangular blocky structure; friable; about 1 percent coarse fragments; strongly acid; abrupt, wavy boundary.

B22—18 to 24 inches, dark yellowish-brown (10YR 4/4) loam; weak, fine and very fine, subangular blocky structure; friable; about 1 percent coarse fragments; very strongly acid; clear, wavy boundary.

B23—24 to 29 inches, yellowish-brown (10YR 5/4) loam; moderate, fine and medium, subangular blocky structure; friable; about 2 percent coarse fragments; very strongly acid; clear, wavy boundary.

IIB3—29 to 32 inches, yellowish-brown (10YR 5/4) loamy fine sand; moderate, fine and medium, subangular blocky structure to structureless; loose; about 5 percent coarse fragments; strongly acid; clear, wavy boundary.

IIC1—32 to 39 inches, brownish-yellow (10YR 6/6) soft sandstone, dominantly of fine sand; very strongly acid; clear, wavy boundary.

IIC2—39 to 68 inches, brownish-yellow (10YR 6/6) soft sandstone that contains thin yellow (10YR 7/6) strata, light-gray (10YR 7/2) fine sand dominating, and few dark yellowish-brown (10YR 5/4) bands; very strongly acid.

Thickness of the solum and depth to sandstone bedrock range from 20 to 40 inches. The Ap horizon ranges from very dark grayish brown to dark brown. In undisturbed areas, these soils have a black or very dark grayish-brown A1 horizon that ranges from 6 to 12 inches in thickness. The Ap and A1 horizons typically are fine sandy loam but range to loam. Reaction is slightly acid or medium acid. The B2 horizon ranges from sandy loam to fine sandy loam or loam. The IIB3 horizon ranges from loamy fine sand to sandy loam or fine sandy loam. The IIC1 horizon ranges from 0 to 10 inches in thickness and is sand or fine sand. Reaction ranges from very strongly acid to medium acid.

The Etter soils have more clay and less sand in the solum than the associated Boone soils. They have more sand and less silt in the solum than the associated Dodgeville soils.

**Etter fine sandy loam, 2 to 6 percent slopes** (EtB).—This soil is in areas that range from 5 to 40 acres in size. It is on side slopes, where it is associated with the Boone, Sogn, and Dodgeville soils. The surface layer of this soil has commonly been disturbed by burrowing rodents.

Included with this soil in mapping are a few areas of eroded soils in which the surface layer has been mixed with part of the browner subsoil.

This soil is moderately droughty. Runoff is medium. There is a slight hazard of water erosion and soil blowing. Some areas of this soil are wooded, and some are used for cultivated crops. Capability unit IIIe–4; woodland group 3; building site group 3.

**Etter fine sandy loam, 6 to 15 percent slopes** (EtC).—This soil is in areas that range from 5 to 20 acres in size. It is on side slopes below or above less sloping Etter soils. It has the profile described as representative of the series. Burrowing rodents have disturbed the surface layer.

Included with this soil in mapping are a few areas of eroded soils in which part of the browner subsoil has been mixed with the surface layer.

This soil is moderately droughty. Runoff is rapid. The hazard of water erosion and soil blowing is severe. Most areas of this soil are in permanent pasture, but a few remain in trees. Capability unit VIe–2; woodland group 3; building site group 3.

## Fairhaven Series

The Fairhaven series consists of nearly level to gently sloping, well-drained, silty soils that formed in 24 to 40 inches of silty sediment over sand and gravel. These soils are on broad flats and side slopes in the glacial outwash plains. Slopes are both uniform and complex.

The native vegetation was tall prairie grass and a few groves of oak.

In a representative profile the surface layer is black silt loam about 17 inches thick. The subsoil is dark yellowish-brown to brown, friable loam about 11 inches thick. The upper 4 inches of underlying material is dark-brown to brown, very friable sandy loam. The lower part of the underlying material is light olive-brown and grayish-brown, loose gravelly coarse sand.

Permeability is moderately rapid. Runoff is slow to medium. The water table is below a depth of 10 feet. Available water capacity is moderate, organic-matter content is high, and natural fertility is medium.

Most areas of these soils are in crops, but a few small areas remain in trees. The soils are suited to most crops if they are properly managed. Crop growth is limited by lack of available water in some years. Controlling erosion on the more sloping soils is the major management need.

Representative profile of Fairhaven silt loam, 0 to 2 percent slopes, in Richland Township, 1,080 feet south and 160 feet east of the center of sec. 8, T. 109 N., R. 19 W.

Ap—0 to 11 inches, black (10YR 2/1) silt loam, very dark brown (10YR 2/2) rubbed; weak, fine, subangular blocky structure; friable; slightly acid; abrupt, smooth boundary.

A1—11 to 17 inches, black (10YR 2/1) silt loam; weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

B1—17 to 21 inches, dark yellowish-brown (10YR 3/4) loam that is high in content of silt; friable; weak, fine, subangular blocky structure; neutral; clear, wavy boundary.

B2—21 to 28 inches, dark-brown to brown (10YR 4/3) loam that is high in content of silt; friable; weak, fine, subangular blocky structure; neutral; clear, wavy boundary.

IIC1—28 to 32 inches, dark-brown to brown (10YR 4/3) sandy loam; massive; very friable; neutral; clear, wavy boundary.

IIC2—32 to 60 inches, light olive-brown (2.5Y 5/4) and grayish-brown (2.5Y 5/2) gravelly coarse sand; single grained; loose; mildly alkaline; strongly effervescent.

Thickness of the solum and depth to sand and gravel range from 24 to 36 inches. The Ap and A1 horizons are very dark brown, very dark gray, or black. Dry colors are very dark gray and dark grayish brown to grayish brown. The Ap and A1 horizons range from 8 to 17 inches in combined thickness. Reaction in these horizons is neutral or slightly acid. The B1 horizon is dark yellowish brown or dark brown and is 2 to 6 inches thick. Reaction is neutral or slightly acid. The B horizon is 7 to 20 inches thick. In some profiles a few thin clay films are on faces of peds. Reaction is neutral or slightly acid in the B2 horizon. The IIC1 horizon is lacking in some profiles. The IIC2 horizon is gravelly coarse sand or stratified sand and gravel. Depth to free carbonates is 32 to 48 inches.

Fairhaven soils have more silt in the A and B horizons than the associated Estherville and Dickman soils.

**Fairhaven silt loam, 0 to 2 percent slopes** (FaA).—This soil is on flat tops of large, low-lying hills and on broad outwash plains. It is associated with the Biscay and Kato soils. The areas range from 5 to 100 acres in size. It has the profile described as representative of the series.

Included with this soil in mapping are a few areas of soils that have a surface layer of loam that has a high content of silt.

This soil is moderately droughty. Runoff is slow. There is a slight hazard of soil blowing. Most areas of this soil are used for crops. Capability unit IIs–1; woodland group 3; building site group 1.

**Fairhaven silt loam, 2 to 6 percent slopes** (FaB).—This soil is on small hills of irregular shape and on broad outwash plains. It is in areas that range from 5 to 160 acres in size. Included with it in mapping are a few areas of eroded soils in which part of the subsoil is mixed with the original surface layer. Here, the present surface layer is lighter colored, lower in content of organic matter, and less friable than the original one.

This soil is moderately droughty. Runoff is medium. There is a slight hazard of water erosion. Most areas of this soil are used for crops. Capability unit IIe–4; woodland group 3; building site group 1.

## Fairhaven Series, Loamy Subsoil Variant

The Fairhaven series, loamy subsoil variant, consists of nearly level to gently sloping, well-drained, silty soils that formed in 24 to 40 inches of silty sediment over stratified loamy and sandy sediment. These soils are on broad flats and side slopes on glacial outwash plains. Slopes are both uniform and complex. The native vegetation was tall prairie grass and groves of oak or brush.

In a representative profile the surface layer is very dark gray and very dark grayish-brown silt loam about 12 inches thick. The subsoil is dark-brown to brown, friable silt loam, loam, and sandy clay loam about 29 inches thick. The underlying material is yellowish-brown and brown, stratified very fine sandy loam, sandy loam, and loamy coarse sand.

Permeability is moderate. Runoff is slow to medium. The water table is below a depth of 10 feet. Available water capacity is high, organic-matter content is high, and natural fertility is medium.

Most areas of these soils are in crops, but a few small areas remain in trees. The soils are suited to most crops if they are properly managed. Crop growth is limited by lack of available water in some years. Controlling erosion on the more sloping soils is the major management need.

Representative profile of Fairhaven silt loam, loamy subsoil variant, 0 to 2 percent slopes, in Bridgewater Township, 1,600 feet north and 100 feet east of the southwest corner of sec. 28, T. 111 N., R. 20 W.

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

A3—7 to 12 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, very fine, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

B1—12 to 15 inches, dark grayish-brown (10YR 4/2) loam; weak, fine and medium, subangular blocky structure; friable; few sand and silt grains on faces of peds; slightly acid; gradual, wavy boundary.

B21—15 to 24 inches, dark-brown to brown (10YR 4/3) silt loam; faces of peds are dark grayish brown (10YR 4/2); weak, medium, subangular blocky structure; friable; few sand and silt grains on faces of peds; slightly acid; clear, wavy boundary.

B22—24 to 29 inches, dark-brown to brown (10YR 4/3) loam; faces of peds are dark grayish-brown (10YR 4/2); structureless to weak, fine and medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

B31—29 to 40 inches, brown (10YR 5/3) sandy clay loam; faces of peds are dark grayish brown (10YR 4/2); weak, medium, subangular blocky structure; friable; medium acid; abrupt, smooth boundary.

B32—40 to 44 inches, brown (10YR 5/3) and yellowish-brown (10YR 5/4) silt loam; massive; friable; neutral; abrupt, smooth boundary.

C1—44 to 48 inches, yellowish-brown (10YR 5/4) very fine sandy loam; massive; friable; neutral; abrupt, smooth boundary.
C2—48 to 54 inches, brown (10YR 5/3) loamy coarse sand; single grained; loose; few, fine, distinct, strong-brown (7.5YR 5/8) mottles; medium acid; abrupt, smooth boundary.
C3—54 to 64 inches, brown (10YR 5/3) sandy loam; massive; friable; slightly acid.

Thickness of the solum and depth to loamy sediments range from 24 to 48 inches. The Ap and A1 horizons are very dark brown, very dark gray, or black. Dry colors are very dark gray or dark grayish brown to grayish brown. The A horizon ranges from 8 to 17 inches in combined thickness. Its reaction is neutral to medium acid. The B2 horizon is dark yellowish brown, dark brown, or brown and is 20 to 36 inches thick. Reaction is neutral to medium acid. In some profiles a few thin clay films are on faces of peds. Reaction is neutral to medium acid in the B2 horizon. The IIC horizons are stratified loam, silt loam, sandy loam, gravelly coarse sand, or stratified sands and gravel. Depth to free carbonates is 40 to 80 inches.

Fairhaven, loamy subsoil variant, soils have more silt in the A horizon than the associated Estherville soils. They have more silt in the A and B horizons than the associated Dickman soils. They have loamy sediment in their underlying material, whereas the associated normal Fairhaven soils have sand and gravel.

**Fairhaven silt loam, loamy subsoil variant, 0 to 2 percent slopes** (FlA).—This soil is on flat tops of larger, low-lying hills and in broad outwash areas. Tracts range from 5 to 100 acres in size. The soil is associated with Biscay and Kato soils. It has the profile described as representative of the series.

Included with this soil in mapping are a few areas of soils that have a surface layer of loam that is high in content of silt.

This soil has no major limitation to use for crops. Runoff is slow. There is a slight hazard of soil blowing. Most areas of the soil are used for crops. Capability unit I–1; woodland group 1; building site group 5.

**Fairhaven silt loam, loamy subsoil variant, 2 to 6 percent slopes** (FlB).—This soil is in tracts that range from 5 to 160 acres in size and are on small hills of irregular shape and in broad outwash areas. Included with it in mapping are a few areas of eroded soils in which part of the subsoil is mixed with the original surface layer. This new surface layer is lower in content of organic matter and less friable than the original one.

Most areas of this soil are used for crops. Runoff is medium. There is a moderate hazard of water erosion. Capability unit IIe–1; woodland group 1; building site group 5.

## Faxon Series

The Faxon series consists of nearly level, poorly drained, loamy soils that formed in 20 to 40 inches of loamy sediment over bedrock. These soils are in depressions and sluggish drainageways on terraces along streams. The native vegetation was principally water-tolerant prairie grasses.

In a representative profile the surface layer is black and very dark gray clay loam and loam about 15 inches thick. The subsoil is dark-gray, gray, and greenish-gray, friable loam and fine sandy loam about 19 inches thick. Below this is limestone bedrock.

Permeability is moderate. Runoff is slow to ponded. Depth to the water table commonly ranges from 0 to 3 feet. The available water capacity is only moderate, but the available water is recharged from the water table. Organic-matter content and natural fertility are high.

Some areas of these soils are in crops. If properly drained, the soils are suited to most crops. Controlling the water table is the principal management need.

Representative profile of Faxon clay loam, in Bridgewater Township, 1,800 feet north and 460 feet east of southwest corner of sec. 14, T. 111 N., R. 20 W.

A1—0 to 10 inches, black (N 2/0) clay loam; weak, fine and medium, subangular blocky structure; sticky, friable; about 1 percent coarse fragments; very slightly effervescent; mildly alkaline; clear, wavy boundary.
A3—10 to 15 inches, very dark gray (10YR 3/1) loam; weak, fine and medium, subangular blocky structure; sticky, friable; about 1 percent coarse fragments; mildly alkaline; clear, wavy boundary.
B21g—15 to 20 inches, dark-gray (10YR 4/1) loam; many, fine, distinct, strong-brown (7.5YR 5/6) mottles; weak, fine and medium, subangular blocky structure; sticky, friable; about 2 percent coarse fragments; mildly alkaline; clear, wavy boundary.
B22t—20 to 26 inches, gray (5Y 5/1) fine sandy loam; many, coarse, prominent, light olive-brown (2.5Y 5/4) mottles; weak, medium, prismatic structure; sticky, friable; about 2 percent coarse fragments; mildly alkaline; abrupt, wavy boundary.
B3g—26 to 34 inches, greenish-gray (5GY 5/1) loam; many, coarse, prominent, strong-brown (7.5YR 5/8) mottles; mildly alkaline; few lime pebbles; about 5 percent coarse fragments; abrupt, smooth boundary.
IIR—34 inches, hard limestone bedrock.

Depth to the R horizon ranges from 20 to 40 inches. The A horizon is loam, sandy clay loam, or clay loam and is 8 to 20 inches thick. The B2 horizon is loam, fine sandy loam, or clay loam about 8 to 20 inches thick. In some profiles the B2 horizon has free carbonates. The B3 horizon is fine sandy loam, sandy clay loam, loam, or clay loam about 2 to 8 inches thick. Reaction is neutral or mildly alkaline. The R horizon typically is limestone bedrock, but in some profiles it is sandstone.

Faxon soils are more poorly drained than the associated Copaston soils, and they have a lower chroma in the B horizon than those soils.

**Faxon clay loam** (0 to 2 percent slopes) (Fx).—This soil is in swales 3 to 20 acres in size. Small areas of Biscay soils are included with it in mapping.

This soil is wet. Improved drainage is needed for most crops, but bedrock limits installation of adequate drainage in some places. The water table is lowered significantly in places if an outlet ditch is installed nearby. Some areas of this soil are used for crops, and some are in permanent pasture. Capability unit VIw–2; woodland group 8; building site group 12.

## Garwin Series

The Garwin series consists of nearly level, poorly drained, silty soils that formed in calcareous loess. These soils are in broad swales and drainageways. The native vegetation was water-tolerant prairie grass.

In a representative profile the surface layer is black and very dark gray, friable silty clay loam about 17 inches thick. The upper part of the subsoil is mottled, dark grayish-brown, friable silty clay loam about 14 inches thick. The lower part of the subsoil is distinctly mottled, olive-gray, friable silt loam about 24 inches thick. The underlying material is grayish-brown, calcareous, friable silt loam.

Permeability is moderately slow. Runoff is slow to ponded. Depth to the water table commonly ranges from

0 to 3 feet. Available water capacity is high. Organic-matter content and natural fertility are high.

Most areas of these soils are in crops. Undrained, these soils are only moderately well suited to poorly suited to most crops. If adequately drained, however, they are well suited to crops. Controlling the water table and maintaining good tilth are the major management needs.

Representative profile of Garwin silty clay loam, in Wheeling Township, 1,500 feet east and 100 feet north of southwest corner of sec. 2, T. 110 N., R. 19 W.

A1—0 to 13 inches, black (N 2/0) silty clay loam; weak, fine, granular structure; friable; neutral; clear, wavy boundary.

A3—13 to 17 inches, very dark gray (10YR 3/1) silty clay loam; weak, fine, granular structure; friable; neutral; clear, wavy boundary.

B1g—17 to 24 inches, dark grayish-brown (2.5Y 4/2) silty clay loam; few, fine, distinct, strong-brown (7.5YR 5/8) mottles; weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

B21g—24 to 31 inches, dark grayish-brown (2.5Y 4/2) silty clay loam; few, fine, distinct, light olive-brown (2.5Y 5/6) mottles; weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

B22g—31 to 40 inches, olive-gray (5Y 5/2) silt loam; many, fine, distinct, light olive-brown (2.5Y 5/6) mottles; weak, fine, subangular blocky structure; friable; clear, wavy boundary.

B3g—40 to 55 inches, grayish-brown (2.5Y 5/2) silt loam; few, fine, distinct, strong-brown (7.5YR 5/8) mottles; many concretions of manganese and iron; structureless to weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

C1g—55 to 59 inches, grayish-brown (2.5Y 5/2) silt loam; light olive-brown (2.5Y 5/6) concretions of manganese and iron; massive; friable; slightly effervescent; mildly alkaline; abrupt, wavy boundary.

C2g—59 to 70 inches, grayish-brown (2.5Y 5/2) silt loam; light olive-brown (2.5Y 5/6) concretions of manganese and iron; massive; friable; strongly effervescent; mildly alkaline.

Thickness of the solum and depth to free carbonates range from 30 to 60 inches. The Ap and A1 horizons have a combined thickness of 10 to 20 inches. Reaction in these horizons ranges from slightly acid to mildly alkaline. The A3 horizon, which is not in all profiles, is silty clay loam or silt loam and neutral or mildly alkaline. The B horizon has a matrix of dark gray, gray, olive gray, grayish brown, or dark grayish brown. Texture of this horizon is silt loam or silty clay loam, and thickness is 16 to 38 inches. In some profiles this horizon has free carbonates in the lower part.

The Garwin soils of Rice County are outside the defined range of the series because they have less clay in the solum. However, this difference does not appreciably affect their usefulness or behavior.

Garwin soils formed in loess, whereas the similar Maxfield and Maxcreek soils formed in a mantle of loess and in glacial till. Garwin soils have more silt and less sand than the similar Webster soils.

**Garwin silty clay loam** (0 to 2 percent slopes) (Ga).—This soil is in broad areas that range from 10 to 50 acres in size. It occurs in association with Judson, Bold, and Port Byron soils. Included with it in mapping are small areas of Maxfield soils that formed in thinner silts. A few small depressions are also included, and in a few areas the surface layer is calcareous and the underlying material has pockets or strata of sand.

This soil is wet. Improved drainage is needed for dependable growth of present crops. Properly designed and installed drainage systems effectively remove excess water. Most areas of this soil are used for cultivated crops. Capability unit IIw-1; woodland group 7; building site group 10.

## Glencoe Series

The Glencoe series consists of nearly level, very poorly drained soils that formed in alluvium over glacial deposits of loam. These soils are in many of the depressions and sluggish drainageways. The native vegetation was sedges and water-tolerant grasses.

In a representative profile the surface layer is black and very dark gray clay loam about 20 inches thick. The subsoil is very dark gray, friable clay loam about 7 inches thick. The underlying material is calcareous, gray and olive-gray, friable clay loam.

Permeability is moderately slow. Runoff is slow to ponded. Depth to the water table commonly ranges from 0 to 3 feet. The available water capacity is high. Organic-matter content and natural fertility are high.

Undrained, these soils are only moderately well suited to poorly suited to crops. If these soils are adequately drained, however, they are suited to row crops and, in most areas, are used for crops.

Representative profile of Glencoe clay loam, in Warsaw Township, 700 feet south and 660 feet east of northwest corner of sec. 26, T. 109 N., R. 21 W.

Ap—0 to 7 inches, black (N 2/0) clay loam; massive (cloddy); friable; neutral; abrupt, smooth boundary.

A1—7 to 12 inches, black (N 2/0) clay loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

A3—12 to 20 inches, very dark gray (10YR 3/1) clay loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B2g—20 to 27 inches, very dark gray (10YR 3/1) clay loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

C1g—27 to 36 inches, gray (5Y 5/1) and olive-gray (5Y 5/2) clay loam; many, fine, distinct, strong-brown (7.5YR 5/8) mottles; weak, fine, subangular blocky structure; friable; mildly alkaline; gradual, wavy boundary.

C2g—36 to 64 inches, gray (5Y 5/1) and olive-gray (5Y 5/2) clay loam; many, fine, distinct, strong-brown (7.5YR 5/8) mottles; massive; friable; about 4 percent coarse fragments; mildly alkaline; calcareous.

Thickness of the solum and depth to free carbonates range from 27 to 54 inches. The Ap and A1 horizons are clay loam or silty clay loam and range from 12 to 30 inches in combined thickness. Reaction in these horizons is commonly neutral but ranges from slightly acid to mildly alkaline. The A3 horizon is clay loam or silty clay loam and ranges from 7 to 12 inches in thickness. Reaction is neutral or mildly alkaline. The B horizon typically is clay loam or silty clay loam and ranges from 7 to 24 inches in thickness. Reaction is neutral or mildly alkaline. The C horizon is loam or clay loam.

Glencoe soils have a thicker A horizon than the associated Webster soils. They have more sand and less silt in the A horizon than the similar Colo soils. They have less clay and more sand in the A and B horizons than the similar Rolfe soils.

**Glencoe clay loam** (0 to 2 percent slopes) (Gc).—This soil is in small depressions and in long, winding, low-gradient drainageways. Areas range from 5 to 40 acres in size. In some places there are small areas of included soils that have a calcareous surface layer. Also included are small depressions of Rolfe soils near the crest of drainage divides. In some undisturbed areas, a thin layer of organic material covers the mineral surface layer.

This soil is very wet. Depth to the water table commonly ranges from 0 to 3 feet in undrained areas (fig. 6). Improved drainage is essential if this soil is used for common crops. Most areas are used for crops. Capability unit IIIw-1; woodland group 8; building site group 12.

*Figure 6.*—**Watering pit used to supply water for livestock in permanent pasture. The soil is Glencoe clay loam.**

## Hayden Series

The Hayden series consists of undulating to very steep, well-drained, loamy soils that formed in loam glacial till. These soils are on knolls, hillsides, and valley slopes in the uplands. Slopes are complex. The native vegetation was mixed deciduous trees.

In a representative profile the surface layer is very dark gray, very dark grayish-brown, and dark grayish-brown loam about 8 inches thick. The subsoil is dominantly dark-brown and yellowish-brown, friable clay loam about 32 inches thick. The underlying material is calcareous, light olive-brown loam.

Permeability is moderate. Runoff is medium to rapid. The water table is below a depth of 10 feet. Available water capacity is high, organic-matter content is moderate, and natural fertility is high.

Most areas of these soils are used for crops. Some areas remain in trees or wooded pasture. Controlling erosion and maintaining good tilth are the principal management concerns.

Representative profile of Hayden loam, 2 to 6 percent slopes, in Wells Township, 1,920 feet east and 30 feet north of southwest corner of sec. 1, T. 110 N., R. 21 W.

A1—0 to 2 inches, very dark gray (10YR 3/1) loam; weak, fine, granular structure; friable; about 2 percent coarse fragments; neutral; abrupt, wavy boundary.

A21—2 to 4 inches, very dark grayish-brown (10YR 3/2) loam, light gray (10YR 6/1) dry; moderate, thin, platy structure; friable; about 2 percent coarse fragments; slightly acid; clear, wavy boundary.

A22—4 to 8 inches, dark grayish-brown (10YR 4/2) and dark-brown (10YR 4/3) loam, gray (10YR 5/1) dry; moderate, thin, platy structure; friable; about 2 percent coarse fragments; medium acid; clear, wavy boundary.

B1t—8 to 11 inches, dark grayish-brown (10YR 4/2) and dark-brown (10YR 4/3) clay loam; moderate, fine, subangular blocky structure; friable; about 4 percent coarse fragments; many, thin, continuous, dark grayish-brown (10YR 4/2) clay films on faces of peds; medium acid; clear, wavy boundary.

B21t—11 to 20 inches, yellowish-brown (10YR 4/4) clay loam; moderate, fine, subangular blocky structure; friable; about 4 percent coarse fragments; many, thin, dark yellowish-brown (10YR 5/4) clay films on faces of peds; medium acid; clear, wavy boundary.

B22t—20 to 36 inches, yellowish-brown (10YR 5/4) clay loam; weak, medium, prismatic structure; friable; about 4 percent coarse fragments; common, thin, dark yellowish-brown (10YR 4/4) clay films on faces of peds; slightly acid; clear, wavy boundary.

B3t—36 to 40 inches, yellowish-brown (10YR 5/4) clay loam; weak, medium, subangular blocky structure; friable; about 4 percent coarse fragments; common, fine, prominent, yellowish-red (5YR 4/8) mottles; common, thin, dark-brown (10YR 3/3) clay films on faces of peds; neutral; abrupt, wavy boundary.

C—40 to 60 inches, light olive-brown (2.5Y 5/4) loam; massive; friable; about 4 percent coarse fragments; few, fine, faint, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/6) mottles and common, fine, prominent, yellowish-red (5YR 4/8) mottles; mildly alkaline; strongly effervescent.

Thickness of the solum and depth to free carbonates range from 30 to 45 inches. In uncultivated areas these soils have a very dark gray A1 horizon about 1 to 5 inches thick. The A1 and Ap horizons are loam, silt loam, or sandy loam. In cultivated areas the Ap horizon is grayish brown or light grayish brown when dry. The Ap and A1 horizons are slightly acid to medium acid. The A2 horizon is dark grayish-brown or grayish-brown loam or sandy loam about 2 to 6 inches thick. Its structure is weak, fine or medium, platy or subangular blocky. Its reaction is slightly acid to medium acid. In cultivated areas the A2 horizon has been incorporated with the Ap horizon. The B horizon is loam or clay loam about 25 to 35 inches thick. The maximum content of clay is in the B21t and B22t horizons. The C horizon has free lime in the form of threads and soft masses.

Hayden soils have a thinner A1 horizon and a lighter colored Ap horizon than the associated Lester soils. They have more sand and less silt in the A and B horizons than the similar Renova soils.

**Hayden loam, 2 to 6 percent slopes** (HaB).—This soil is on irregularly shaped knolls that range from 5 to 80 acres in size. Slopes are 80 to 150 feet long. This soil occurs above more sloping Hayden soils and is closely associated with Dundas, Le Sueur, and Webster soils. It has the profile described as representative of the series. The layers are thinner where slopes are more convex.

Included with this soil in mapping are small areas of Dundas, Le Sueur, and Webster soils. These are identified on the soil map by a symbol for drainageway or depression. Also included are small areas where the surface layer is fine sandy loam and sandy loam or is gravelly. The sandy loam areas are identified on the soil map by a sand symbol, and the gravelly areas by a gravel symbol. In addition, a few areas of eroded soils are included.

Runoff is medium. The hazard of erosion is moderate. Good tilth is hard to maintain without special management practices. This soil is used mostly for crops, but a few areas remain in trees. Capability unit IIe–2; woodland group 1; building site group 5.

**Hayden loam, 6 to 12 percent slopes** (HaC).—This soil is on irregularly shaped knolls and hillsides that range from 5 to 20 acres in size. Slopes are 80 to 150 feet long. This soil has a profile similar to the one described as representative of the series, but the soil layers are thinner where slopes are more convex.

Included with this soil in mapping are a few small areas of Dundas, Le Sueur, and Webster soils in concave positions. On the soil map these are identified by a symbol for drainageway or depression. Also included are small areas where the surface layer is fine sandy loam and sandy loam or is gravelly. The sandy loam areas are identified on the soil map by a sand symbol, and the gravelly areas by a gravel symbol. A few small areas of convex, sloping Storden soils and a few areas of eroded soils are also included.

Runoff is medium. The hazard of erosion is moderate to severe. Good tilth is hard to maintain without special management practices. This soil is well suited to most crops grown in the county. Capability unit IIIe–2; woodland group 1; building site group 5.

**Hayden loam, 12 to 18 percent slopes** (HaD).—This soil is on a few irregularly shaped knolls that range from 5 to 20 acres in size, but most of it is in 5- to 20-acre tracts on hillsides that are crossed in many places by shallow, downslope draws and in a few places by deep ravines. Slopes are 80 to 120 feet long. This soil has a profile similar to the one described as representative of the series, but the soil layers are thinner, especially where the slopes are more convex.

Included with this soil in mapping are areas where slopes are less than 12 percent or more than 18 percent. The shallow downslope drains are occupied by included Dundas, Le Sueur, or Webster soils. Also included are small areas where the surface layer is fine sandy loam and sandy loam or is gravelly. On the soil map these are identified by a sand symbol or by a gravel symbol, respectively. A few small areas of Storden soils are included where slopes are convex and a few areas of eroded soils are also included.

Runoff is rapid. The hazard of erosion is severe. South- and west-facing slopes have much greater variations in soil temperature than those facing east and north. Some areas of this soil are used for crops. Capability unit IVe–2; woodland group 1; building site group 5.

**Hayden loam, 18 to 30 percent slopes** (HaE).—This soil is on a few irregularly shaped knolls that range from 5 to 20 acres in size, but most of it is in tracts of 5 to 20 acres on hillsides that are crossed in many places by shallow downslope draws and deep ravines. Slopes are 80 to 150 feet long. This soil has a profile similar to the one described as representative of the series, but its layers are thinner.

Included with this soil in mapping are a few areas where slopes are less than 18 percent or more than 30 percent. The shallow downslope draws are occupied by included Dundas, Le Sueur, or Webster soils. Also included are small areas where the surface layer is fine sandy loam and sandy loam or is gravelly. On the soil map these are identified by a symbol for sand or for gravel, as appropriate. In addition, small areas of included Storden soils are on some of the more convex hillsides.

Runoff is rapid. The hazard of erosion is very severe. South- and west-facing slopes have much greater variations in soil temperature than slopes facing east and north. This soil is used for trees or as permanent pasture. Capability unit VIe–1; woodland group 1; building site group 5.

## Judson Series

The Judson series consists of gently sloping to sloping, well drained to moderately well drained, silty soils that formed in more than 40 inches of silty alluvium. These soils are on toe slopes of the more rolling soils. The native vegetation was tall prairie grass and other grasses, deciduous trees, and willows.

In a representative profile the surface layer is very dark brown and black silt loam about 30 inches thick. The subsoil is yellowish-brown, very friable silt loam about 30 inches thick. The underlying material is yellowish-brown, very friable silt loam.

Permeability is moderate. Runoff is medium. Depth to the water table commonly ranges from 2 to 5 feet. Available water capacity is high, and organic-matter content and natural fertility are high.

Most areas of these soils are used for crops. Some areas are permanent pasture or are wooded.

Representative profile of Judson silt loam, 4 to 12 percent slopes, in Northfield Township, 1,400 feet east

and 75 feet north of center of sec. 22, T. 111 N., R. 19 W.

A11—0 to 5 inches, very dark brown (10YR 2/2) silt loam; structureless to weak, very fine, granular structure; very friable; slightly acid; abrupt, smooth boundary.
A12—5 to 16 inches, black (10YR 2/1) silt loam; weak, very fine, granular structure; very friable; slightly acid; clear, wavy boundary.
A13—16 to 30 inches, very dark brown (10YR 2/2) silt loam; black (10YR 2/1) coatings on faces of peds; weak, medium, subangular blocky structure; very friable; few bleached sand and silt grains on faces of peds; slightly acid; clear, wavy boundary.
B21—30 to 40 inches, yellowish-brown (10YR 5/4) silt loam; dark yellowish brown (10YR 4/4) coatings on faces of peds; weak, medium, subangular blocky structure; very friable; few bleached sand and silt grains on faces of peds; medium acid; clear, wavy boundary.
B22—40 to 60 inches, yellowish-brown (10YR 5/4) silt loam; dark yellowish-brown (10YR 4/4) coatings on faces of peds; few, fine, faint, strong-brown (7.5YR 5/8) mottles; few bleached sand and silt grains on faces of peds; weak, medium and coarse, subangular blocky structure; very friable; medium acid; clear, wavy boundary.
C—60 to 94 inches, yellowish-brown (10YR 5/4) silt loam; few, fine, faint, grayish-brown (2.5Y 5/2) mottles and few, fine, faint, strong-brown (7.5YR 5/8) mottles; massive; very friable; neutral.

The solum ranges from 40 to 60 inches in thickness. The A horizon is black, very dark brown, or very dark gray silt loam about 18 to 35 inches thick. The B horizon is dark-brown, brown, dark yellowish-brown, or yellowish-brown silt loam about 20 to 35 inches thick.

Judson soils have more silt and less sand than the similar Terril soils. They have a thicker A horizon than the associated Port Byron soils.

**Judson silt loam, 4 to 12 percent slopes** (JuC).—This soil is in areas 3 to 40 acres in size. It is associated with the Port Byron and Garwin soils. Included with this soil in mapping are a few small areas of Port Byron soils. Also included are small areas of Garwin soils in narrow draws, some of which are indicated on the soil map by the symbol for drainageway. A few areas where slopes are nearly 15 percent are also included.

This soil is seasonally wet. Runoff is medium, and the hazard of erosion is moderate. Most areas of this soil are used for crops and are well suited to this use. Capability unit IIIe–1; woodland group 1; building site group 6.

## Kasson Series

The Kasson series consists of nearly level to gently sloping, moderately well drained soils that formed in a silty mantle and in the underlying firm, loamy glacial drift. A sandy layer commonly separates the silt mantle from the loamy material. The native vegetation was dominantly oak or brush.

In a representative profile the surface layer is very dark grayish-brown silt loam about 7 inches thick. The subsurface layer is dark grayish-brown, friable silt loam about 3 inches thick. The subsoil is about 48 inches thick. The upper 14 inches of the subsoil is brown, friable silty clay loam, and the lower part is dark yellowish-brown and yellowish-brown, firm loam. The underlying material is olive-brown and dark yellowish-brown, firm loam.

Permeability is moderately slow. Runoff is slow to medium. Depth to the water table commonly ranges from 2 to 5 feet. Available water capacity is high, organic-matter content is moderate, and natural fertility is medium.

Some areas of these soils are used for crops and some for trees or permanent pasture. Kasson soils are well suited to most crops grown in the county and have few limitations. Maintaining good tilth and fertility is the major management need.

Representative profile of Kasson silt loam, 1 to 3 percent slopes, in Wheeling Township, 2,600 feet north and 50 feet east of southwest corner of sec. 22, T. 110 N., R. 19 W.

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; massive (cloddy); friable; neutral; abrupt, smooth boundary.
A2—7 to 10 inches, dark grayish-brown (10YR 4/2) silt loam, gray (10YR 6/1) dry; weak, thin, platy structure; friable; medium acid; clear, wavy boundary.
B21—10 to 18 inches, brown (10YR 4/3) silty clay loam; dark grayish brown (10YR 4/2) on faces of peds; moderate, fine and medium, subangular blocky structure; friable; common bleached silt and sand grains on faces of peds; strongly acid; clear, wavy boundary.
B22—18 to 24 inches, brown (10YR 4/3) silty clay loam; dark grayish brown (10YR 4/2) on faces of peds; common, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, fine, prismatic structure; firm; common, thick, dark grayish-brown (2.5Y 4/2) clay films on faces of peds and in old root channels; very strongly acid; clear, wavy boundary.
IIB23—24 to 40 inches, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/6) loam; many, fine, distinct, grayish-brown (10YR 5/2) mottles; moderate, coarse, prismatic structure that breaks to moderate, fine and medium, subangular blocky; firm; about 5 percent coarse fragments; thick, light-gray (10YR 7/1), bleached silt and sand grains on faces of peds; few thick clay films on faces of peds and in old root channels; strongly acid; clear, wavy boundary.
IIB3—40 to 58 inches, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/6) loam; weak, coarse, prismatic structure; firm; about 5 percent coarse fragments; very thick, continuous, light-gray (10YR 7/1), bleached silt and sand grains on faces of peds; medium acid; clear, wavy boundary.
IIC—58 to 78 inches, olive-brown (2.5Y 4/4) and dark yellowish-brown (10YR 4/4) loam; massive; firm; about 5 percent coarse fragments; light-gray (10YR 7/1) lime segregations; calcareous; mildy alkaline.

The solum ranges from 40 to 72 inches in thickness. The Ap horizon is very dark grayish brown to black and dries to grayish brown or dark grayish brown. In undisturbed areas there is a black to very dark grayish-brown A1 horizon 3 to 8 inches thick. Reaction is neutral to medium acid. The A2 horizon is dark grayish brown or brown and ranges from 2 to 4 inches in thickness. Structure is weak or moderate, thin or medium, platy. Reaction is slightly acid to medium acid.

The B21 horizon is silt loam to silty clay loam and the B22 horizon is silt loam, loam, or silty clay loam. Reaction in the B21 and B22 horizons is medium acid to very strongly acid. The IIB23 horizon, where present, is variable in texture and ranges from sand to loam. It commonly ranges from 2 to 10 inches in thickness. Reaction is medium acid or strongly acid. The IIB3 horizon is loam or sandy clay loam that generally is firm but ranges from slightly firm to very firm. Thickness of the IIB3 horizon ranges from 15 to 30 inches. Primary structure is weak or moderate, medium or coarse, prismatic. Some profiles have weak or moderate, fine or medium, angular or subangular blocky secondary structure in this horizon. Clay films are on the faces of prisms in some profiles. Reaction is medium acid or strongly acid, but in some places it is slightly acid or neutral in the lower part. The IIC horizon is loam or sandy clay loam. It commonly is calcareous and mildly alkaline, but the upper part is leached in some places.

Kasson soils have a brighter B horizon than the associated Skyberg soils. They have a thinner dark-colored A horizon than the similar Klinger soils.

**Kasson silt loam, 1 to 3 percent slopes** (KaA).—This soil is on slight rises in the uplands. Included with it in mapping are a few small areas of Skyberg soils. Also included are small areas of soils that have a thinner, lighter colored surface layer than this soil and a higher content of clay in the upper part of the subsoil. In a few areas, sandy gravel beds are below a depth of 6 feet.

This soil is seasonally wet. Runoff is slow to medium. The hazard of erosion is slight. The soil can be properly tilled only within a narrow range of moisture content. The different textural layers in the root zone slow the movement of water through the soil. This soil is used for crops, trees, or wooded pasture. Capability unit IIe–3; woodland group 2; building site group 8.

## Kato Series

The Kato series consists of nearly level, poorly drained, silty soils that formed in 2 to 3 feet of silty sediment over coarse sand and fine gravel. These soils are on broad flats and in depressions and sluggish drainageways on outwash plains and terraces. The native vegetation was water-tolerant prairie grasses.

In a representative profile the surface layer is black and very dark gray silty clay loam about 20 inches thick. The subsoil is mottled, olive-gray and light olive-gray, silty clay loam about 9 inches thick. The underlying material is mottled, light olive-gray and light-gray sand and gravelly coarse sand.

Permeability is moderate. Runoff is slow to ponded. Depth to the water table commonly ranges from 0 to 3 feet. Available water capacity is moderate to high. Organic-matter content and fertility are high.

Most areas of these soils are used for crops. The soils are well suited to most crops if they are properly drained. Controlling the water table and maintaining good tilth and fertility are the principal management needs.

Representative profile of Kato silty clay loam, in Richland Township, 1,200 feet north and 40 feet east of southwest corner of sec. 10, T. 109 N., R. 19 W.

Ap—0 to 7 inches, black (N 2/0) silty clay loam; massive (cloddy); friable; neutral; abrupt, smooth boundary.

A1—7 to 15 inches, very dark gray (5Y 3/1) silty clay loam; many, fine, distinct, strong-brown (7.5YR 5/8) mottles; weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

A3—15 to 20 inches, very dark gray (5Y 3/1) and dark olive-gray (5Y 3/2) silty clay loam; many, medium, distinct, strong-brown (7.5YR 5/8) mottles; moderate, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

B2g—20 to 29 inches, olive-gray (5Y 5/2) and light olive-gray (5Y 6/2) silty clay loam that has a moderate content of sand; many, medium, distinct, strong-brown (7.5YR 5/8) mottles; weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

IIC1g—29 to 39 inches, light olive-gray (5Y 6/2) sand that has a few pebbles; few inclusions of sandy loam; many, medium, distinct, strong-brown (7.5YR 5/8) mottles; single grained; loose; neutral; clear, wavy boundary.

IIC2g—39 to 64 inches, light-gray (5Y 7/2) and light olive-gray (5Y 6/2) gravelly coarse sand; single grained; loose; neutral in upper part, mildly alkaline and strongly effervescent in lower part.

Thickness of the solum and depth to the coarse-textured IIC horizon range from 24 to 40 inches. The Ap and A1 horizons are silty clay loam or silt loam and range from 13 to 20 inches in combined thickness. Reaction is slightly acid to neutral. The A3 horizon ranges from silty clay loam to silt loam and from 3 to 6 inches in thickness. Reaction is slightly acid or neutral. The B2 horizon is 8 to 18 inches thick; its texture ranges from silt loam to silty clay loam. The IIC horizon commonly is sand, coarse sand, or gravelly coarse sand, but in some profiles it is stratified sand and gravel or is calcareous in all parts.

Kato soils have more silt and less sand in the A and B horizons than the similar Biscay soils.

**Kato silty clay loam** (0 to 2 percent slopes) (Kc).—This soil occupies tracts that range from 3 to 100 acres in size on outwash plains and terraces. Included with it in mapping are a few small areas where the surface layer is calcareous and a few areas where the surface layer is loamy rather than silty.

This soil is wet, and improved drainage is needed for most crops presently grown. Tile drainage effectively removes excess water. Maintaining tilth and fertility is a minor management need. Capability unit IIw–2; woodland group 7; building site group 9.

## Kilkenny Series

The Kilkenny series consists of gently sloping to steep, well-drained soils that formed in a mantle of shaly, loamy till 3 to 10 feet thick. These soils occupy convex positions on knolls and side slopes. Slopes are both simple and complex. Slopes range from 2 to 25 percent and generally are 75 to 200 feet long. The native vegetation was deciduous trees and tall prairie grass.

In a representative profile the surface layer is very dark gray clay loam, about 7 inches thick. The subsurface layer is very dark gray clay loam about 4 inches thick. The subsoil is friable or firm clay loam, about 34 inches thick, that is mainly olive brown. The lower 6 inches of the subsoil is grayish brown and light olive brown. The underlying material is mottled, light olive-brown, friable, calcareous clay loam.

Permeability is moderately slow. Runoff is medium to rapid. The water table is below a depth of 10 feet. Available water capacity is high. Organic-matter content is moderate, and natural fertility is high.

Some areas of these soils are wooded, and some are cultivated. Kilkenny soils are suited to most crops if they are properly managed. Maintaining good tilth and controlling erosion are the principal management needs.

Representative profile of Kilkenny clay loam, 6 to 12 percent slopes, eroded, in Erin Township, 1,400 feet west and 60 feet south of northeast corner of sec. 14, T. 111 N., R. 22 W.

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

A2—7 to 11 inches, very dark gray (10YR 3/1) and dark grayish-brown (10YR 4/2) clay loam, dark grayish brown (10YR 4/2) rubbed, gray (10YR 5/1) dry; fine, medium, subangular blocky structure; friable; medium acid; clear, wavy boundary.

B1t—11 to 15 inches, olive-brown (2.5Y 4/3) clay loam, grayish brown (10YR 5/2) dry; very dark grayish-brown (10YR 3/2) coatings on faces of peds; moderate, medium, subangular blocky structure; friable; about 2 percent coarse fragments; common thin clay films on faces of peds; pitting and etching on ped surfaces; strongly acid; clear, wavy boundary.

B21t—15 to 24 inches, olive-brown (2.5Y 4/4) clay loam; very dark grayish-brown (10YR 3/2) coatings on faces of peds; moderate, medium, prismatic structure; firm; about 2 percent coarse fragments; many bleached sand and silt grains on faces of peds; common thin clay films on faces of peds; strongly acid; clear, wavy boundary.

B22t—24 to 33 inches, olive-brown (2.5Y 4/4) clay loam; moderate, medium, prismatic structure; firm; about 2 percent coarse fragments; many, thick, very dark grayish-brown (10YR 3/2) clay films on faces of of peds; strongly acid; clear, wavy boundary.

B23t—33 to 39 inches, light olive-brown (2.5Y 5/4) clay loam; moderate, medium, prismatic structure; firm; about 4 percent coarse fragments; many, thick, very dark grayish-brown (10YR 3/2) clay films on faces of peds; medium acid; clear, wavy boundary.

B3t—39 to 45 inches, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) clay loam; moderate, medium, subangular blocky structure; firm; about 4 percent coarse fragments; few, medium, dark-brown (10YR 4/3) clay films on faces of peds; slightly acid; clear, wavy boundary.

C—45 to 80 inches, light olive-brown (2.5Y 5/4) clay loam; many, fine, distinct, grayish-brown (2.5Y 5/2) mottles; massive; friable; about 4 percent coarse fragments; mildly alkaline; slightly effervescent.

Thickness of the solum and depth to free carbonates range from 36 to 54 inches. The A horizon ranges from very dark gray to very dark grayish brown. The A1 or Ap horizon is clay loam, loam, or silt loam and ranges from 5 to 10 inches in thickness. Structure is weak, fine, granular or subangular blocky in undisturbed areas, and in some profiles it is weak or moderate, medium, subangular blocky where the soils are cultivated. Reaction is slightly acid to medium acid. The A2 horizon is loam, clay loam, or silty clay loam and is 1 to 4 inches thick. Structure is weak, medium, platy in some profiles. Part of this horizon is incorporated into the Ap horizon in some profiles. Reaction is slightly acid to medium acid. The B1 horizon is clay loam, silty clay loam, or loam. The B2 horizon is clay loam, silty clay loam, silty clay, or clay. The B horizon ranges from 28 to 45 inches in combined thickness. The B1 horizon is strongly or medium acid, the B2 horizon is medium to very strongly acid, and the B3 horizon is slightly acid or medium acid.

Kilkenny soils have more clay in their B2 horizon than the the similar Lester soils. They have brighter colors in the B horizon than the associated Lerdal soils.

**Kilkenny clay loam, 2 to 6 percent slopes** (KkB).—This soil occupies areas that range from 5 to 20 acres in size and is on knolls that have concave and convex relief. Slopes are 80 to 150 feet in length. This soil has a profile similar to the one described as representative of the series, but the surface layer is thicker and darker in color because of less erosion.

Included with this soil in mapping are a few areas of eroded soils that have a surface layer less than 10 inches thick. Also included, in shallow draws or downslope drainageways, are a few small areas of Lerdal and Shields soils.

Runoff is medium, and the hazard of erosion is moderate. This soil is used mostly for cultivated crops, but a few areas remain in trees. Capability unit IIe–3; woodland group 2; building site group 7.

**Kilkenny clay loam, 6 to 12 percent slopes, eroded** (KkC2).—This soil is in areas that range from 5 to 20 acres in size. It is on knolls that have concave and convex slopes and on uniform sidehills below less sloping Kilkenny soils. Slopes range from 80 to 150 feet in length. This soil has the profile described as representative of the series. Erosion, deep tillage, and tree removal have mixed part of the brownish subsoil into the surface layer. The resulting surface layer is lighter in color, lower in organic-matter content, and less friable than one in an uneroded area.

Included with this soil in mapping are a few areas where free-lime carbonates are near a depth of 20 inches, a few slopes that are less than 6 percent or more than 12 percent, a few narrow swales of Mazaska and Cordova soils, and depressions of Glencoe soils. Also included are small areas of Dundas, Lerdal, and Shields soils. These are in narrow, shallow draws, on concave slopes, or in downslope drains. A soil that has a thickened surface layer commonly occurs at the base of the slope and is included because it is in narrow areas and makes up only a small acreage.

Runoff is medium to rapid on this Kilkenny soil, and the hazard of erosion is severe. A few uneroded areas remain in trees, but much of the acreage is used for cultivated crops. Capability unit IIIe–3; woodland group 2; building site group 7.

**Kilkenny clay loam, 12 to 18 percent slopes, eroded** (KkD2).—This soil is in areas of 5 to 20 acres. It is mainly on hillsides that are crossed in many places by narrow draws and in a few places by deep ravines. A few areas of the soil are on irregularly shaped knolls. Slopes are 80 to 150 feet long. This soil has a profile similar to the one described as representative of the series, but the soil layers are thinner where slopes are convex.

Included with this soil in mapping are a few areas where slopes are less than 12 percent or more than 18 percent and small areas of Storden soils on convex side slopes. Shallow, narrow, downslope drainageways are occupied by Shields, Lerdal, Mazaska, and Cordova soils. Small gravelly areas are identified on the soil map by a gravel symbol. A soil that has a thickened surface layer is at the base of many slopes. It is included in mapping because it is only in narrow areas. Also included are some areas of uneroded soils that are wooded.

Runoff is rapid on this Kilkenny soil, and the hazard of erosion is severe. Good tilth is hard to maintain without special management practices. This soil is used for crops, trees, or wooded pasture. Capability unit IVe–3; woodland group 2; building group 7.

**Kilkenny clay loam, 18 to 25 percent slopes** (KkE).—This soil is on wooded and pastured side slopes. Slopes are 80 to 300 feet long and are both convex and concave. This soil is dissected in many places by shallow, downslope drains and by a few abrupt and deep, narrow ravines. The soil has a profile similar to the one described as representative of the series, but the surface layer is thicker and the subsoil is thinner.

Included with this soil in mapping are a few small areas of Storden soils on convex side slopes, a few areas of Estherville soils mixed with Storden soil, and some areas that have a thin mantle of sandy loam. A few eroded areas in which the surface layer consists mostly of subsoil material are also included.

Runoff is rapid, and the hazard of erosion is very severe. This soil is mainly wooded, but a few areas of it are used as permanent pasture. The steep, wooded slopes provide an esthetic enhancement of the natural environment. Capability unit VIe–1; woodland group 2; building site group 7.

## Klinger Series

The Klinger series consists of nearly level to gently sloping, moderately well drained, silty soils. These soils formed in multilayered material consisting of a silty mantle over loamy glacial drift and commonly an intervening coarser textured layer. Slopes are uniform. The native vegetation was tall prairie grass.

In a representative profile the surface layer is black silt loam about 14 inches thick. The upper part of the subsoil

is mottled, very dark grayish-brown, brown, and yellowish-brown, friable silt loam about 15 inches thick. The lower part is yellowish-brown, firm loam about 18 inches thick. The underlying material is calcareous, yellowish-brown, firm loam.

Permeability is moderately slow. Runoff is slow to medium. Depth to the water table commonly ranges from 2 to 5 feet. Available water capacity is high. Organic-matter content and natural fertility are high.

Most areas of these soils are in crops. Klinger soils have few limitations that affect crop growth. Controlling erosion in the more sloping areas and maintaining good tilth and a high level of fertility are the major management needs.

Representative profile of Klinger silt loam, 1 to 3 percent slopes, in Cannon City Township, 670 feet north and 60 feet west of southeast corner of sec. 25, T. 110 N., R. 20 W.

A1—0 to 14 inches, black (10YR 2/1) silt loam; weak, fine, granular structure; friable; slightly acid; abrupt, smooth boundary.

B1—14 to 18 inches, very dark grayish-brown (10YR 3/2) silt loam; moderate, fine and medium, subangular blocky structure; friable; crushes to dark brown (10YR 3/3); tongues of black (10YR 2/1) from above; medium acid; clear, wavy boundary.

B21—18 to 24 inches, brown (10YR 5/3) silt loam; many, fine, faint, grayish-brown (10YR 5/2) mottles; moderate, fine and medium, subangular blocky structure; friable; medium acid; clear, wavy boundary.

B22—24 to 29 inches, yellowish-brown (10YR 5/4) silt loam; many, fine, faint, brown (10YR 5/3) mottles; moderate, fine and medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

IIB31—29 to 36 inches, yellowish-brown (10YR 5/4) loam; moderate, fine and medium, subangular blocky structure; firm; about 5 percent coarse fragments; slightly acid; clear, wavy boundary.

IIB32—36 to 47 inches, yellowish-brown (10YR 5/6) loam; moderate, fine and medium, subangular blocky structure; firm; about 5 percent coarse fragments; neutral; clear, wavy boundary.

IIC—47 to 60 inches, yellowish-brown (10YR 5/6) loam; massive; firm; about 5 percent coarse fragments; few, light-gray (10YR 7/2), feathered segregations of lime; slightly effervescent; mildly alkaline.

Thickness of the solum and depth to free carbonates range from 40 to 60 inches. The thickness of the loess mantle ranges from 18 to 32 inches. The A horizon and the part of the B horizon that formed in loess range from silt loam to light silty clay loam. Some profiles have an A3 horizon that is as much as 8 inches thick and is very dark gray to very dark grayish brown. The A horizon ranges from 8 to 16 inches in thickness. Reaction in this horizon ranges from slightly acid to medium acid.

The B1 and B2 horizons range from 6 to 16 inches in combined thickness. In some profiles a stone line or partly sorted layer, as much as 12 inches thick, separates the part of the profile that formed in loess from the part that formed in till. Texture is variable in such layers, and it ranges from gravelly loamy sands or gravelly sandy loam to loamy sand, sandy loam, or sandy clay loam. The rest of the IIB horizon and the IIC horizon typically are loam but range to sandy clay loam in a few profiles. Reaction in the B1, B2, and IIB31 horizons ranges from medium acid to slightly acid. A few thin clay films are on faces of peds in the B horizon of some profiles.

The Klinger soils in this county are outside the range defined for the series because they have less translocated clay in their B horizon and have higher chroma in the upper part of that horizon. These differences do not appreciably alter their usefulness and behavior.

The Klinger soils are associated mainly with Ostrander and Maxfield soils and are similar to the Merton soils. They have mottles in the upper part of the B horizon, whereas the well-drained Ostrander soils lack mottles in that part. They have a brighter colored B horizon than the wetter Maxfield soils. Klinger soils have firm consistence in the IIB and IIC horizons, whereas the Merton soils have friable consistence in those horizons.

**Klinger silt loam, 1 to 3 percent slopes** (KlA).—This soil is in areas that range from 3 to 100 acres in size. Included with it in mapping are a few small areas of Maxfield and Ostrander soils. Also included are small areas of Maxfield soils in draws, which are identified on the soil map by the drainageway symbol. Also included are a few areas where the convex slopes are slightly eroded, some areas of soils that have thinner surface and subsurface layers, and in some places soils that are similar to Klinger soils but have a thinner mantle of loess.

This soil has few limitations to use for crops. Wetness is a slight limitation and tile is installed in a few areas to remove excess water. This soil is used mostly for crops and is well suited to this use. Capability unit I–1; woodland group 1; building site group 8.

## Lake Beaches

Lake beaches (La) consists of sandy and gravelly material, occurring on beaches, sandbars, and ice ramparts around the edges of the lakes and larger peat bogs. The materials are so intermingled and so variable that they cannot be classified by soil series (fig. 7).

This land type is wet or droughty, depending on lake levels or drainage development. Most of the mapping unit is in its natural state, but a few areas are cropped where the adjacent organic soils are artificially drained. Capability unit VIw–1; woodland group 7; building site group 13.

## Lerdal Series

The Lerdal series consists of nearly level to moderately steep, moderately well drained to somewhat poorly drained, loamy soils that formed in a mantle of shaly, clayey material 3 to 10 feet thick. These soils are on till plains in uplands. Slopes are simple and complex, and they range from 1 to 18 percent. They commonly are 75 to 150 feet in length. The native vegetation was deciduous trees.

In a representative profile the surface layer is very dark gray silt loam about 6 inches thick. The subsoil is about 34 inches thick. The upper 7 inches of the subsoil is dark grayish-brown, firm clay loam; the middle part is mottled, grayish-brown, very firm clay; and the lower 8 inches is mottled, grayish-brown, firm clay loam. The underlying material is calcareous, olive-gray, friable clay loam.

Permeability is slow. Runoff is medium to rapid. Depth to the water table commonly ranges from 2 to 5 feet. The available water capacity is high. Organic-matter content is moderate to high, and natural fertility is medium.

Some areas of these soils are used for crops, and some areas are wooded. Maintaining good tilth and controlling erosion are the principal management needs.

Representative profile of Lerdal silt loam, 1 to 6 percent slopes, in Erin Township, 1,200 feet east and 30 feet north of center of sec. 26, T. 111 N., R. 22 W.

Ap—0 to 6 inches, very dark gray (10YR 3/1) silt loam; cloddy; friable; slightly acid; abrupt, smooth boundary.

B1—6 to 8 inches, dark grayish-brown (2.5Y 4/2) clay loam; moderate, fine and very fine, subangular blocky

*Figure* 7.—**Shoreline of one of the many lakes in the county.**

structure; friable; about 2 percent coarse fragments; few dark-gray (10YR 4/1) and very dark gray (10YR 3/1) root channels; slightly acid; clear, wavy boundary.

B21tg—8 to 13 inches, dark grayish-brown (2.5Y 4/2) clay loam; moderate, fine and medium, subangular blocky structure; firm; about 2 percent coarse fragments; common, fine, distinct, light olive-brown (2.5Y 5/4) mottles; few, flaky, shale fragments; common, thin, dark grayish-brown (2.5Y 4/2) clay films on faces of peds; very strongly acid; clear, wavy boundary.

B22tg—13 to 18 inches, grayish-brown (2.5Y 5/2) clay; moderate, fine and medium, subangular blocky structure; firm; about 2 percent coarse fragments; common, fine, distinct, light olive-brown (2.5Y 5/4) mottles; many, thin, dark grayish-brown (2.5Y 4/2) clay films on faces of peds; very strongly acid; clear, wavy boundary.

B23tg—18 to 25 inches, grayish-brown (2.5Y 5/2) clay; moderate, medium, prismatic structure; firm; about 2 percent coarse fragments; many, fine, distinct, light olive-brown (2.5Y 5/4) mottles; common, fine, rounded, sand-size shale particles; many, thin, dark grayish-brown (2.5Y 4/2) clay films on faces of peds; medium acid; clear, wavy boundary.

B24tg—25 to 32 inches, grayish-brown (2.5Y 5/2) clay; medium, coarse, prismatic structure; firm; about 2 percent coarse fragments; many, fine, distinct, light olive-brown (2.5Y 5/4) mottles; many, fine, black root channels filled with clay; many, thin, dark grayish-brown (2.5Y 4/2) clay films on faces of peds; slightly acid; clear, wavy boundary.

B3tg—32 to 40 inches, grayish-brown (2.5Y 5/2) clay loam; many, fine, faint, light olive-brown (2.5Y 5/4) mottles; massive; firm; about 4 percent coarse fragments; few black filllings in root channels; slightly acid; abrupt, smooth boundary.

Cg—40 to 64 inches, olive-gray (5Y 5/2) clay loam; massive; friable; about 4 percent coarse fragments; common feathered segregations of lime; strongly effervescent; mildly alkaline.

Thickness of the solum and depth to free carbonates ranges from 35 to 60 inches. The Ap horizon is black or very dark gray silt loam, silty clay loam, or clay loam about 6 to 10 inches thick. Its reaction is slightly acid or medium acid. An A2 horizon is present in some profiles. It is as much as 4 inches thick and very dark gray or dark gray. It is clay loam or silty clay loam. Its structure is weak, fine, granular or moderate,

medium, platy. Reaction is slightly acid or medium acid. This A2 horizon commonly is incorporated into the Ap horizon.

The B1 horizon is clay loam or silty clay loam 2 to 8 inches thick. Its reaction is slightly acid or medium acid. The B2 horizon is silty clay loam that is high in sand, clay loam, clay, or silty clay. Mottles range from few to many and from prominent to distinct in these horizons. Consistence is firm or very firm, and reaction is very strongly acid to slightly acid. The C horizon is loam, clay loam, or silty clay loam that has enough sand to feel gritty. Consistence is friable or firm. A few soft masses of lime are in the upper part of this horizon in some profiles.

Lerdal soils have a higher content of clay than the similar Le Sueur soils. They have more grayish colors in the B horizon than the associated Kilkenny soils.

**Lerdal silt loam, 1 to 6 percent slopes** (LbB).—This soil is on knolls, gentle rises, and hilltops that range from 5 to 30 acres in size. Slopes are 75 to 150 feet long. This soil has the profile described as representative of the series.

Included with this soil in mapping are a few areas of eroded soils. In these the surface layer is mixed with some of the subsoil and is now lower in organic-matter content and less friable. Also included are a few areas of soils that have lime as near as 20 inches to the surface and a few small areas of Dundas, Glencoe, Kilkenny, Rolfe, Mazaska, and Shields soils.

Runoff is medium and the hazard of erosion is moderate. Wetness is a slight limitation. Good tilth is hard to maintain without special management practices. Bulk-density value of the surface layer is much lower in wooded areas. A few areas are wooded, but much of this soil is used for crops. Capability unit IIe–3; woodland group 2; building site group 7.

**Lerdal clay loam, 6 to 12 percent slopes, eroded** (LeC2).—This soil is on 5- to 20-acre knolls and has concave and convex slopes. In places it is also on hillsides. It has a profile similar to that described as representative of the series but is eroded. The resulting surface layer of clay loam is lower in organic-matter content and is less friable than the original one. The surface layer is thinnest where the slopes are convex.

Included with this soil in mapping are a few small areas of Kilkenny and Shields soils.

Runoff is medium, and the hazard of erosion is severe. Wetness is a slight limitation. Good tilth is hard to maintain without special management practices. Most of this soil is used for crops. Capability unit IIIe–3; woodland group 2; building site group 7.

**Lerdal clay loam, 12 to 18 percent slopes, eroded** (LeD2).—This soil is on knolls that are 5 to 20 acres in size and have concave and convex slopes. In places it is also on hillsides. It has a profile similar to the one described as representative of the series but is eroded. The resulting surface layer is lighter colored clay loam that contains less organic matter and is less friable than the original surface layer. The surface layer is thinnest where the slopes are convex.

Included with this soil in mapping are a few small areas of Kilkenny and Shields soils.

Runoff is rapid, and the hazard of erosion is severe. Good tilth is hard to maintain without special management practices. Most areas of this soil are used for crops. Capability unit IVe–3; woodland group 2; building site group 7.

## Lester Series

The Lester series consists of undulating to steep, well-drained, loamy soils that formed in glacial till. These soils are on knolls and the sides of hills and valleys on the upland till plain. Slopes are convex and concave. The native vegetation was deciduous trees and tall prairie grasses.

In a representative profile the surface layer is black loam about 5 inches thick. The subsurface layer, about 3 inches thick, is very dark gray, friable loam. The subsoil is about 32 inches thick. The upper 6 inches of the subsoil is brown, friable clay loam; the middle part is brown and dark yellowish-brown, friable clay loam; and the lower 4 inches is light olive-brown, friable loam. The underlying material also is light olive-brown loam.

Permeability is moderate. Runoff is medium to rapid. The water table is below a depth of 10 feet. The available water capacity is high, organic-matter content is moderate to high, and natural fertility is high.

Most of the less sloping areas of these soils are used for crops. The steeper areas are wooded or in permanent pasture. The hazard of erosion is the major limitation to use of these soils for crops, and maintaining good tilth is a special management need.

Representative profile of Lester loam, 2 to 6 percent slopes, in Wells Township, 2,440 feet east and 60 feet south of northwest corner of sec. 2, T. 110 N., R. 21 W.

A1—0 to 5 inches, black (10YR 2/1) loam; weak, fine, granular structure; friable; about 2 percent coarse fragments; neutral; abrupt, smooth boundary.

A2—5 to 8 inches, very dark gray (10YR 3/1) loam; weak, fine and medium, subangular blocky structure; friable; common bleached sand grains on faces of peds; about 2 percent coarse fragments; slightly acid; abrupt, smooth boundary.

B1—8 to 14 inches, brown (10YR 4/3) clay loam; very dark grayish-brown (10YR 3/2) coatings on faces of peds; strong, medium, angular blocky structure; friable; few bleached sand grains on faces of peds; about 4 percent coarse fragments; slightly acid; clear, wavy boundary.

B21t—14 to 22 inches, brown (10YR 4/3) clay loam; dark-brown (10YR 3/3) coatings on faces of peds; strong, medium, angular blocky structure; friable; few thin clay films on faces of peds; few bleached sand grains on faces of peds; about 4 percent coarse fragments; medium acid; clear, wavy boundary.

B22t—22 to 36 inches, dark yellowish-brown (10YR 4/4) clay loam; moderate, coarse, prismatic structure; friable; many, thin, dark-brown (10YR 3/3) clay films on faces of peds; about 4 percent coarse fragments; some root channels filled with black (10YR 2/1) and very dark gray (10YR 3/1) clay films; medium acid; clear, wavy boundary.

B3t—36 to 40 inches, light olive-brown (2.5Y 4/4) loam; strong, coarse, prismatic structure; friable; many, thin, dark-brown (10YR 3/3) clay films on faces of peds; about 4 percent coarse fragments; some root channels filled with black (10YR 2/1) and very dark gray (10YR 3/1) clay films; slightly acid; abrupt, smooth boundary.

C—40 to 64 inches, light olive-brown (2.5Y 5/4) loam; massive; about 4 percent coarse fragments; common, fine, distinct, light olive-brown (2.5Y 5/6) and light brownish-gray (2.5Y 6/2) mottles; strongly effervescent; mildly alkaline.

The solum ranges from 25 to 48 inches in thickness. The Ap horizon, or A1 horizon, is black, very dark gray, or very dark grayish brown. Structure is weak, fine or medium, subangular blocky or weak, fine, granular. Reaction is slightly acid or medium acid. The A1 horizon is 6 to 10 inches thick and is neutral or slightly acid. The A2 horizon is very dark gray to dark grayish brown. Dry color is dark grayish brown or grayish brown. Structure is weak, thin, platy; weak, fine, subangular

blocky; or weak, fine, granular. Reaction is slightly acid or medium acid. Thickness of the A2 horizon is as much as 4 inches, but in some profiles this horizon is incorporated with the Ap horizon. The B1 horizon is dark brown or brown and is slightly acid or medium acid. The B2 horizon is medium or strongly acid. Its combined thickness is 9 to 22 inches. The B3 horizon is slightly acid or neutral.

Lester soils have a thinner A1 horizon and more clay in the B horizon than the associated Clarion soils. They have a thicker A1 horizon and a darker colored Ap horizon than the associated Havden soils. Lester soils formed in glacial till, whereas the similar Moland soils formed in multiple glacial materials.

**Lester loam, 2 to 6 percent slopes** (L1B).—This soil is on irregularly shaped knolls that range from 5 to 80 acres in size. It is above more sloping Lester soils. This soil has the profile described as representative of the series. Slopes are 80 to 150 feet long. The soil layers are thinner where slopes are more convex.

Included with this soil in mapping are a few small areas of Storden soils where slopes are convex. The concave slopes are occupied by small areas of Dundas, Le Sueur, or Webster soils, and these are identified on the soil map by a symbol for drainageway or depression. Small gravelly pockets are identified by a gravel symbol.

Runoff is medium. The hazard of erosion is moderate. Good tilth is hard to maintain without special management practices. Most of this soil is used for crops. A few areas are wooded. Capability unit IIe–1; woodland group 1; building site group 5.

**Lester loam, 6 to 12 percent slopes** (L1C).—This soil is on irregularly shaped knolls and hillsides that range from 5 to 20 acres in size. Slopes are 80 to 150 feet long. This soil has a profile similar to the one described as representative of the series, but the soil layers are thinner where slopes are move convex.

Included with this soil in mapping are a few areas of soils that have slopes of less than 6 percent or more than 12 percent and small areas of sloping Storden soils that have convex slopes. The concave slopes are occupied by small areas of Dundas, Le Sueur, or Webster soils; these are identified on the soil map by a symbol for drainageway or depression. Also included are small gravelly areas identified by gravel symbol, and a few eroded areas where part of the subsoil has been mixed with the original surface layer.

Runoff is medium. The hazard of erosion is moderate. A high level of fertility and good tilth are hard to maintain without special management practices. Some of this soil is wooded, and some is used for crops (fig. 8). The soil is well suited to most crops grown in the county. Capability unit IIIe–1; woodland group 1; building site group 5.

**Lester loam, 6 to 12 percent slopes, eroded** (L1C2).—This soil is on irregularly shaped knolls and hillsides that have convex and concave slopes and are 5 to 20 acres in size. Slopes are 80 to 150 feet long. This soil has a profile

*Figure 8.*—**Contour strips on Lester soils to help control erosion.**

similar to the one described as representative of the series, but erosion, tree removal, and deep tillage have caused a mixing of part of the subsoil with the original surface layer. The present surface layer has less organic matter and is less friable than the original one. The more convex slopes have thinner soil layers.

Included with this soil in mapping are a few areas where slopes are less than 6 percent or more than 12 percent and small convex areas of sloping Storden soils. The concave slopes are occupied by Dundas, Le Sueur, and Webster soils that are identified on the soil map by a symbol for drainageway or depression. Also included are small areas of gravelly soils that are identified by a gravel symbol and a few areas of uneroded soils.

Runoff is medium, and the hazard of erosion is severe. Good tilth is hard to maintain without special management practices. Most of this soil is used for crops. Capability unit IIIe–1; woodland group 1; building site group 5.

**Lester loam, 12 to 18 percent slopes, eroded** (LlD2).—This soil is on a few irregularly shaped knolls 5 to 20 acres in size, but most areas of it are 5 to 20 acres in size and are on hillsides that are crossed in many places by narrow draws and in a few places by deep ravines. Slopes are 80 to 150 feet long. This soil has a profile similar to the one described as representative of the series, but because of erosion part of the subsoil has been mixed with the original surface layer. The present surface layer is lower in organic-matter content and less friable than the original one. The more convex slopes have thinner soil layers.

Included with this soil in mapping are a few areas where slopes are less than 12 percent or more than 18 percent; small convex areas of sloping Storden soils; shallow, narrow, downslope drains that are occupied by Dundas, Le Sueur, or Webster soils; and small gravelly areas that are identified on the soil map by a gravel symbol. A soil that has a thickened surface layer is at the base of many slopes and is included because the areas are narrow. Also included are some wooded areas of uneroded soil.

Runoff is rapid, and the hazard of erosion is severe. Good tilth is hard to maintain without special management practices. Part of the acreage is used for crops, but many areas are used for pasture or remain in trees. Capability unit IVe–1; woodland group 1; building site group 5.

**Lester loam, 18 to 25 percent slopes** (LlE).—This soil occupies wooded and pastured slopes along the major rivers and their tributaries. Slopes are 80 to 300 feet long and are both convex and concave. This soil is dissected in many places by shallow, downslope drains and in a few places by abrupt, deep and narrow ravines. This soil has a profile similar to the one described as representative of the series, but the soil layers are thinner.

Included with this soil in mapping are a few small, convex areas of sloping Storden soils; a few areas where Estherville soils are intermingled with the Storden soils; and some areas of soils that have a thin mantle of sandy loam. A few areas of eroded soils in which the surface layer consists mostly of subsoil material are also included.

Runoff is rapid, and the hazard of erosion is severe. Most of this soil is wooded, but a few areas are used for permanent pasture. The steep, wooded slopes commonly limit use of this soil to esthetic enhancement of the natural environment. Capability unit VIe–1; woodland group 1; building site group 5.

## Le Sueur Series

The Le Sueur series consists of nearly level to gently sloping, moderately well drained to somewhat poorly drained, loamy soils that formed in friable loam or clay loam glacial till. These soils are on knolls and a few hillsides on the upland till plain. Slopes range from 1 to 3 percent, are both uniform and complex, and are 75 to 100 feet in length. The native vegetation was mixed hardwoods.

In a representative profile the surface layer is black and very dark gray clay loam about 14 inches thick. The subsoil, about 22 inches thick, is mostly very dark grayish-brown and dark grayish-brown, friable clay loam. The underlying material is calcareous, mottled, grayish-brown clay loam.

Permeability is moderate. Runoff is slow to medium. Depth to the water table commonly ranges from 2 to 5 feet. Available water capacity is high. Organic-matter content and natural fertility are high.

Most areas of Le Sueur soils are in crops, but some remain in trees. These soils are well suited to most crops and have few limitations.

Representative profile of Le Sueur clay loam, 1 to 3 percent slopes, in Forest Township, 1,700 feet north and 150 feet east of southwest corner of sec. 36, T. 111 N., R. 21 W.

A1—0 to 11 inches, black (10YR 2/1) clay loam; weak, fine, granular structure; friable; about 2 percent coarse fragments; slightly acid; clear, wavy boundary.

A3—11 to 14 inches, very dark gray (10YR 3/1) clay loam; weak, fine, subangular blocky structure; friable; common, medium, gray (10YR 6/1 dry), porous coatings on faces of peds; about 2 percent coarse fragments; slightly acid; clear, wavy boundary.

B1—14 to 19 inches, very dark grayish-brown (10YR 3/2) clay loam; weak, fine and medium, subangular blocky structure; friable; about 4 percent coarse fragments; many, thin, dark-gray (10YR 4/1), porous coatings on faces of peds; slightly acid; clear, wavy boundary.

B21t—19 to 29 inches, dark grayish-brown (10 YR 4/2) clay loam; moderate, medium, prismatic structure that breaks to moderate, medium, subangular blocky; friable; about 4 percent coarse fragments; few, fine, faint, light olive-brown (2.5Y 5/4) mottles; common, thin, dark-gray (10YR 4/1), porous coatings on faces of peds; many thin clay films on faces of peds; medium acid; clear, wavy boundary.

B22t—29 to 33 inches, dark grayish-brown (2.5Y 4/2) clay loam; moderate, medium, prismatic structure; friable; about 4 percent coarse fragments; few, fine, faint, olive-brown (2.5Y 5/4) mottles; black (10YR 2/1) fillings in some root channels; many thin clay films on faces of peds; medium acid; clear, wavy boundary.

B3t—33 to 36 inches, olive-brown (2.5Y 4/4) clay loam; many, fine, distinct, yellowish-brown (10YR 5/6) mottles; moderate, medium, subangular blocky structure; friable; about 4 percent coarse fragments; many, thin, dark grayish-brown (2.5Y 4/2) clay films on faces of peds; common, black (10YR 2/1), clayey fillings in root channels; neutral; clear, wavy boundary.

C—36 to 64 inches, grayish-brown (2.5Y 5/2) loam; many, fine, faint, light olive-brown (2.5Y 5/4) mottles; massive; common feathered segregations of lime; friable; about 4 percent coarse fragments; strongly effervescent; mildly alkaline.

The solum ranges from 30 to 50 inches in thickness. The Ap and A1 horizons are black or very dark gray clay loam or loam. Their structure is weak, fine, granular or weak, fine and medium, subangular blocky. Their reaction is slightly acid to medium acid. The A1 horizon is 6 to 12 inches thick. The A3 horizon is lacking in some profiles, but in others it ranges to as much as 5 inches in thickness. Reaction is slightly acid to

medium acid. The B horizon ranges from 22 to 40 inches in thickness. The B3 horizon is loam or clay loam. The C horizon is clay loam or loam.

Le Sueur soils have less clay in the B horizon than the similar Lerdal soils. They have more clay in the B horizon than the similar Nicollet soils.

**Le Sueur clay loam, 1 to 3 percent slopes** (Lu A).—This soil is on rises that range from 5 to 30 acres in size. It is within areas of Hayden, Lester, Webster, and Glencoe soils and occurs on hilltops above more sloping Lester soils. Included with it in mapping, near the major rivers, are a few areas of soils that have a thinner surface layer.

This soil has few limitations to use for crops. Seasonal wetness is a moderate limitation, however. Most of the acreage is in crops, but some areas remain in trees. Capability unit I–1; woodland group 1; building site group 6.

## Marsh

Marsh (Ma) is in shallow lakes and ponds, in shallow bays, and along the fringes of the larger lakes. The water is shallow, and areas of open water are small. Water-tolerant reeds, sedges, and shrubs grow in these areas.

Several marshes have been preserved and developed to provide suitable environment for wildlife. A few areas have been developed for field crops. The soil material is generally peat, muck, or limnic materials. Capability unit VIIIw–1; woodland group 8; building site group 12.

## Maxcreek Series

The Maxcreek series consists of nearly level, poorly drained, silty soils that formed in 2 to 3 feet of silty sediment over loamy glacial deposits. In a few places a sandy layer separates the silty material from the underlying friable, loamy glacial drift. The largest acreage is on broad upland flats, but these soils also occupy depressions and sluggish drainageways. The native vegetation was principally grass in wet prairie.

In a representative profile the surface layer is black and very dark gray silty clay loam about 18 inches thick. The upper part of the subsoil is mottled, olive-gray and dark grayish-brown, friable silt loam about 8 inches thick. The lower part is mottled, olive, friable silt loam about 10 inches thick. The underlying material is mottled, grayish-brown loam.

Permeability is moderate. Runoff is slow to ponded. Depth to the water table commonly ranges from 0 to 3 feet or is near the depth of tile where the soils are drained. Available water capacity is high. Organic-matter content and natural fertility are high.

Most areas of these soils are in crops. Undrained, the soils are only moderately well suited to poorly suited to most crops. If adequately drained, they are well suited to crops. Controlling the water table and maintaining good tilth are the major management needs.

Representative profile of Maxcreek silty clay loam, in Richland Township, 1,500 feet south and 100 feet west of center of sec. 34, T. 109 N., R. 19 W.

Ap—0 to 8 inches, black (N 2/0) silty clay loam; weak, fine, subangular blocky structure (cloddy); friable; neutral; abrupt, smooth boundary.

A12—8 to 14 inches, black (N 2/0) silty clay loam; weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

A3—14 to 18 inches, very dark gray (2.5Y 3/1) silty clay loam; weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

B21—18 to 26 inches, dark grayish-brown (2.5Y 4/2) and olive-gray (5Y 4/2) silt loam; common, fine, distinct, light olive-brown (2.5Y 5/4) and yellowish-brown (10YR 5/6) mottles; weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

B22g—26 to 36 inches, olive (5Y 4/3) silt loam; few, prominent, yellowish-brown (10YR 5/8) mottles; weak, fine, subangular blocky structure; friable; neutral; clear, wavy boundary.

IICg—36 to 68 inches, grayish-brown (2.5Y 5/2) loam; many, prominent, yellowish-brown (10YR 5/6) mottles; areas of olive gray (5Y 4/2); massive; friable; about 5 percent coarse fragments; slightly effervescent; mildly alkaline.

Thickness of the solum ranges from 30 to 44 inches, and that of the loess over glacial till ranges from 26 to 40 inches. In some profiles an A1 horizon as much as 6 inches thick underlies the Ap horizon and is silty clay loam or silt loam. Reaction in these horizons commonly is neutral but ranges from slightly acid to mildly alkaline. The A1 and Ap horizons are 10 to 16 inches in combined thickness. The A3 horizon is 4 to 10 inches thick and is neutral or mildly alkaline in reaction. The lower boundary of this horizon in some profiles tongues into the B horizon.

The B horizon typically is neutral or mildly alkaline. This horizon, which formed in the overlying sediment, has subangular blocky structure. The B2 horizon is silty clay loam or silt loam. The B21 horizon is gray, dark grayish brown, or olive gray. In some profiles mottles increase in abundance with depth. In some profiles there is a IIB horizon that formed in glacial till and has prismatic structure. The IICg horizon typically is loam, but the upper part is sandy clay loam to sandy loam and loamy sand. Thickness of the coarser textured upper part typically ranges from 5 to 10 inches, but this part is lacking in some profiles. Depth to free lime ranges from 20 to 40 inches.

Maxcreek soils have more silt and less sand in the A and B horizons than the similar Webster soils. They are friable in the glacial till, whereas the similar Maxfield soils are firm in the glacial till. Maxcreek soils lack free lime in the A horizon, but the associated Canisteo soils have free lime in that horizon.

**Maxcreek silty clay loam** (0 to 2 percent slopes) (Mb).—This soil occupies tracts that are 3 to 50 acres in size. It has the profile described as representative of the series. Small areas of Canisteo and Merton soils are included with this soil in mapping. Also included are some areas where the silty mantle is thinner or is loamy and has a high content of silt.

This soil is wet. Runoff is slow. Depth to the water table commonly ranges from 0 to 3 feet in the undrained areas. Improved drainage is needed for most crops presently grown. A properly designed and installed drainage system effectively removes excess water. Most areas of this soil have been drained and are used for crops. Capability unit IIw–1; woodland group 7; building site group 10.

**Maxcreek silty clay loam, swales** (0 to 2 percent slopes) (Mc).—This soil is in small depressions and in long, winding, low-gradient swales 5 to 40 acres in size. It has a profile similar to the one described as representative of the series, but the surface layer is somewhat thicker and colors of the subsoil are grayer. Included with this soil in mapping are a few small areas of Canisteo soils and soils that have a calcareous surface layer.

This soil is very wet. Runoff is slow to ponded. Depth to the water table commonly ranges from 0 to 3 feet in undrained areas. Improved drainage is needed for most crops presently grown. A properly designed and installed drainage system effectively removes excess water. Surface waterways are used in places to prevent ponding. Most of the acreage is used for crops. Capability unit IIIw–1; woodland group 8; building site group 12.

## Maxfield Series

The Maxfield series consists of nearly level, poorly drained, silty soils that formed in 2 to 3 feet of silty sediment over loamy glacial deposits. In a few areas of these soils, a sandy layer separates the silty material from the underlying firm, loamy glacial drift. Maxfield soils are mainly on broad upland flats. They also occupy depressions and sluggish drainageways. The native vegetation was principally water-tolerant prairie grasses.

In a representative profile the surface layer is black and very dark gray silty clay loam about 20 inches thick. The upper part of the subsoil is mottled, dark grayish-brown, friable silt loam about 7 inches thick. The lower part is mottled, yellowish-brown, firm loam about 18 inches thick. The underlying material is yellowish-brown loam.

Permeability is moderate to moderately slow. Runoff is slow to ponded. Depth to the water table commonly ranges from 0 to 3 feet. Available water capacity is high. Organic-matter content and natural fertility are high.

Most areas of Maxfield soils are in crops. Undrained, these soils are only moderately well suited to poorly suited to most crops. Where these are adequately drained, they are well suited to crops. Controlling the water table and maintaining good tilth are the major management needs.

Representative profile of Maxfield silty clay loam, in Wheeling Township, 2,660 feet east and 60 feet north of southwest corner of sec. 31, T. 110 N., R. 19 W.

Ap—0 to 8 inches, black (N 2/0) silty clay loam; weak, fine, granular structure (cloddy); friable, sticky; neutral; abrupt, smooth boundary.

A1—8 to 15 inches, black (N 2/0) silty clay loam; weak, fine, granular structure; friable, sticky; neutral; clear, wavy boundary.

A3—15 to 20 inches, very dark gray (10YR 3/1) silty clay loam; weak, fine, granular structure; friable, sticky; neutral; clear, wavy boundary.

B21g—20 to 23 inches, dark grayish-brown (2.5Y 4/2) silt loam; few, fine, distinct, light olive-brown (2.5Y 5/6) mottles; weak, fine, subangular blocky structure; friable, sticky; neutral; clear, wavy boundary.

B22g—23 to 27 inches, dark grayish-brown (2.5Y 4/2) silt loam; few, medium, distinct, light olive-brown (2.5Y 5/6) mottles; weak, fine, subangular blocky structure; friable, sticky; neutral; clear, wavy boundary.

IIB3—27 to 37 inches, yellowish-brown (10YR 5/4) loam; common, fine, distinct, grayish-brown (2.5Y 5/2) mottles; weak, fine, subangular blocky structure; firm, extremely hard when dry; about 5 percent coarse fragments; neutral; clear, wavy boundary.

IIB32—37 to 45 inches, yellowish-brown (10YR 5/4) loam; common, fine, distinct, grayish-brown (2.5Y 5/2) mottles; weak, fine, subangular blocky structure; firm, extremely hard when dry; about 5 percent coarse fragments; neutral; clear, wavy boundary.

IIC—45 to 64 inches, yellowish-brown (10YR 5/4) loam; common, fine, distinct, grayish-brown (2.5Y 5/2) mottles and few, medium, distinct, strong-brown (7.5YR 5/8) mottles; firm, extremely hard when dry; massive; about 5 percent coarse fragments; mildly alkaline.

The solum ranges from 36 to 50 inches in thickness. In some profiles an A1 horizon, as much as 7 inches thick, underlies the Ap horizon and is silty clay loam or silt loam. Reaction in the Ap and A1 horizons commonly is neutral but in places is slightly acid. Combined thickness of these horizons is 10 to 16 inches. The A3 horizon is 4 to 8 inches thick and is silt loam or silty clay loam. Reaction is neutral to slightly acid. The lower part of this horizon in some profiles tongues into the B horizon. Mottles commonly increase in abundance with depth in the B horizon. Reaction in the B horizon typically is neutral but in places is slightly acid. The B2 horizon is silty clay loam or silt loam. The B21g horizon is gray, dark grayish brown, or olive gray. The 11B3g horizon is typically loam, but the upper part ranges from sandy clay loam to sandy loam or loamy sand in some profiles. Thickness of this horizon typically ranges from 5 to 18 inches, but the horizon is lacking in some profiles. Depth to free lime ranges from 20 to 40 inches.

Maxfield soils have more silt and less sand in the A and B horizons than the similar Webster soils. Maxfield soils are firm in the glacial till, whereas the similar Maxcreek soils are friable in the glacial till.

**Maxfield silty clay loam** (0 to 2 percent slopes) (Mf).—This soil is in areas of 3 to 50 acres. It has the profile described as representative of the series. Small areas of Canisteo and Klinger soils are included with this soil in mapping. In some included areas, the silty mantle is thinner or is loamy and has a high content of silt.

This soil is wet. Runoff is slow. Depth to the water table commonly ranges from 0 to 3 feet in undrained areas. Improved drainage is needed for most crops presently grown. A properly designed and installed drainage system effectively removes excess water. Most of the acreage has been drained and is used for crops. Capability unit IIw–1; woodland group 7; building site group 10.

**Maxfield silty clay loam, swales** (0 to 2 percent slopes) (Mh).—This soil is in small depressions and in long, winding, low-gradient swales 5 to 40 acres in size. It has a profile similar to the one described as representative of the series, but the surface layer is somewhat thicker and colors of the subsoil are grayer.

Included with this soil in mapping are a few small areas of Canisteo soils and of soils that have a calcareous surface layer.

This soil is very wet. Runoff is slow to ponded. Depth to the water table commonly ranges from 0 to 3 feet in undrained areas. Improved drainage is needed for most crops presently grown. A properly designed and installed drainage system effectively removes excess water. Surface waterways are used in places to prevent ponding. Most of the acreage is used for crops. Capability unit IIIw–1; woodland group 8; building site group 12.

## Mazaska Series

The Mazaska series consists of nearly level, poorly drained soils on uplands that formed in the upper part of a shaly, clayey mantle 3 to 10 feet thick. These soils are in nearly flat areas and in shallow draws on uplands. The native vegetation was deciduous trees and water-tolerant prairie grasses.

In a representative profile the surface layer is black and is about 15 inches thick. The upper part of this layer is silty clay loam about 6 inches thick, and the lower part is clay loam. The subsoil is mottled, olive-gray, firm clay loam and clay about 27 inches thick. The underlying material is calcareous, mottled, olive-gray, friable clay loam.

Permeability is slow. Runoff is slow. Depth to the water table commonly ranges from 0 to 3 feet. Available water capacity is high. Organic-matter content and natural fertility are high.

Some areas of Mazaska soils are in crops, and some remain in trees or wooded pasture. These soils are well suited to most crops. Maintaining good tilth and fertility and controlling the water table are the major management needs.

Representative profile of Mazaska silty clay loam, in Erin Township, 1,280 feet east and 960 feet south of northwest corner of sec. 12, T. 111 N., R. 22 W.

A1—0 to 6 inches, black (10YR 2/1) silty clay loam; weak, fine, subangular blocky structure; sticky, friable; slightly acid; abrupt, smooth boundary.

A3—6 to 15 inches, black (10YR 2/1) clay loam, dark gray (10YR 4/1) and gray (10YR 5/1) dry; moderate, fine and medium, subangular blocky structure; sticky, friable; few, thin, porous, grayish coatings on faces of peds; medium acid; abrupt, smooth boundary.

B21tg—15 to 22 inches, olive-gray (5Y 5/2) clay loam; moderate, fine and medium, subangular blocky structure; sticky, firm; few, thick, very dark grayish-brown (2.5Y 3/2) clay films on faces of peds; about 3 percent coarse fragments, mostly shale; very strongly acid; abrupt, smooth boundary.

B22tg—22 to 34 inches, olive-gray (5Y 5/2) clay; common, fine, prominent, dark-brown (7.5YR 4/4) mottles; moderate, fine and medium, prismatic structure parting to moderate, fine and medium, subangular blocky; sticky, firm; common, thick, very dark gray (5Y 3/1) and dark-gray (5Y 4/1) clay films on faces of peds; about 8 percent coarse fragments, mostly shale; very strongly acid; abrupt, smooth boundary.

B3tg—34 to 42 inches, olive-gray (5Y 5/2) clay; common, fine, distinct, light olive-brown (2.5Y 5/6) mottles; moderate, fine and medium, prismatic structure parting to moderate, fine and medium, subangular blocky; sticky, firm; olive-gray (5Y 4/2 and 3/2) clay films on faces of peds and in old root channels; about 3 percent coarse fragments, mostly shale; strongly acid; abrupt, smooth boundary.

C—42 to 62 inches, oilve-gray (5Y 5/2) clay loam; many, medium, prominent, light olive-brown (2.5Y 5/6) mottles; massive; sticky, friable; some dark-colored concentrations; few lime pebbles; about 5 percent coarse fragments; slightly effervescent; mildly alkaline.

The solum ranges from 30 to 50 inches in thickness. The Ap and A1 horizons are silt loam or silty clay loam. In undisturbed areas, the A1 horizon is black or very dark gray and ranges from 4 to 8 inches in thickness. Reaction in the Ap and A1 horizons is medium acid or slightly acid. Some profiles have a thin A2 horizon that is slightly acid or medium acid. In the B horizon the faces of peds vary considerably in color. The darkest colors on faces of peds commonly are in the middle or upper part of the B horizon. The B2 horizon ranges from clay loam or silty clay loam to silty clay or clay. This horizon is 35 to 50 percent clay. Reaction in the B2 horizon ranges from medium acid to very strongly acid. The B3g horizon ranges from clay loam or silty clay loam to clay or silty clay. The C horizon ranges from clay loam or silty clay loam to clay.

The Mazaska soils have more clay in the B horizon than the similar Cordova soils.

**Mazaska silty clay loam** (0 to 2 percent slopes) (Mk).—This soil is in areas that range from 5 to 80 acres in size. Included with it in mapping are a few small areas of Cordova, Rolfe, and Shields soils and some areas of soils adjacent to the rims of drainageways that have a calcareous surface layer.

This soil is wet. Depth to the water table commonly ranges from 0 to 3 feet in undrained areas. Runoff is slow. Improved drainage is needed for crops presently grown. A properly designed and installed drainage system effectively removes excess water. Most of the acreage is in crops. Capability unit IIw–1; woodland group 7; building site group 11.

## Merton Series

The Merton series is made up of nearly level to gently sloping, moderately well drained, silty soils on uplands. These soils formed in multilayered material that consists of a loess mantle over loam glacial till. A coarser textured layer is between those two kinds of material some places. Slopes are uniform. The native vegetation was tall prairie grass.

In a representative profile the surface layer is black silt loam about 15 inches thick. The subsoil is about 31 inches thick. The upper part of the subsoil is dark grayish-brown and light olive-brown, friable silt loam about 13 inches thick. The lower part is light olive-brown and dark grayish-brown, friable loam about 18 inches thick. The underlying material is calcareous, light olive-brown, friable loam.

Permeability is moderate. Runoff is slow to medium. Depth to the water table commonly ranges from 2 to 5 feet. Available water capacity is high. Organic-matter content and natural fertility are high.

These soils are mostly in crops. They have few limitations that affect their use for crops. Controlling erosion in the more sloping areas and maintaining good tilth and a high level of fertility are the major management needs.

Representative profile of Merton silt loam, 1 to 3 percent slopes, in Richland Township, 700 feet south and 30 feet west of center of sec. 34, T. 109 N., R. 19 W.

Ap—0 to 8 inches, (10YR 2/1) silt loam; weak, fine, subangular blocky structure (cloddy); friable; slightly acid; abrupt, smooth boundary.

A3—8 to 15 inches, black (10YR 2/1) silt loam, very dark grayish brown (10YR 3/2) rubbed; weak, fine, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

B1—15 to 22 inches, dark grayish-brown (2.5Y 4/2) silt loam; few tongues of very dark gray (10YR 3/1); weak, fine, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

IIB21—22 to 28 inches, light olive-brown (2.5Y 5/4) silt loam, high in content of sand; dark grayish-brown (2.5Y 4/2) coatings on faces of peds; weak, fine and medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

IIB22—28 to 34 inches, dark grayish-brown (2.5Y 4/2) loam; few, fine, faint, light olive-brown (2.5Y 5/4) mottles; weak, fine and medium, subangular blocky structure; friable; about 5 percent coarse fragments; slightly acid; clear, wavy boundary.

IIB23—34 to 46 inches, light olive-brown (2.5Y 5/4) loam; weak, medium, prismatic structure parting to moderate, fine and medium, subangular blocky; friable; about 5 percent coarse fragments; neutral; clear, wavy boundary.

IIC—46 to 60 inches, light olive-brown (2.5Y 5/4) loam; massive; friable; about 5 percent coarse fragments; mildly alkaline; strongly effervescent.

The solum ranges from 36 to 60 inches in thickness. The mantle of loess ranges from 18 to 24 inches in thickness. The Ap and A1 horizons are silt loam 8 to 16 inches thick. Their reaction is slightly or medium acid. The A3 horizon is black, dark gray, or very dark grayish brown and is 3 to 8 inches thick. Its reaction is slightly acid or medium acid. The B1 and IIB21 horizons are 6 to 13 inches in combined thickness. The B1 horizon is medium acid or slightly acid. The IIB22 horizon is variable in texture. It is sand, sand and gravel, loamy sand, sandy loam, sandy clay loam, or loam, and it ranges from 0 to 12 inches in thickness. Reaction ranges from medium acid to neutral in the IIB horizon. The IIC horizon typically is loam but is sandy loam in some profiles.

Merton soils have more silt and less sand in the A horizon and in the upper part of the B horizon than the similar Nicollet soils. They formed in multiple glacial materials, whereas the Nicollet soils formed entirely in glacial till. Merton soils have friable consistence in the IIB and IIC horizons, but the similar Klinger soils have firm consistence in those horizons.

**Merton silt loam, 1 to 3 percent slopes** (MnA).—This soil occupies tracts that range from 3 to 100 acres in size. Included with it in mapping are a few small areas of

Maxcreek and Moland soils. Narrow draws of Maxcreek soils are identified on the soil map by the drainageway symbol. Also included are a few areas of soils that have a mantle of loess as much as 30 inches thick and a few areas of slightly eroded soils that have convex slopes and a thinner surface layer.

This soil has few limitations that affect its use for crops. Wetness is a slight limitation, and tile lines are installed in a few areas to remove excess water. Most of the acreage is used for crops and is well suited to this use. Capability unit I–1; woodland group 1; building site group 6.

## Moland Series

The Moland series is made up of gently sloping to moderately steep, well-drained, silty soils on uplands. These soils formed in multilayered material that consists of a loess mantle over loam glacial till. A coarser textured layer is between these two kinds of material in some places. Slopes are slightly convex. The native vegetation was mainly tall prairie grass. A few slope crests supported a thin stand of brush.

In a representative profile the surface layer is black and dark-brown silt loam about 14 inches thick. The subsoil is 35 inches thick. The upper part of the subsoil is dark-brown, friable silt loam about 6 inches thick. The lower part is yellowish-brown and light olive-brown, friable loam about 29 inches thick. The underlying material is light olive-brown, calcareous, friable loam.

Permeability is moderate. Runoff is medium to rapid. The water table is below a depth of 10 feet. The available water capacity is high. Organic-matter content and natural fertility are high.

These soils are mostly in crops and are well suited to this use. They have few limitations that affect their use for crops. Controlling erosion in the more sloping areas and maintaining high fertility are the major management needs.

Representative profile of Moland silt loam, 2 to 6 percent slopes, in Cannon City Township, 1,240 feet north and 1,280 feet west of southeast corner of sec. 26, T. 110 N., R. 20 W.

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

A3—10 to 14 inches, dark-brown (10YR 3/3) silt loam that has very dark grayish-brown (10YR 3/2) coatings on faces of peds; weak, fine, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

B21—14 to 20 inches, dark-brown (10YR 4/3) silt loam that has dark yellowish-brown (10YR 3/4) coatings on faces of peds; weak, fine and medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

IIB22—20 to 24 inches, yellowish-brown (10YR 5/4) loam that has dark yellowish-brown (10YR 3/4) coatings on faces of peds; weak, medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

IIB23—24 to 31 inches, light olive-brown (2.5Y 5/4) loam that has dark grayish-brown (2.5Y 4/2) coatings on faces of peds; weak, medium, prismatic structure; friable; few bleached sand grains on faces of peds; few thin clay films on faces of peds; about 4 percent coarse fragments; slightly acid; clear, wavy boundary.

IIB31—31 to 45 inches, light olive-brown (2.5Y 5/4) loam that has olive-brown (2.5Y 4/3) coatings on faces of peds; weak, medium, prismatic structure; friable; about 4 percent coarse fragments; slightly acid; clear, wavy boundary.

IIB32—45 to 49 inches, light olive-brown (2.5Y 5/4) loam that has few grayish-brown (2.5Y 5/2) coatings on faces of peds; weak, medium, prismatic structure; friable; about 4 percent coarse fragments; neutral; clear, wavy boundary.

IIC—49 to 64 inches, light olive-brown (2.5Y 5/4) loam; few, fine, distinct, brown (10YR 5/3) mottles; massive; friable; few white segregations of lime; about 4 percent coarse fragments; strongly effervescent; mildly alkaline.

The solum ranges from 36 to 60 inches in thickness. The mantle of loess ranges from 18 to 24 inches in thickness. The Ap horizon is black, very dark brown, or very dark gray. It typically is silt loam, but in some profiles it is loam that is high in content of silt. Reaction is slightly acid or medium acid. The A3 horizon is very dark grayish brown or very dark brown and commonly is 2 to 6 inches in thickness. Reaction is slightly acid or medium acid. This horizon is lacking in some profiles.

The B21 horizon ranges from 4 to 9 inches in thickness. The upper part of the IIB2 horizon is variable in texture. It ranges from loam or sandy clay loam to sandy loam, loamy sand or sand and gravel. The sandy loam or coarser part of this horizon is less than 5 inches thick. Reaction is neutral to medium acid in the B21 and IIB2 horizons. The IIB3 horizon is loam or light clay loam and is 10 to 24 inches thick. Reaction is neutral to slightly acid. The IIC horizon typically is loam but ranges to sandy loam.

Moland soils have more silt and less sand in the A horizon and in the upper part of the B horizon than the similar Clarion and Lester soils. They have friable consistence in the IIB and IIC horizons, whereas the similar Ostrander soils have firm consistence in those horizons.

**Moland silt loam, 2 to 6 percent slopes** (MoB).—This soil occupies knolls and rises that are 3 to 15 acres in size. Slopes are 75 to 150 feet in length and are mainly 3 or 4 percent.

This soil has the profile described as representative of the series.

Included with this soil in mapping are a few small areas of Maxcreek soils in downslope drains. These are identified on the soil map by a wet spot symbol. Also included are a few small areas of Merton soils and a few areas where the loess mantle is as much as 28 inches thick.

Runoff is medium, and the hazard of erosion is moderate. This soil is used mostly for crops. Capability unit IIe–1; woodland group 1; building site group 5.

**Moland silt loam, 6 to 12 percent slopes** (MoC).—This soil is on upland knolls and rises, 3 to 20 acres in size, and on a few irregular hills. It has a profile similar to the one described as representative of the series, but in small areas the soil has been eroded and some of the brownish subsoil has been mixed with the surface layer. Also, a few cobblestones and pebbles are at the surface in some places.

Included with this soil in mapping are a few areas of sharply convex soils on knolls that have a loamy rather than a silty mantle. Also included are a few small areas of Merton soils.

Runoff is medium, and the hazard of erosion is moderate. This soil is used mostly for crops. Capability unit IIIe–1; woodland group 1; building site group 5.

**Moland silt loam, 12 to 18 percent slopes, eroded** (MoD2).—This soil is on upland knolls and rises that are 3 to 20 acres in size. It has a profile similar to that described as representative for the series, but the layers generally are somewhat thinner. Erosion and tillage have resulted in a mixing of some of the subsoil with the surface layer. A few cobblestones and pebbles are at the surface in some places.

Included with this soil in mapping are a few areas of convex soils on knolls that have a loamy rather than a silty

mantle, and a few areas of soils on irregularly shaped hills where slopes are more than 18 percent. Included also are a few small areas of Merton soils and a few small areas of slightly eroded soils.

Runoff is rapid, and the hazard of erosion is severe. This soil is used mostly for crops. Capability unit IVe–1; woodland group 1; building site group 5.

## Muskego Series

The Muskego series consists of nearly level, very poorly drained, muck soils that formed mostly in decomposed reeds and sedges over muck material. These soils are in bogs that formerly were lakes.

In a representative profile the surface layer is black muck about 33 inches thick. Below this is lake sediment of black, coprogenous earth about 38 inches thick. The underlying material is black, dark-gray, and very dark gray, calcareous loam.

Permeability is moderate. Runoff is slow to ponded. Depth to the water table commonly ranges from 0 to 3 feet or, if the soils are drained, near tile depth. Available water capacity and organic-matter content are very high. Natural fertility is low.

Some areas of these soils are in crops. Undrained, the soils are poorly suited to most crops. Where they are adequately drained, they are suited to early maturing crops. Wetness, frost hazard, and soil blowing are the major limitations to the use of these soils for field crops.

Representative profile of Muskego muck, in Cannon City Township, 1,120 feet east and 40 feet south of northwest corner of sec. 5, T. 110 N., R. 20 W.

Oa1—0 to 8 inches, black (N 2/0 broken face and rubbed) sapric material; about 5 percent fibers, less than 5 percent rubbed; weak, very fine, granular structure; fibers are herbaceous; about 45 percent mineral material; neutral; abrupt, smooth boundary.

Oa2—8 to 33 inches, black (N 2/0 broken face and rubbed) sapric material; about 10 percent fibers, less than 5 percent rubbed; fibers are herbaceous; about 25 percent mineral material; medium acid; clear, wavy boundary.

Lco1—33 to 46 inches, black (N 2/0 broken face and rubbed) coprogenous earth; about 10 percent plant detritus; massive; detritus is herbaceous; about 25 percent mineral material; medium acid; gradual, wavy boundary.

Lco2—46 to 71 inches, black (N 2/0 broken face and rubbed) coprogenous earth; about 40 percent mineral material; mildly alkaline; massive; clear, wavy boundary.

IIA11b—71 to 74 inches, black (N 2/0) mucky silt loam; few light-gray (10YR 7/1) snail shells; mildly alkaline; massive; clear, wavy boundary.

IIA12b—74 to 104 inches, dark-gray (2.5Y 4/1) and very dark gray (5Y 3/1) banded loam, sandy clay loam, and sandy loam; mildly alkaline; massive.

The thickness of sapric material over coprogenous earth ranges from 16 to more than 51 inches. The Oa horizon is black or very dark gray and contains a trace to as much as 30 percent fiber. The Lco horizon ranges from 30 to 60 inches or more in thickness. It is black, very dark gray, or very dark grayish brown. The underlying mineral material is mucky silt loam, loam, sandy clay loam, or sandy loam, which begins at a depth ranging from 51 inches to 10 feet or more.

The Muskego soils lack a mineral substratum above a depth of 51 inches, but in the similar Palms soils, a mineral substratum begins at a depth ranging from 16 inches to as much as 51 inches. Muskego soils consist mostly of sapric material over limnic material, whereas the similar Caron soils consist mostly of hemic material over limnic material.

**Muskego muck** (0 to 2 percent slopes) (Mu).—This soil is in small depressions and several large bogs. A few moderately steep sidehill seeps are included. The muck layer is more than 51 inches thick and is underlain by clay loam, silty clay loam, or sandy loam, generally between depths of 60 and 80 inches but at a greater depth in a few places. The edges of the large bogs commonly have a narrow, discontinuous strip of sandy or gravelly underlying material.

Included with this soil in mapping are a few small sandy islands and sandbars. Also included are small areas where the muck is less than 51 inches thick because the surface of the underlying material is irregular. A few areas where the surface layer is calcareous are also included.

Some of the larger areas of this soil are used for crops, and some areas are in pasture, but several of the larger bogs remain in their natural condition. Maintaining adequate drainage and fertility are the major management needs if this soil is to be used for crops. Dikes are needed in some places to control flooding. Capability unit IIIw–2; woodland group 8; building site group 12.

## Nicollet Series

The Nicollet series consists of nearly level to gently sloping, moderately well drained to somewaht poorly drained, loamy soils that formed in loamy glacial till. These soils are on flats and low knolls in the uplands. The native vegetation was tall prairie grass.

In a representative profile the surface layer is black and very dark grayish-brown clay loam about 19 inches thick. The subsoil is mottled, dark grayish-brown, friable clay loam about 21 inches thick. The underlying material is calcareous, grayish-brown, friable loam that has light olive-brown mottles.

Permeability is moderate. Runoff is slow to medium. Depth to the water table commonly ranges from 2 to 5 feet. Available water capacity is high. Organic-matter content and natural fertility are high.

These soils are used mostly for crops, to which they are well suited. They have few limitations for crop production. Maintaining good tilth and a high level of fertility and controlling erosion in the more sloping areas are the major management needs.

Representative profile of Nicollet clay loom, 1 to 3 percent slopes, in Warsaw Township, 1,260 feet west and 20 feet south of northeast corner of sec. 33, T. 109 N., R. 21 W.

Ap—0 to 9 inches, black (10YR 2/1) clay loam; weak, fine, subangular blocky structure (cloddy); friable; about 2 percent coarse fragments; slightly acid; abrupt, smooth boundary.

A1—9 to 14 inches, black (10YR 2/1) clay loam; weak, fine, subangular blocky structure; friable; about 2 percent coarse fragments; slightly acid; clear, wavy boundary.

A3—14 to 19 inches, very dark grayish-brown (10YR 3/2) clay loam; very dark brown (10YR 2/2) coatings on faces of peds; weak, fine, subangular blocky structure; friable; about 4 percent coarse fragments; slightly acid; clear, wavy boundary.

B21—19 to 25 inches, dark grayish-brown (2.5Y 4/2) clay loam; very dark grayish-brown (10YR 3/2) coatings on faces of peds; weak, fine, subangular blocky structure; friable; about 4 percent coarse fragments; slightly acid; clear, wavy boundary.

B22—25 to 30 inches, dark grayish-brown (2.5Y 4/2) clay loam; very dark grayish-brown (10YR 3/2) coatings on faces of peds; few, fine, faint, light olive-brown

(2.5Y 5/4) mottles; weak, fine, subangular blocky structure; friable; about 4 percent coarse fragments; neutral; clear, wavy boundary.

B23—30 to 40 inches, dark grayish-brown (2.5Y 4/2) clay loam; very dark grayish-brown (2.5Y 3/2) coatings on faces of peds; few, fine, distinct, strong-brown (7.5YR 5/8) mottles and few, fine, faint, light olive-brown (2.5Y 5/6) mottles; weak, medium, subangular blocky structure; friable; about 4 percent coarse fragments; neutral; clear, wavy boundary.

C—40 to 60 inches, grayish-brown (2.5Y 5/2) loam; many, fine, faint, light olive-brown (2.5Y 5/4) mottles and few, fine, distinct, strong-brown (7.5YR 5/8) mottles; massive; friable; about 4 percent coarse fragments; mildly alkaline; strongly effervescent.

The solum ranges from 24 to 48 inches in thickness. The Ap and A1 horizons are black or very dark gray and range from 8 to 16 inches in combined thickness. Their reaction is slightly or medium acid. The A3 horizon is very dark gray or very dark grayish brown and is 3 to 6 inches thick. Its reaction is slightly or medium acid. The B22 horizon is dark grayish-brown, very dark grayish-brown, or light olive-brown clay loam or loam that commonly is mottled. The B horizon ranges from 12 to 26 inches in thickness. Reaction in the B horizon is slightly acid or neutral.

Nicollet soils have less clay in the B horizon than the similar Le Sueur soils. They formed almost entirely in glacial till, whereas the similar Merton soils formed in multiple glacial material.

**Nicollet clay loam, 1 to 3 percent slopes** (NcA).—This soil is in 5- to 30-acre upland tracts. It occurs as slight rises within larger areas of Webster soils and as nearly level areas above more sloping Clarion soils.

Included with this soil in mapping are a few areas of soils that have a surface layer of loam. A few small areas of Webster soils and Clarion soils are also included.

This soil has few limitations that affect its use for crops. Wetness is a slight limitation, and tile lines have been installed in a few areas to remove excess water. This soil is used mostly for cultivated crops and is well suited to this use. Capability unit I–1; woodland group 1; building site group 6.

## Ostrander Series

The Ostrander series is made up of nearly level to very steep, well-drained, loamy soils that formed in multilayered material that consists of a silty or loamy mantle and the underlying loamy glacial drift. These soils are on uplands. Slopes are slightly complex. The native vegetation was mainly tall prairie grass, but a few slope crests had thin stands of brush.

In a representative profile the surface layer is black and very dark brown silt loam about 11 inches thick. The upper part of the subsoil is dark-brown and yellowish-brown, friable silt loam about 7 inches thick. The lower part is yellowish-brown, firm loam about 24 inches thick. The underlying material is yellowish-brown, calcareous, firm loam.

Permeability is moderate. Runoff is slow to very rapid. The water table is below a depth of 10 feet. Available water capacity, organic-matter content, and natural fertility all are high.

Most areas of Ostrander soils are in crops. These soils have few limitations that affect their use for crops. Controlling erosion in the more sloping areas and maintaining a high level of fertility are the major management needs.

Representative profile of Ostrander silt loam, 2 to 6 percent slopes, in Cannon City Township, 1,100 feet west and 1,500 feet north of southeast corner of sec. 25, T. 110 N., R. 20 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam; weak, fine, subangular blocky structure (cloddy); friable; neutral; abrupt, smooth boundary.

A3—8 to 11 inches, very dark brown (10YR 2/2) silt loam; black (10YR 2/1) coatings on faces of peds; weak, fine, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

B1—11 to 15 inches, dark-brown (10YR 3/3) silt loam; very dark grayish-brown (10YR 3/2) coatings on faces of peds; weak, fine, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

B21—15 to 18 inches, yellowish-brown (10YR 5/4) silt loam; dark yellowish-brown (10YR 4/4) coatings on faces of peds; weak, fine and medium, subangular blocky structure; friable; medium acid; abrupt, wavy boundary.

IIB22—18 to 27 inches, yellowish-brown (10YR 5/4) loam; moderate, fine, prismatic structure parting to weak, fine and medium, subangular blocky; firm; about 5 percent coarse fragments; few sand and silt grains on faces of peds; medium acid; clear, wavy boundary.

IIB23—27 to 36 inches, yellowish-brown (10YR 5/4) loam; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; firm; about 5 percent coarse fragments; common sand and silt grains on faces of peds; medium acid; clear, wavy boundary.

IIB3—36 to 42 inches, yellowish-brown (10YR 5/6) loam; moderate, medium, prismatic structure; firm; about 5 percent coarse fragments; slightly acid; clear, wavy boundary.

IIC—42 to 60 inches, yellowish-brown (10YR 5/6) loam; massive; firm; about 5 percent coarse fragments; few, fine, faint, strong-brown (7.5YR 5/8) mottles; mildly alkaline; slightly effervescent.

The solum ranges from 36 to 60 inches in thickness. The Ap horizon is black, very dark brown, or very dark gray. It typically is silt loam, but in some profiles it is loam that is high in content of silt. Its reaction is neutral to medium acid. The A3 horizon is very dark grayish brown or very dark brown and is commonly 2 to 6 inches thick. Reaction is slightly acid or medium acid. This horizon is lacking in some profiles.

The B1 and B21 horizons have a combined thickness of 6 to 14 inches. The B1 horizon is lacking in some profiles and is thicker in profiles that lack a B22 horizon. The IIB22 horizon is variable in texture. It ranges from loam, sandy clay loam, and sandy loam to loamy sand or sand and gravel. It commonly is 2 to 10 inches thick, but it is lacking in some profiles. Reaction is neutral to medium acid. The IIB3 horizon is loam or light clay loam 6 to 12 inches thick. Reaction is neutral to medium acid. The IIC horizon typically is loam, but the upper few inches in some profiles is sandy clay loam. Also, Ostrander bedrock substratum soils have limestone bedrock that begins at a depth ranging from 5 to 8 feet.

The Ostrander soils of Rice County are outside the defined range of the series because they lack a stratified IIB2 horizon that has a dominant texture of sandy clay loam. However, this difference does not appreciably affect their usefulness or behavior.

Ostrander soils have a firm IIC horizon, whereas the similar Moland soils have a friable IIC horizon. They have a thicker A1 horizon and a darker colored Ap horizon than the similar Renova soils. Ostrander soils formed in loess and till material, whereas the similar Clarion soils formed in glacial till.

**Ostrander loam, 12 to 18 percent slopes, eroded** (OsD2).—This soil is on knolls and rises 3 to 15 acres in size. Slopes are 100 to 250 feet in length and, in most places, are 14 to 16 percent. The profile of this soil is coarser textured but otherwise is similar to the one described as representative of the series. Because of erosion, the surface layer is mostly very dark brown loam.

Included with this soil in mapping are a few small areas of Maxfield soils in downslope draws, some of which are identified on the soil map by a symbol for drainageway. A few small areas of Klinger soils are also included.

Runoff is rapid, and the hazard of erosion is severe. This soil is used mostly for crops. Capability unit IVe–1; woodland group 1; building site group 8.

**Ostrander loam, 18 to 30 percent slopes, eroded** (OsE2).—This soil is in areas of 3 to 80 acres in the uplands. It has a coarser textured profile than that described as representative of the series, and the soil layers are thinner. Because of erosion, the surface layer is mostly very dark brown loam.

Some uneroded areas are included with this soil in mapping. Westerly facing, convex slopes have a few cobblestones on the surface. The convex knobs in some areas have a gravelly layer. In some places there are small beds of sand and gravel at a depth below 6 feet.

Runoff is very rapid, and the hazard of erosion is very severe. Most areas remain in permanent pasture. Capability unit VIe–1; woodland group 1; building site group 8.

**Ostrander silt loam, 2 to 6 percent slopes** (OtB).—This soil is on knolls and rises 3 to 15 acres in size. Slopes are 100 to 250 feet in length and, in most places, are 3 to 4 percent. This soil has the profile described as representative of the series.

Included with this soil in mapping are a few areas of Maxfield soils in downslope draws, some of which are identified on the soil map by a waterway symbol. A few small areas of Klinger soils are also included.

Runoff is medium, and the hazard of erosion is moderate. This soil is used mostly for crops. Capability unit IIe–1; woodland group 1; building site group 8.

**Ostrander silt loam, 6 to 12 percent slopes, eroded** (OtC2).—This soil is in areas of 3 to 20 acres on upland knolls and rises where most slopes are 8 to 10 percent. It also is on a few irregularly shaped hills where slopes are 6 to 8 percent. This soil has a profile similar to the one described as representative of the series, but erosion and tillage have resulted in a mixing of part of the subsoil with the surface layer. Also, a few cobblestones and pebbles are at the surface in some places.

Included with this soil in mapping are a few areas of of soils on convex knolls that have a loamy rather than a silty mantle. Also included are a few small areas of Klinger soils and few small areas of uneroded soils.

Runoff is medium, and the hazard of erosion is moderate. This soil is used mostly for crops. Capability unit IIIe–1; woodland group 1; building site group 8.

**Ostrander silt loam, bedrock substratum, 0 to 2 percent slopes** (OuA).—This soil is on broad flats within the uplands. It has a profile similar to the one described as representative of the series, but bedrock occurs at a depth of 5 to 8 feet or more.

Included with this soil in mapping are a few small areas of Maxfield soils in draws, some of which are identified on the soil map by a waterway symbol. A few small areas of Klinger soils are also included.

Runoff is slow, and the hazard of erosion is slight. Most of this soil is used for crops. Capability unit I–1; woodland group 1; building site group 3.

## Palms Series

The Palms series consists of nearly level, very poorly drained muck soils that formed in decomposed reeds and sedges.

In a representative profile the surface layer is black muck about 10 inches thick. The next layer is very dark brown muck about 25 inches thick. The underlying material is olive-gray silty clay loam.

Permeability is moderately rapid. Runoff is slow to ponded. The water table is at a depth of 0 to 3 feet or is near tile depth if the soils are drained. Available water capacity and organic-matter content are very high. Natural fertility is low.

Some areas of the Palms soils are in crops. Undrained, these soils are poorly suited to most crops. Where the soils are adequately drained, they are suited to early maturing crops. Wetness, a frost hazard, and soil blowing are the major limitations to crop production.

Representative profile of Palms muck, in Warsaw Township, 200 feet east and 200 feet south of center of sec. 30, T. 109 N., R. 21 W.

Oa1—0 to 10 inches, black (10YR 2/1 broken face and rubbed) sapric material; about 5 percent fiber, trace rubbed; weak, fine, subangular blocky structure; slightly sticky; herbaceous fibers; about 40 percent mineral material; slightly acid; abrupt, smooth boundary.

Oa2—10 to 25 inches, very dark brown (10YR 2/2 broken face) sapric material on black (10YR 2/1 rubbed); about 10 percent fiber, about 5 percent rubbed; weak, fine, subangular blocky structure; slightly sticky; herbaceous fibers; about 30 percent mineral material; slightly acid; gradual, wavy boundary.

Oa3—25 to 35 inches, very dark brown (10YR 2/2 broken face) sapric material on black (10YR 2/1 rubbed); about 10 percent fiber, about 5 percent rubbed; weak, fine, subangular blocky structure; slightly sticky; herbaceous fibers; about 60 percent mineral material; neutral; abrupt, smooth boundary.

IICg—35 to 60 inches, olive-gray (5Y 4/2) silty clay loam; massive; sticky; neutral in upper part, mildly alkaline in lower part.

Depth to the underlying material is 16 to 51 inches. The Oa1 horizon ranges from 5 to 15 inches in thickness. The Oa2 and Oa3 horizons are 10 to 36 inches thick and are very dark brown, very dark gray, or black. The IIC horizon is mucky silt loam, silty clay loam, clay loam, or loam.

Palms soils have a mineral substratum beginning at a depth ranging from 16 to 51 inches, but the similar Caron and Muskego soils lack a mineral substratum above a depth of 51 inches.

**Palms muck** (0 to 2 percent slopes) (Pa).—This soil is in depressions, on the rims of depressions, and in the larger bogs. It contains mucky layers that are thinner than 16 inches and have an organic-matter content of less than 30 percent. The edges of the larger bogs have a narrow, discontinuous strip of sandy or gravelly underlying material in many places. Occasionally, a thin sandy layer separates the muck from the finer textured material.

Many of the areas are in crops, but some bogs are in pasture. Dikes and pumps are needed to prevent ponding in some areas. Improved drainage is the major management need. Capability unit IIIw-2; woodland group 8; building site group 12.

## Port Byron Series

The Port Byron series consists of nearly level to moderately steep, well-drained, silty soils that formed in loess. These soils are in the uplands on knolls and the sides of hills. The native vegetation was grass prairie and a few thin stands of oak or brush.

In a representative profile the surface layer is very dark gray and very dark grayish-brown silt loam about 14 inches thick. The subsoil, about 28 inches thick, is brown and yellowish-brown, friable silt loam. The underlying

material is calcareous, yellowish-brown, very friable silt loam.

Permeability is moderate. Runoff is medium to rapid, depending on slope. The water table is below a depth of 10 feet. Available water capacity is very high. Organic-matter content is high, except in eroded areas. Natural fertility is high.

Most areas of these soils are in crops. A few areas are in trees or permanent pasture. The hazard of erosion is the major limitation.

Representative profile of Port Byron silt loam, 2 to 6 percent slopes, in Wheeling Township, 900 feet north and 120 feet west of southeast corner of sec. 1, T. 110 N., R. 19 W.

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

A3—10 to 14 inches, very dark grayish-brown (10YR 3/2) silt loam; very dark gray (10YR 3/1) coatings on faces of peds; weak, fine, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

B2—14 to 23 inches, brown (10YR 5/3) silt loam; few sand and silt grains on faces of peds; moderate, fine and medium, subangular blocky structure; friable; slightly acid; clear, wavy boundary.

B3—23 to 42 inches, yellowish-brown (10YR 5/4) silt loam; massive; very friable; neutral; clear, wavy boundary.

C1—42 to 46 inches, yellowish-brown (10YR 5/4) silt loam; many, fine, faint, dark yellowish-brown (10YR 4/4) mottles; massive; very friable; mildly alkaline; slightly effervescent; clear, wavy boundary.

C2—46 to 64 inches, yellowish-brown (10YR 5/4) silt loam; many, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; massive; very friable; mildly alkaline; strongly effervescent.

The solum ranges from 36 to 60 inches in thickness. The Ap and A1 horizons are black, very dark brown, or very dark gray. They range from 7 to 13 inches in combined thickness. Their reaction is neutral to medium acid. The B2 horizon is dark brown, brown, or dark yellowish brown and ranges from 9 to 30 inches in thickness. Structure is weak or moderate, fine and medium, subangular blocky. Reaction is slightly acid or medium acid in the B2 horizon and generally is neutral in the B3 horizon. The C horizon is light olive brown or yellowish brown.

In some areas the Port Byron soils of Rice County have a slightly thinner A horizon or a slightly thinner solum than the range defined for the series. However, this difference does not appreciably affect their usefulness or behavior.

Port Byron soils have more silt and less sand in their solum than the similar Moland and Ostrander soils. They have a B horizon, whereas the associated Bold soils lack a B horizon. Free carbonates are leached to a depth of 2 feet or more in the Port Byron soils, but in the Bold soils they occur in all horizons.

**Port Byron silt loam, 0 to 2 percent slopes** (PbA).—This soil is on knolls and rises that range from 5 to 20 acres in size. Slopes are 75 to 150 feet long and are convex and concave. Included with this soil in mapping are small areas of Judson soils. Also included are narrow draws and small depressions of Garwin soils, some of which are identified on the soil map by a symbol for drainageway or depression.

Runoff is medium, and the hazard of erosion is slight. Most of the acreage is used for crops, and the soil is well suited to this use. Capability unit I–1; woodland group 1; building site group 5.

**Port Byron silt loam, 2 to 6 percent slopes** (PbB).—This soil is on knolls and rises that range from 5 to 20 acres in size. Slopes are 75 to 150 feet long and are convex and concave. This soil has the profile described as representative for the series. However, the layers are thinner where the slopes are more convex.

Included with this soil in mapping are small areas of Judson soils. Also included are narrow draws and small depressions occupied by Garwin soils, some of which are identified on the soil map by a symbol for drainageway or depression.

Runoff is medium, and the hazard of erosion is slight. This soil is used mostly for crops and is well suited to this use. Capability unit IIe–1; woodland group 1; building site group 5.

**Port Byron silt loam, 6 to 12 percent slopes** (PbC).—This soil is in irregularly shaped areas, 5 to 30 acres in size, on knolls that have concave and convex slopes. It also is in irregularly shaped areas, 5 to 15 acres in size, on hillsides. The hillside slopes are 75 to 150 feet long. This soil has a profile similar to the one described as representative of the series, but in a few areas the present surface layer consists partly of brownish subsoil material. This layer is less friable and contains less organic matter than the original surface layer. Also, the layers of this soil are thinner than is typical, especially where slopes are more convex.

Included with this soil in mapping are areas where the surface layer is loam; a few areas where slopes are more than 12 percent; small areas of Bold soils; and, at the base of some slopes, areas of a soil that has a thickened surface layer. Narrow, downslope drains and small depressions contain included Garwin soils, and these are identified on the soil map by a symbol for drainageway or depression.

Runoff is medium, and the hazard of erosion is moderate. Most of this soil is used for crops. Capability unit IIIe–1; woodland group 1; building site group 5.

**Port Byron silt loam, 12 to 18 percent slopes** (PbD).—This soil is in irregularly shaped areas, 5 to 30 acres in size, on knolls where slopes are concave and convex. It also is in irregularly shaped areas, 5 to 15 acres in size, on hillsides. Slopes are 75 to 150 feet long. This soil has a profile that is similar to the one described as representative of the series, but in a few areas the present surface layer is now mostly material from the subsoil. This layer is less friable and contains less organic matter than the original surface layer. The layers of this soil are thinner than is typical, especially where slopes are more convex.

Included with this soil in mapping are areas where the surface layer is loam, a few areas where slopes are more than 18 percent, small areas of Bold soils, and, at the base of some slopes, areas of a soil that has a thickened surface layer. Also included are small areas of Garwin soils in narrow, downslope drains and small depressions; these are identified on the soil map by a symbol for drainageway or depression.

Runoff is rapid, and the hazard of erosion is severe. Most of this soil is used for crops. Capability unit IVe–1; woodland group 1; building site group 5.

**Port Byron-Bold silt loams, 6 to 12 percent slopes** (PoC).—This complex is in irregularly shaped areas of 5 to 30 acres on knolls. Slopes are concave and convex. The mapping unit is about 70 percent Port Byron silt loam and 30 percent lighter colored Bold silt loam. Each of these soils has a profile similar to that described as representative of its series. In areas of the Port Byron

soil, however, erosion and deep tillage have caused a mixing of part of the subsoil into the surface layer. The present surface layer is less friable and contains less organic matter than the original surface layer.

Included in mapping are a few areas of soils that have slopes of less than 6 percent or more than 12 percent. Also included, at the base of some slopes, are areas of a soil that has a thickened surface layer.

Runoff is medium, and the hazard of erosion is moderate. Temperature variations are greater on south- and west-facing slopes than on north- and east-facing slopes. Special fertility treatment is beneficial on the calcareous Bold soil. Most of this complex is used for crops. Capability unit IIIe–1; woodland group 1; building site group 5.

**Port Byron-Bold silt loams, 12 to 18 percent slopes** (PoD).—This complex is in irregularly shaped areas, 5 to 30 acres in size, on knolls and hillsides. Slopes are 75 to 150 feet long. The complex is about 60 percent Port Bryon silt loam and 50 percent lighter colored Bold silt loam. The Bold soil has convex slopes. The Port Bryon soil has a profile similar to that described as representative of its series, but the soil layers are thinner. The Bold soil has the profile described as representative of its series. In some areas of the Port Bryon soils, erosion and deep tillage have caused a mixing of part of the subsoil into the surface layer. This layer is less friable and contains less organic matter than the original surface layer.

Included in mapping are a few areas of soils that have slopes of less than 12 percent or more than 18 percent. Also included, at the base of many slopes, are areas of a soil that has a thickened surface layer.

Runoff is rapid, and the hazard of erosion is severe. Temperature variations are much greater on south- and west-facing slopes than on slopes facing north and east. Special fertility treatment is beneficial on the calcareous Bold soil. Most of this complex is used for crops. Capability unit IVe–1; woodland group 1; building site group 5.

## Renova Series

The Renova series consists of gently sloping to very steep, well-drained, loamy soils that formed in a silty mantle and the underlying firm, loamy glacial drift. These soils are on uplands. Most slopes are uniform. The native vegetation was deciduous trees.

In a representative profile the surface layer is very dark gray silt loam about 3 inches thick. This layer dries to gray. The subsurface layer is dark grayish-brown and grayish-brown silt loam about 7 inches thick. This layer dries to light gray. The subsoil is about 42 inches thick. The upper 15 inches of the subsoil is dark yellowish-brown silty clay loam and yellowish-brown friable loam, and the lower 27 inches is yellowish-brown, firm loam. The underlying material is yellowish-brown, firm loam.

Permeability is moderate to moderately slow, and runoff is medium to very rapid. Available water capacity is high. The water table is below a depth of 10 feet. Organic-matter content is moderate, and natural fertility is medium.

Some areas of these soils are used for crops, and some areas remain in trees or are wooded pasture. Controlling erosion and maintaining fertility and good tilth are the principal management needs.

Representative profile of Renova silt loam, 2 to 6 percent slopes, in Wheeling Township, 500 feet west and 20 feet north of southeast corner of sec. 9, T. 110 N., R. 19 W.

A1—0 to 3 inches, very dark gray (10YR 3/1) silt loam, very dark grayish brown (10YR 3/2) rubbed, gray (10YR 5/1) dry; weak, fine, granular structure; friable, slightly acid; abrupt, smooth boundary.

A21—3 to 7 inches, dark grayish-brown (10YR 4/2) silt loam, brown (10YR 5/3) rubbed, light gray (10YR 7/2) dry; weak, medium, platy structure parting to weak, very fine, subangular blocky; friable; slightly acid; abrupt, smooth boundary.

A22—7 to 10 inches, grayish-brown (10YR 5/2) silt loam; brown (10YR 5/3) rubbed, light gray (10YR 7/2) dry; weak, medium, platy structure; friable; common tubular pores; medium acid; clear, irregular boundary.

B21t—10 to 19 inches, dark yellowish-brown (10YR 4/4) silty clay loam; moderate, medium, subangular blocky structure; friable; thin, nearly continuous, brown (10YR 4/3) clay films; common tubular pores; medium acid; clear, wavy boundary.

IIB22t—19 to 25 inches, yellowish-brown (10YR 5/6) loam; moderate, fine and medium, subangular blocky structure; friable; about 5 percent coarse fragments; thin, continuous, brown (10YR 4/3) clay films; few vesicular pores; thin stoneline in upper part; strongly acid; abrupt, wavy boundary.

IIB23t—25 to 27 inches, yellowish-brown (10YR 5/6) sandy clay loam; moderate, medium and coarse, subangular blocky structure; friable; about 5 percent coarse fragments; thin, light olive-brown (2.5Y 5/4) silt and fine sand coatings on faces of peds; strongly acid; abrupt, wavy boundary.

IIB24t—27 to 34 inches, yellowish-brown (10YR 5/6) loam; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky; firm; about 5 percent coarse fragments; thin discontinuous clay films in pores; thin, light olive-brown (2.5Y 5/4) and light-gray (10YR 7/2), dry, silt and fines and coatings on faces of peds; medium acid; clear, wavy boundary.

IIB25t—34 to 42 inches, yellowish-brown (10YR 5/6) and light olive-brown (2.5Y 5/6) loam; moderate, coarse, prismatic structure parting to weak, coarse, subangular blocky; firm; about 5 percent coarse fragments; thin discontinuous clay films in pores; thin, light olive-brown (2.5Y 5/4) and light-gray (10YR 7/2), dry, silt and fine sand coatings on faces of peds; slightly acid; clear, wavy boundary.

IIB3t—42 to 52 inches, yellowish-brown (10YR 5/6) and light olive-brown (2.5Y 5/6) loam; massive in some parts and weak, coarse, prismatic structure in other parts; few oblique partings; firm; about 5 percent coarse fragments; thin dark clay fillings in old root channels; neutral; abrupt, wavy boundary.

IIC—52 to 60 inches, yellowish-brown (10YR 5/6) loam; many, medium, distinct, grayish-brown (2.5Y 5/2) mottles and few, fine, distinct, strong-brown (7.5YR 5/8) mottles; massive; firm; about 5 percent coarse fragments; common, fine, limy concretions in upper part and thin, segregated, limy filaments along vertical partings in the lower part; slightly effervescent; mildly alkaline.

The solum ranges from 42 to 74 inches in thickness. The A horizon is silt loam or loam that is high in content of silt. Reaction is slightly acid or medium acid. The A1 horizon is very dark brown or very dark gray and ranges from 2 to 6 inches in thickness. The Ap horizon is dark grayish brown. The A2 horizon is 3 to 8 inches thick. In cultivated areas it is mixed with the Ap horizon.

The B21t horizon is silt loam, silty clay loam, or loam that is high in content of silt and is 5 to 10 inches thick. The IIB22t and IIB23t horizons are variable in texture, which ranges from loam or sandy clay loam to sandy loam, loamy sand, or sand. These horizons range from 2 to 16 inches in thickness. In places, some gravel, stones, or cobblestones are in this horizon. The rest of the IIB horizon is loam, sandy clay loam, or clay loam and is 15 to 30 inches thick. Porous, grayish coatings are

on the faces of the prisms in some places, and this is pronounced where the A2 horizon is thickest and where the Ap or A1 horizon is grayer.

Renova soils have a thinner A1 horizon than the similar Ostrander soils, and they lack the dark-colored A3 horizon of those soils. Renova soils formed in multiple glacial materials, whereas the similar Hayden soils formed almost entirely in glacial till.

**Renova silt loam, 2 to 6 percent slopes** (RnB).—This soil is in tracts of 3 to 80 acres in the uplands. It has the profile described as representative of the series.

Included with this soil in mapping are some areas of eroded soils. In places the surface layer is grayer and tilth is not as good as that of most Renova soils. Westerly facing, convex slopes have a loamy mantle and a few cobblestones on the surface. In some places there are small beds of sand and gravel at a depth below 6 feet.

Runoff is medium, and the hazard of erosion is moderate. This soil is used for crops, trees, or wooded pasture. Capability unit IIe–2; woodland group 1; building site group 8.

**Renova silt loam, 6 to 12 percent slopes** (RnC).—This soil is in tracts that range from 3 to 20 acres in size on uplands. Included in mapping are a few areas of soils that have slopes of less than 6 percent or more than 12 percent and a few cobblestones on the surface.

Runoff is medium, and the hazard of erosion is severe. This soil is used for crops, trees, or wooded pasture. Capability unit IIIe–2; woodland group 1; building site group 8.

**Renova silt loam, 12 to 18 percent slopes, eroded** (RnD2).—This soil is in tracts that range from 3 to 20 acres in size on uplands. It has a profile similar to the one described as representative of the series, but erosion and tillage have resulted in mixing of part of the subsoil with the surface layer.

Included with this soil in mapping are some areas of slightly eroded soils and a few areas of soils that have slopes of less than 12 percent or more than 18 percent. Some severely eroded soils that have a few cobblestones on the surface are also included.

Runoff is rapid, and the hazard of erosion is severe. Some areas of this soil are used for crops, and some remain in trees or wooded pasture. Capability unit IVe–2; woodland group 1; building site group 8.

**Renova silt loam, 18 to 30 percent slopes** (RnE).—This soil is in tracts that range from 3 to 20 acres in size on uplands. It has a profile similar to the one described as representative of the series, but the soil layers are thinner. A few areas have a surface layer that formerly was part of the brownish subsoil.

Some areas of eroded soils are included with this soil in mapping. Also included are a few areas of soils that have slopes of less than 18 percent or more than 30 percent. In addition, some eroded slopes that have a few cobblestones on the surface are included.

Runoff is very rapid, and the hazard of erosion is very severe. Most of the acreage remains in trees or in wooded pasture. Capability unit VIe-1; woodland group 1; building site group 8.

## Rolfe Series

The Rolfe series consists of nearly level, poorly drained, loamy soils that formed in clayey sediment 3 to 10 feet thick. These soils occupy some of the depressions and sluggish drainageways. The native vegetation was water-tolerant prairie grasses.

In a representative profile the surface layer is very dark gray silt loam about 7 inches thick. The subsurface layer is very dark gray and dark-gray, friable silt loam about 5 inches thick. The upper part of the subsoil is mottled, very dark grayish-brown, grayish-brown, and olive-gray, firm clay about 21 inches thick. The lower part is olive-gray, firm clay loam about 21 inches thick. The underlying material is mottled, olive-gray, firm clay loam.

Permeability is slow. Runoff is slow to ponded. The water table is at a depth of 0 to 3 feet or is near tile depth where the soils are drained. Available water capacity is high, organic-matter content is moderate, and natural fertility is medium.

Some areas of the Rolfe soils are used for crops. Undrained, these soils are only moderately well suited to poorly suited to most crops. Where the soils are adequately drained, they are suited to crops. Controlling the water table and maintaining good tilth and fertility are the major management needs.

Representative profile of Rolfe silt loam, in an area of Rolfe silty clay loam in Erin Township, 1,140 feet west of southeast corner of sec. 27, T. 111 N., R. 22 W.

Ap—0 to 7 inches, very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) dry; weak, fine, granular structure (cloddy); friable; slightly acid; abrupt, smooth boundary.

A2—7 to 12 inches, very dark gray (10YR 3/1) and dark-gray (10YR 4/1) silt loam, light gray (10YR 6/1) dry; weak, medium, platy structure; friable; strongly acid; abrupt, smooth boundary.

B1tg—12 to 16 inches, very dark grayish-brown (10YR 3/2) clay; moderate, fine and medium, subangular blocky structure; firm; about 2 percent coarse fragments; many, thick, very dark gray (10YR 3/1) clay films on faces of peds; strongly acid; clear, wavy boundary.

B21tg—16 to 21 inches, grayish-brown (2.5Y 5/2) clay; many, fine, distinct, light olive-brown (2.5Y 5/4) mottles; moderate, medium, prismatic structure; firm; about 12 percent coarse fragments; many, medium and thick, very dark grayish-brown (2.5Y 3/2) clay films on faces of peds; many, very dark gray (10YR 3/1), clayey fillings in root channels; very strongly acid; clear, wavy boundary.

B22tg—21 to 26 inches, grayish-brown (2.5Y 5/2) clay; many, fine, distinct, light olive-brown (2.5Y 5/4) mottles; moderate, medium, prismatic structure; firm; about 2 percent coarse fragments; many, medium, very dark grayish-brown (2.5Y 3/2) clay films on faces of peds; very strongly acid; clear, wavy boundary.

B23tg—26 to 33 inches, olive-gray (5Y 5/2) clay; moderate, medium and coarse, prismatic structure; firm; about 2 percent coarse fragments; common, very dark grayish brown (2.5Y 3/2), clayey fillings in root channels; strongly acid; clear, wavy boundary.

B31tg—33 to 40 inches, olive-gray (5Y 5/2) clay loam; many, fine, distinct, yellowish-brown (10YR 5/8) mottles; massive; firm; few, black (10YR 2/1), clayey fillings in root channels; medium acid; clear, wavy boundary.

B32tg—40 to 54 inches, olive-gray (5Y 5/2) clay loam; many, medium, distinct, light olive-brown (2.5Y 5/4) mottles; massive; firm; about 4 percent coarse fragments; few, black (10YR 2/1), clayey fillings in root channels; neutral; clear, wavy boundary.

C—54 to 76 inches, olive-gray (5Y 5/2) clay loam; many, medium, distinct, light olive-brown (2.5Y 5/4) mottles; massive; firm; about 4 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 40 to 60 inches in thickness. The Ap horizon is silt loam or silty clay loam. The A2 horizon is 3 to 8 inches thick. A few dark-brown and reddish-brown mottles are in these horizons in some profiles. Reaction ranges from slightly acid to strongly acid. The B2 horizon is silty clay or

clay. Reaction ranges from very strongly acid to medium acid. The C horizon typically is clay loam or loam, but in places it is silty clay, clay, or silty clay loam. The C horizon is neutral or mildly alkaline in the upper part and mildly alkaline in the lower part. Lime is leached to a depth of 40 to 70 inches.

Rolfe soils contain more clay and less sand than the similar Glencoe soils, and they have a thinner A horizon than those soils. They have a greater change in content of clay between the A horizon and the B horizon than the similar Mazaska soils. Rolfe soils have more clay and less silt and sand in the B horizon than the similar Cordova soils.

**Rolfe silty clay loam** (0 to 2 percent slopes) (Ro).—This soil is in small depressions, in drains, and on short side slopes. It also is in long, winding, low-gradient drainageways 5 to 20 acres in size. Included with this soil in mapping are areas of soils that have a thin organic mat in some undrained areas. Also included are small areas of Mazaska soils.

This soil is very wet. Depth to the water table commonly ranges from 0 to 3 feet. Runoff is slow to ponded. Improved drainage is needed for crops presently grown. A properly designed and installed drainage system effectively removes excess water. This soil can be tilled only within a narrow range of moisture content. If the soil is worked wet, compaction occurs, tilth is destroyed, and aeration is reduced. The soil is hard and cloddy when dry. Its shrink-swell potential is high. During dry periods, cracks form and extend into the subsoil. Most of this soil is used for crops. Capability unit IIIw–1; woodland group 8; building site group 12.

## Rough Broken Land

Rough broken land (Ru) consists of areas of narrow, steeply sloping glacial drift and shallow bedrock adjacent to major streams and lakes. Slopes are more than 30 percent. Runoff is very rapid, and the hazard of erosion is very severe. Rough broken land is too steep to be cultivated. Capability unit VIIe–1; woodland group 5; building site group 3.

## Salida Series

The Salida series consists of gently sloping to very steep, excessively drained soils that formed in gravelly and coarse sandy glacial outwash sediment. These soils occupy sharply convex, gravelly knolls and short steep slopes of outwash plains. Slopes are both uniform and complex. The native vegetation was tall prairie grass.

In a representative profile the surface layer is very dark grayish-brown gravelly sandy loam about 3 inches thick. The subsoil is dark grayish-brown and dark-brown loamy coarse sand about 6 inches thick. The underlying material is calcareous, dark-brown, brown, and light yellowish-brown, loose sand and gravel.

Permeability is very rapid. Runoff is medium to rapid. The water table is below a depth of 10 feet. Available water capacity is very low. Organic-matter content is low to moderate, and natural fertility is low.

Many areas of these soils are in crops and are farmed with adjoining major soils. The very low available water capacity makes the soils poorly suited to most crops. Droughtiness is the major limitation.

Representative profile of Salida gravelly sandy loam, 12 to 30 percent slopes, in Bridgewater Township, 2,600 feet east and 200 feet north of center of sec. 32, T. 111 N., R. 20 W.

A1—0 to 3 inches, very dark grayish-brown (10YR 3/2) gravelly sandy loam; massive; loose; slightly effervescent in spots; mildly alkaline; gradual, wavy boundary.

B2—3 to 9 inches, dark grayish-brown (10YR 4/2) and dark-brown to brown (10YR 4/3) gravelly loamy coarse sand; single grained; loose; slightly to strongly effervescent; mildly alkaline; gradual, wavy boundary.

C—9 to 100 inches, mixed dark-brown (10YR 4/3), brown (10YR 5/3), and light yellowish-brown (10YR 6/4) sand and gravel; single grained; loose; strongly and violently effervescent; mildly alkaline.

The solum ranges from 7 to 14 inches in thickness. The Ap and A1 horizons are very dark grayish brown or very dark brown and range from gravelly sandy loam or gravelly loamy coarse sand to gravelly coarse sandy loam or gravelly coarse sand. They are 3 to 10 inches in combined thickness. The B horizon is 3 to 8 inches thick. These horizons generally are neutral or slightly acid but are calcareous and mildly alkaline in some profiles. The C horizon is gravel, sandy gravel, gravelly coarse sand, or stratified sands and gravel.

Salida soils are thinner and coarser textured than the associated Estherville soils.

**Salida gravelly sandy loam, 4 to 12 percent slopes** (SaC).—This soil is on convex, gravelly knolls and side slopes. Included with it in mapping are some small areas of Estherville soils.

This soil is very droughty. Runoff is medium, and the hazard of erosion is moderate. The very low available water capacity and shallow rooting zone are the principal limitations to use for most crops. Permanent vegetation is a better use of this soil. Capability unit VIs–1; woodland group 4; building site group 2.

**Salida gravelly sandy loam, 12 to 30 percent slopes** (SaD).—This soil is on convex, gravelly knolls and side slopes. It has the profile described as representative of the series. Included with it in mapping are small areas of Estherville soils.

This soil is very droughty. Runoff is rapid, and the hazard of erosion is severe. The very low available water capacity and shallow rooting zone are the principal limitations to use for most crops. Permanent vegetation is a better use. Capability unit VIIs–1; woodland group 5; building site group 2.

## Shields Series

The Shields series consists of nearly level to gently undulating, somewhat poorly drained soils that formed in a shaly, clayey mantle 3 to 10 feet thick or more. These soils occupy low knolls, nearly level tracts, and shallow draws in the uplands. The native vegetation was deciduous trees.

In a representative profile the surface layer is black and very dark gray silt loam about 7 inches thick. The subsurface layer is dark-gray silty clay loam about 4 inches thick. The subsoil is mottled, olive-gray, firm silty clay about 27 inches thick. The underlying material is calcareous, mottled, olive-gray, friable clay loam.

Permeability is slow. Runoff is slow to medium. Depth to the water table commonly ranges from 2 to 5 feet. Available water capacity is high, organic-matter content is moderate, and natural fertility is medium.

Most areas of Shields soils are in crops, but a few areas remain in trees or are wooded pasture. These soils are

moderately well suited to most crops, but they can be properly tilled only within a narrow range of moisture content. Maintaining good tilth and fertility and controlling the water table are the major management needs.

Representative profile of Shields silt loam, in Shieldsville Township, 600 feet west and 100 feet north of southeast corner of sec. 11, T. 110 N., R. 22 W.

Ap—0 to 7 inches, black (10YR 2/1) and very dark gray (10YR 3/1) silt loam, gray (10YR 5/1) dry; weak, fine, granular structure (cloddy); friable; about 2 percent coarse fragments; medium acid; abrupt, smooth boundary.

A2—7 to 11 inches, dark-gray (10YR 4/1) silty clay loam, gray (10YR 6/1) dry; weak, medium, platy structure and moderate, medium, subangular blocky structure; friable; about 2 percent coarse fragments; medium acid; clear, wavy boundary.

B21tg—11 to 18 inches, olive-gray (5Y 4/2) silty clay; many, medium, distinct, olive (5Y 4/3) mottles; strong, fine and medium, angular blocky structure; firm; many, medium, thick, very dark gray (10YR 3/1) clay films on faces of peds; few, very dark grayish-brown (2.5Y 3/2) shale fragments; about 2 percent coarse fragments; strongly acid; clear, wavy boundary.

B22tg—18 to 30 inches, olive-gray (5Y 5/2) silty clay; few, fine, distinct, olive (5Y 4/3) mottles; strong, medium, prismatic structure parting to strong, medium, angular blocky; firm; many, medium, dark grayish-brown (2.5Y 4/2) clay films on faces of peds; common, very dark grayish-brown (2.5Y 3/2), clayey fillings in root channels; about 4 percent coarse fragments; strongly acid; clear, wavy boundary.

B23tg—30 to 38 inches, olive-gray (5Y 4/2) silty clay; many, fine, faint, olive (5Y 4/3) mottles and few, fine, distinct, strong-brown (7.5YR 5/8) mottles; strong, medium and coarse, prismatic structure; firm; about 4 percent coarse fragments; common, medium, very dark gray (5Y 3/1) clay films on faces of peds; common, black (10YR 2/1), clayey fillings in root channels; medium acid; clear, wavy boundary.

C—38 to 64 inches, olive-gray (5Y 4/2) clay loam; many, fine, faint, grayish-brown (2.5Y 4/2) and light olive-brown (2.5Y 5/4) mottles and many, medium, prominent, strong-brown (7.4YR 5/8) mottles; massive; friable; about 4 percent coarse fragments; few black (10YR 2/1) concretions; few, black (10YR 2/1), clayey fillings in root channels in the upper part; strongly effervescent; mildly alkaline.

The solum ranges from 30 to 60 inches in thickness. The Ap horizon is black to very dark gray silt loam or silty clay loam that is dark gray or gray when dry. In undisturbed areas the A1 horizon is black or very dark gray silt loam or silty clay loam 4 to 8 inches in thickness. Reaction in the Ap and A1 horizons is medium acid to slightly acid. An A2 horizon ranges from 2 to 8 inches in thickness. It is dark-gray, gray, or grayish-brown silt loam or light silty clay loam. The A2 horizon dries to gray or light gray and gives a spotty appearance to the Ap horizon where mixed with that horizon. Reaction is slightly acid or medium acid.

The B2 horizon is silty clay or clay and contains 40 to 60 percent clay. The darkest colors on faces of peds commonly are in the B22 horizon or B21 horizon, but in some profiles they are in the B23 horizon. Reaction in the B2 horizon ranges from medium acid to very strongly acid. Some profiles have a B3g horizon that ranges from clay loam, silty clay loam, or clay to silty clay. The C horizon ranges from clay loam or silty clay loam to clay.

Shields soils have more clay in the B horizon than Dundas soils. They have a thicker A2 horizon than the similar Mazaska soils. Shields soils have more clay and less sand in their B horizon than the similar Cordova soils.

**Shields silt loam** (0 to 3 percent slopes) (Sh).—This nearly level to gently undulating soil occupies 5- to 80-acre tracts in the uplands. Included with it in mapping are small areas of Lerdal and Rolfe soils. Also included are a few areas where part of the olive-gray subsoil is mixed into the surface layer. Here, the present surface layer is less friable and contains less organic matter than the original surface layer.

Wetness is a limitation that affects the use of this soil. Tile drainage effectively removes excess water if the system is specifically designed for this soil. The optimum range of moisture for proper tillage in this soil is narrow. During dry periods, cracks form in the cultivated layer. When dry and cracked, the soil absorbs water at a moderate rate, but percolation is slowed when the soil is saturated and the cracks seal. The shrink-swell potential of the subsoil is high. The increase in clay and density in the lower part of the subsoil slows the movement of water. Most areas of this soil are used for crops, but a few wooded areas or wooded pastures remain. Capability unit IIIw-3; woodland group 2; building site group 11.

## Skyberg Series

The Skyberg series consists of nearly level to gently sloping, somewhat poorly drained soils that formed in loess and in firm, loamy glacial till. These soils occupy gentle rises and shallow draws in the uplands. The native vegetation was deciduous trees.

In a representative profile the surface layer is very dark gray silt loam 8 inches thick. The subsurface layer is dark-gray and dark grayish-brown, friable silt loam about 5 inches thick. The upper part of the subsoil is mottled, dark grayish-brown and grayish-brown silty clay loam about 13 inches thick. The lower part is mottled, yellowish-brown, firm clay loam and loam about 21 inches thick. The underlying material is calcareous, yellowish-brown, firm loam.

Permeability is moderately slow. Runoff is slow to medium. Depth to the water table commonly ranges from 2 to 5 feet. Available water capacity is high, organic-matter content is moderate, and natural fertility is medium.

Some areas of these soils are used for crops, and some areas are wooded or wooded pasture. Under proper management that includes maintaining good tilth and fertility and controlling the water table, these soils are well suited to crops.

Representative profile of Skyberg silt loam, in Wheeling Township, 1,700 feet west and 60 feet north of southeast corner of sec. 15, T. 110 N., R. 19 W.

Ap—0 to 8 inches, very dark gray (10YR 3/1) silt loam; weak, fine, granular structure (cloddy); friable; neutral; abrupt, smooth boundary.

A2—8 to 13 inches, dark-gray (10YR 4/1) and dark grayish-brown (10YR 4/2) silt loam, gray (10YR 5/1) dry; moderate, medium, platy structure; friable; medium acid; clear, wavy boundary.

B21tg—13 to 20 inches, dark grayish-brown (2.5Y 4/2) silty clay loam; common, fine, distinct, dark-brown, and brown (7.5YR 4/4) mottles; moderate, fine, subangular blocky structure; friable; strongly acid; clear, wavy boundary.

B22tg—20 to 26 inches, grayish-brown (2.5Y 5/2) silty clay loam; many, fine, distinct, dark-brown, and brown (7.5YR 4/4) mottles; moderate, fine, subangular blocky structure; friable; few thin clay films in pores; strongly acid; clear, irregular boundary.

IIB23tg—26 to 33 inches, yellowish-brown (10YR 5/6) clay loam; moderate, coarse, prismatic structure; firm; about 4 percent coarse fragments; many, thick, grayish-brown (2.5Y 5/2), porous coatings on faces of

peds; few black (10YR 2/1) manganese concretions; very strongly acid; clear, wavy boundary.

IIB3tg—33 to 48 inches, yellowish-brown (10YR 5/6) loam; moderate, coarse, prismatic structure; firm; about 4 percent coarse fragments; many, thick, grayish-brown (2.5Y 5/2), porous coatings on faces of peds; few black (10YR 2/1) manganese concretions; very strongly acid; clear, irregular boundary.

IIC—48 to 100 inches, yellowish-brown (10YR 5/6) loam; massive; firm; about 5 percent fragments; neutral in upper part, mildly alkaline and slightly effervescent in lower part.

The solum ranges from 42 to 70 inches in thickness. The Ap horizon is neutral to slightly acid in uncultivated sites, but it ranges to medium acid in fields under long-time cultivation. The A2 horizon is 2 to 8 inches thick. Its reaction is slightly acid to medium acid. The B21tg and B22tg horizons are silty clay loam or silt loam. Their reaction is medium acid to strongly acid. The IIB horizon generally is loam or clay loam, but in some profiles the upper part of the IIB horizon is coarser textured and ranges from sand or sand and gravel to sandy loam or sandy clay loam within a short lateral distance. Such horizons are less than 5 inches thick. The IIB horizon is 20 to 40 inches thick. Reaction ranges from slightly acid to very strongly acid. The upper part of the IIB horizon has the more acid reaction. The IIC horizon generally is calcareous and mildly alkaline, but the upper part of this horizon is noncalcareous and neutral in some profiles.

Skyberg soils have more silt and less sand in the upper part of the B horizon than the similar Dundas soils. They have a grayer B horizon than the associated Kasson soils.

**Skyberg silt loam** (0 to 3 percent slopes) (Sk).—This soil is in areas of 10 to 100 acres on uplands and in areas of 3 to 10 acres on gentle rises and in shallow upland draws. Included with it in mapping are small areas of Kasson and Maxfield soils. In some included areas, the profile has a thinner, lighter colored surface layer and a higher content of clay in the upper part of the subsoil than the profile of this soil.

This soil is seasonally wet. The different textural layers in the rooting zone slow the movement of water through the soil. In some places tile lines have been installed to remove excess water. Tile functions satisfactorily if the drainage system is specifically designed for this soil. This soil is used for crops, trees, or woodland pasture. Capability unit IIIw–3; woodland group 2; building site group 11.

## Sogn Series

The Sogn series consists of steep to very steep, well-drained to excessively drained soils that formed in loamy sediment over limestone bedrock. These soils are on sharply convex knolls and in limestone areas where slopes are short and steep. Slopes are both uniform and complex. The native vegetation was tall prairie grass.

In a representative profile the surface layer is very dark grayish-brown stony loam about 8 inches thick. Below this is limestone bedrock.

Permeability is moderate. Runoff is rapid. The water table is below a depth of 10 feet. Available water capacity is very low, and organic-matter content and natural fertility are low.

Most areas of the Sogn soils are in permanent pasture. These soils are poorly suited to most crops because of the very low available water capacity and shallowness to bedrock. Droughtiness and depth to bedrock are the major limitations.

Representative profile of Sogn stony loam, 18 to 35 percent slopes, in Northfield Township, 40 feet west and 550 feet north of southeast corner of sec. 36, T. 112 N., R. 19 W.

A1—0 to 8 inches, very dark grayish-brown (10YR 3/2) stony loam; weak, fine, subangular blocky structure; mildly alkaline; abrupt, irregular boundary.

R—8 inches, limestone bedrock.

The solum ranges from 6 to 12 inches in thickness. The A horizon is very dark grayish brown or very dark gray and ranges from stony loam to stony clay loam or stony silt loam. This horizon is neutral in some profiles.

Sogn soils have limestone bedrock at a shallower depth than the associated Dodgeville soils.

**Sogn stony loam, 18 to 35 percent slopes** (SoE).—This soil is on side slopes of the buttes or mesas. It is very droughty. Runoff is rapid, and the hazard of erosion is severe to very severe. The very low available water capacity and shallow rooting zone are the principal limitations. Permanent vegetation is likely to be the best use of this soil. Capability unit VIIs-1; woodland group 5; building site group 3.

## Storden Series

The Storden series consists of undulating to steep, somewhat excessively drained, loamy soils that formed in calcareous, loamy glacial till. These soils are on knolls and in convex areas in the uplands. The native vegetation was a sparse growth of grass or trees.

In a representative profile the surface layer is calcareous, very dark grayish-brown loam about 7 inches thick. The underlying material is calcareous, grayish-brown and yellowish-brown, friable loam.

Permeability is moderate. Puddling of the surface commonly slows infiltration. Runoff is medium to rapid, and the hazard of erosion is moderate to severe. The water table is below a depth of 10 feet. Available water capacity is high, organic-matter content is moderate, and natural fertility is medium.

Most areas of these soils are cropped with the associated soils in cultivated fields. Special fertility programs are beneficial to most crops because the content of lime is high.

Representative profile of Storden loam, in an area of Clarion-Storden loams, 6 to 12 percent slopes, in Morristown Township, 500 feet north and 200 feet west of southeast corner of sec. 21, T. 109 N., R. 22 W.

Ap—0 to 8 inches, dark grayish-brown (10YR 4/2) loam; weak, medium, granular structure; friable; about 3 percent coarse fragments; mildly alkaline; strongly effervescent; abrupt, smooth boundary.

C1—8 to 14 inches, grayish-brown (10YR 5/2) loam; common fine inclusions of dark grayish brown (10YR 4/2); weak, medium, granular structure and weak, fine, subangular blocky structure; friable; about 3 percent coarse fragments; mildly alkaline; strongly effervescent; gradual, irregular boundary.

C2—14 to 26 inches, yellowish-brown (10YR 5/4) loam; massive; friable; about 3 percent coarse fragments; mildly alkaline; strongly effervescent; clear, wavy boundary.

C3—26 to 62 inches, brownish-yellow (10YR 6/6) loam; common, medium, distinct, very pale brown (10YR 7/6) mottles and few, fine, faint, grayish-brown (2.5Y 5/2) mottles; massive; friable; about 3 percent coarse fragments; mildly alkaline; strongly effervescent.

The solum ranges from 6 to 10 inches in thickness. The Ap or A1 horizon is dark brown or dark grayish brown.

Storden soils lack a B horizon, whereas the associated Clarion soils have a B horizon. Free carbonates occur in all horizons of Storden soils, but they are leached to a depth of more than 2 feet in Clarion soils.

In Rice County the Storden soils are mapped only in complexes with Clarion and Estherville soils. These complexes are described under the heading "Clarion Series."

## Terril Series

The Terril series consists of nearly level to sloping, moderately well drained, loamy soils that formed in loamy alluvium and glacial sediment. These soils are on toe slopes of the more rolling soils. The native vegetation was tall prairie grass and deciduous trees.

In a representative profile the surface layer is very dark brown loam about 32 inches thick. The subsoil is dark-brown, brown, and dark yellowish-brown loam about 43 inches thick. The underlying material is dark yellowish-brown, friable loam.

Permeability is moderate. Runoff is medium. Depth to the water table commonly ranges from 2 to 5 feet. Available water capacity is high, and organic-matter content and natural fertility are high.

Some areas of Terril soils are in crops, and other areas are in permanent pasture or trees. These soils are well suited to crops grown locally.

Representative profile of Terril loam, 1 to 6 percent slopes, in Warsaw Township, 1,430 feet south and 50 feet east of center of sec. 1, T. 109 N., R. 21 W.

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

A1—8 to 19 inches, very dark brown (10YR 2/2) loam; weak, medium and coarse, subangular blocky structure; friable; about 3 percent coarse fragments; neutral; clear, wavy boundary.

A3—19 to 32 inches, very dark brown (10YR 2/2) loam; weak, fine and medium, subangular blocky structure; friable; about 3 percent coarse fragments; slightly acid; clear, wavy boundary.

B21—32 to 43 inches, dark-brown to brown (10YR 4/3) loam; weak, fine, subangular blocky structure; friable; about 3 percent coarse fragments; slightly acid; clear, wavy boundary.

B22—43 to 63 inches, dark yellowish-brown (10YR 4/4) loam; weak, medium, subangular blocky structure; friable; about 3 percent coarse fragments; slightly acid; clear, wavy boundary.

B3—63 to 75 inches, dark yellowish-brown (10YR 4/4) loam; weak, coarse, subangular blocky structure; friable; about 3 percent coarse fragments; neutral; clear, wavy boundary.

C—75 to 85 inches, dark yellowish-brown (10YR 4/4) loam; massive; friable; about 3 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 36 to 80 inches in thickness. The A horizon is black, very dark brown, or very dark gray. Its texture ranges from loam to clay loam, and its thickness from 24 to 36 inches. The B horizon is loam, clay loam, or sandy clay loam. The C horizon is loam or sandy loam.

Terril soils have more sand and less silt than the similar Judson soils.

**Terril loam, 1 to 6 percent slopes** (TeB).—This soil is in narrow draws associated with more sloping Clarion soils. Areas are 5 to 30 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are a few areas of soils that have a sandy loam surface layer and a few small areas of Webster, Clarion, Lester, and Nicollet soils.

Wetness is a slight limitation that affects the use of this soil. Runoff is medium. Tile has been installed in a few areas to remove excess water. This soil is used mostly for cultivated crops, and it has few limitations for this use. Capability unit IIe-1; woodland group 1; building site group 6.

**Terril loam, 6 to 12 percent slopes** (TeC).—This soil is in narrow draws associated with more sloping Storden and Clarion soils. Areas are 5 to 20 acres in size. Included with this soil in mapping are a few areas of soils that have a surface layer of sandy loam or clay loam and a few small areas of Clarion, Nicollet, Lester, Le Sueur, and Webster soils.

Wetness is a slight limitation that affects the use of this soil. Runoff is medium, and the hazard of erosion is moderate. Tile has been installed in a few areas to remove excess water. This soil is used mostly for cultivated crops, and it has moderate limitations for this use. Capability unit IIIe-1; woodland group 1; building site group 6.

## Vlasaty Series

The Vlasaty series consists of nearly level to gently sloping, moderately well drained, loamy soils in upland flats. These soils formed in a mantle of loess and in the underlying, firm, loamy glacial drift. A sandy layer commonly separates the silty mantle from the loamy material. A few stones are at the surface of the underlying material. The native vegetation was deciduous trees.

In a representative profile the surface layer is very dark gray silt loam about 5 inches thick. The subsurface layer is dark grayish-brown silt loam about 8 inches thick. The upper part of the subsoil is dark grayish-brown and brown, firm and very firm silty clay loam about 10 inches thick. The lower part is yellowish-brown, very firm clay loam and loam about 37 inches thick. The underlying material is mottled, yellowish-brown, firm loam.

Permeability is moderately slow. Runoff is slow to medium. Depth to the water table commonly ranges from 2 to 5 feet. Available water capacity is high, organic-matter content is moderate, and natural fertility is medium.

These soils are wooded. Maintaining good tilth and fertility is the major management need.

Representative profile of Vlasaty silt loam, 1 to 4 percent slopes, in Wheeling Township, 3,340 feet west and 300 feet south of the northeast corner of sec. 16, T. 110 N., R. 19 W.

A1—0 to 5 inches, very dark gray (10YR 3/1) silt loam; moderate, fine and medium, subangular blocky structure; very friable; slightly acid; clear, smooth boundary.

A2—5 to 9 inches, dark grayish-brown (10YR 4/2) silt loam, pale brown (10YR 6/3) dry; weak and moderate, medium, platy structure; very friable; medium acid; clear, smooth boundary.

A&B—9 to 13 inches, dark grayish-brown (10YR 4/2) silt loam; many, medium and thick, light-gray (10YR 7/1 dry), porous coatings on faces of peds; strong, medium, subangular blocky structure; firm; strongly acid; abrupt, smooth boundary.

B&A—13 to 17 inches, dark grayish-brown (10YR 4/2) silty clay loam; strong, medium, subangular blocky structure; firm; many, medium, grayish-brown (10YR 5/2), porous coatings on faces of peds; medium acid; clear, wavy boundary.

B21t—17 to 23 inches, brown (10YR 4/3) silty clay loam; few, fine, distinct, dark grayish-brown (2.5Y 4/2) mottles; weak, coarse, prismatic structure parting to strong, coarse, angular blocky; very firm; few, thin, patchy clay films; few, thin, pale-brown (10YR 6/3), porous coatings on faces of peds; strongly acid; clear, wavy boundary.

IIB22t—23 to 36 inches, yellowish-brown (10YR 5/6) clay loam; strong, coarse, prismatic structure parting to moderate, coarse, subangular blocky; very firm; about 4 percent coarse fragments; thin patchy clay films on faces of peds; strongly acid; clear, gradual boundary.

IIB3t—36 to 60 inches, yellowish-brown (10YR 5/6) loam; strong, coarse, prismatic structure; very firm; about 5 percent coarse fragments; few, soft, dark-colored stains and concretions; few, very dark brown (10YR 2/2), clayey fillings in root channels; slightly acid; gradual, wavy boundary.

IIC—60 to 100 inches, yellowish-brown (10YR 5/4) loam; common, medium, distinct, grayish-brown (2.5Y 5/2) mottles; massive; firm; about 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The thickness of the solum ranges from 40 to 70 inches, and thickness of loess ranges from 18 to 30 inches. The A1 horizon is black or very dark gray. This horizon is slightly acid or neutral. The A2 horizon is dark grayish-brown or brown and ranges from 4 to 8 inches in thickness. Its structure is weak or moderate, thin or medium, platy. Reaction is medium to strongly acid. The B and A horizons are silt loam or silty clay loam.

The B21t horizon is medium acid to very strongly acid. The IIB22t horizon is variable in texture and ranges from sand or sand and gravel to loamy sand, sandy loam, sandy clay loam, loam, or clay loam. This horizon commonly ranges from 2 to 10 inches in thickness, and it is medium acid or strongly acid. The IIB3t horizon is loam or clay loam and ranges from 20 to 50 inches in thickness. Its consistence generally is firm but it ranges from slightly firm to very firm. Primary structure is moderate or strong, medium or coarse, prismatic. Some profiles have secondary structure of weak or moderate, fine or medium, angular or subangular blocky in this horizon. Reaction generally is slightly or medium acid, but in some places it is strongly acid or neutral in the lower part. The IIC horizon is loam or clay loam. Commonly, it is calcareous and mildly alkaline, but the upper few inches of it is leached and is neutral in some profiles.

Vlasaty soils have a brighter colored B horizon than the associated Skyberg soils.

**Vlasaty silt loam, 1 to 4 percent slopes** (VlA).—This soil is in areas, 3 to 200 acres in size, on uplands. Included with it in mapping are a few small areas of Skyberg soils and a few areas where beds of sand and gravel are below a depth of 6 feet.

Wetness is a slight limitation that affects the use of this soil. The hazard of erosion is slight. This soil can be properly tilled only within a narrow range of moisture content. The different textural layers in the rooting zone slow the movement of water through the soil. This soil is used for crops, trees, or wooded pasture. Capability unit IIe–3; woodland group 2; building site group 8.

## Waukegan Series

The Waukegan series consists of nearly level to gently sloping, well-drained, silty soils that formed in 20 to 40 inches of silty alluvial deposits or loess and in the underlying sand and gravel. These soils are on broad flats and in gently sloping areas within the glacial outwash plains. Slopes are both uniform and complex. The native vegetation was tall prairie grass and groves of oak or brush.

In a representative profile the surface layer is black and very dark grayish-brown silt loam about 15 inches thick. The subsoil is about 37 inches thick. The upper part of the subsoil is brown, very friable and friable silt loam about 18 inches thick. The lower part is brown and yellowish-brown gravelly coarse sand about 19 inches thick. The underlying material is brown, yellowish-brown, and grayish-brown gravelly coarse sand.

Permeability is moderate. Runoff is slow to medium. The water table is below a depth of 10 feet. Available water capacity is moderate. Organic-matter content is high, and natural fertility is medium.

Most areas of Waukegan soils are in crops, but a few small areas remain in trees. These soils are well suited to most crops. Crop growth is limited by lack of available water in some areas. Controlling erosion in the more sloping areas is the major management need.

Representative profile of Waukegan silt loam, 0 to 2 percent slopes, in Northfield Township, 190 feet north and 200 feet west of southeast corner of sec. 34, T. 112 N., R. 19 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam, very dark gray (10YR 3/1) rubbed; weak, fine, subangular blocky structure; very friable; neutral; abrupt, smooth boundary.

A12—8 to 12 inches, black (10YR 2/1) silt loam, very dark gray (10YR 3/1) rubbed; weak, fine, granular structure; very friable; neutral; clear, wavy boundary.

A3—12 to 15 inches, very dark grayish-brown (10YR 3/2) silt loam; very dark brown (10YR 2/2) coatings on faces of peds; weak, fine, subangular blocky structure; very friable; slightly acid; clear, wavy boundary.

B21—15 to 22 inches, brown (10YR 4/3) silt loam; dark grayish-brown (10YR 4/2) and brown (10YR 4/3) coatings on faces of peds; weak, fine, subangular blocky structure; very friable; medium acid; clear, wavy boundary.

B22—22 to 30 inches, brown (10YR 4/3) silt loam; few dark-brown (10YR 3/3) and brown (10YR 4/3) coatings on faces of peds; weak, medium, subangular blocky structure; friable; few thin clay films on faces of some peds; few, bleached, light brownish-gray (10YR 6/2 dry) silt grains on faces of peds; medium acid; clear, wavy boundary.

B31—30 to 33 inches, dark yellowish-brown (10YR 4/4) silt loam grading to loam in lower part; few dark-brown (10YR 4/3) coatings on faces of peds; weak, fine, subangular blocky structure; very friable; medium acid; abrupt, smooth boundary.

IIB32—33 to 52 inches, mixed brown (10YR 5/3) and yellowish-brown (10YR 5/4) gravelly coarse sand; single grained; neutral; clear, wavy boundary.

IIC—52 to 60 inches, brown (10YR 5/3), yellowish-brown (10YR 5/4), and grayish-brown (2.5Y 5/2) gravelly coarse sand; single grained; slightly effervescent; mildly alkaline.

The solum ranges from 36 to 60 inches in thickness. The silty mantle ranges from 20 to 40 inches in thickness. The Ap and A1 horizons are very dark brown, very dark gray, or black. They range from 8 to 14 inches in combined thickness, and their reaction is neutral to medium acid. The A3 horizon is very dark grayish brown, very dark brown, or dark brown and is 2 to 6 inches thick. Its reaction is slightly acid or medium acid. The B2 horizon is 10 to 25 inches thick, and its reaction is slightly acid or medium acid. The B31 horizon is 3 to 5 inches thick. The IIC horizon is gravelly coarse sand or stratified sand and gravel. Depth to free carbonates is 40 to 60 inches.

Waukegan soils have more silt in the A and B horizons than the associated Estherville soils and the similar Dickman soils. Waukegan soils are more acid in the B horizon than the similar Fairhaven soils.

**Waukegan silt loam, 0 to 2 percent slopes** (WaA).—This soil is in tracts of 5 to 100 acres on flat tops of large, low-lying hills and in broad outwash areas. It has the profile described as representative of the series (fig. 9).

Included with this soil in mapping are a few areas of soils that have a surface layer and subsoil of loam that is high in content of silt. Small areas of Kato soils are also included.

This is a moderately droughty soil because of the moderate available water capacity. Runoff is slow. The hazard

*Figure 9.*—**In the foreground are Waukegan soils. Etter soils are on the toe slopes, and Sogn and Dodgeville soils are on the sides and top of the butte.**

of soil blowing is slight. This soil is used mostly for crops. Capability unit IIs–1; woodland group 3; building site group 1.

**Waukegan silt loam, 2 to 6 percent slopes** (WaB).—This soil is on small, irregularly shaped hills and in broad outwash areas. Tracts range from 5 to 160 acres in size. Included with this soil in mapping are a few areas of eroded soils in which part of the subsoil is mixed into the surface layer. This browner layer is lower in content of organic matter and is less friable than the original surface layer.

This is a moderately droughty soil because of the moderate available water capacity. Runoff is medium, and the hazard of water erosion is slight. Most areas of this soil are used for crops. Capability unit IIe–4; woodland group 3; building site group 1.

## Webster Series

The Webster series consists of nearly level, poorly drained soils that formed in calcareous, loamy glacial till. These soils are on broad upland flats and in drainageways where they are intermingled with more sloping soils. The native vegetation was water-tolerant prairie grasses.

In a representative profile the surface layer is black and very dark gray clay loam about 20 inches thick. The subsoil is mottled, olive-gray and dark grayish-brown, friable clay loam about 8 inches thick. The underlying material is calcareous, mottled, olive-gray and grayish-brown clay loam and loam.

Permeability is moderate. Runoff is slow to ponded. Depth to the water table commonly ranges from 0 to 3 feet or, where the soils are drained, near tile depth. The available water capacity is high. Organic-matter content and natural fertility are high.

Most areas of Webster soils are in crops. Undrained, these soils are only moderately well suited to poorly suited to crops. Where the soils are adequately drained, they are well suited to crops. Controlling the water table and maintaining good tilth and a high level of fertility are the major management needs.

Representative profile of Webster clay loam, in Warsaw Township, 650 feet south and 100 feet east of northwest corner of sec. 26, T. 109 N., R. 21 W.

Ap—0 to 7 inches, black (N 2/0) clay loam; weak, fine, subangular blocky structure (cloddy); friable; about 2 percent coarse fragments; neutral; abrupt, smooth boundary.

A1—7 to 15 inches, black (N 2/0) clay loam; weak, fine, subangular blocky structure; friable; about 2 percent coarse fragments; neutral; clear, wavy boundary.
A3—15 to 20 inches, very dark gray (10YR 3/1) clay loam; few black (N 2/0) coatings on faces of peds; weak, fine, subangular blocky structure; friable; about 2 percent coarse fragments; neutral; clear, wavy boundary.
B2g—20 to 28 inches, olive-gray (5Y 4/2) and dark grayish-brown (2.5Y 4/2) clay loam; few very dark gray (10YR 3/1) coatings on faces of peds; few, fine, distinct, strong-brown (7.5YR 5/8) mottles; weak, fine, subangular blocky structure; friable; about 3 percent coarse fragments; neutral; clear, wavy boundary.
C1g—28 to 38 inches, olive-gray (5Y 5/2) clay loam; few, fine, faint, strong-brown (7.5YR 5/8) mottles; massive; friable; about 3 percent coarse fragments; slightly effervescent; mildly alkaline; clear, wavy boundary.
C2g—38 to 64 inches, olive-gray (5Y 5/2) and grayish-brown (2.5Y 5/2) loam; moderate, medium, distinct, strong-brown (7.5YR 5/8) and light olive-brown (2.5Y 5/6) mottles; massive; friable; about 4 percent coarse fragments; strongly effervescent; mildly alkaline.

The solum ranges from 24 to 40 inches in thickness. The Ap and A1 horizons are clay loam or silty clay loam 10 to 16 inches thick. Reaction in these horizons is commonly neutral but ranges from slightly acid to mildly alkaline. The A3 horizon is black or very dark gray and is clay loam or silty clay loam 3 to 10 inches thick. Reaction is neutral to mildly alkaline. The B2g horizon is 8 to 14 inches thick. Reaction ranges from neutral to mildly alkaline. The Cg horizon is clay loam or loam.

Webster soils lack free carbonates in the A horizon, whereas the associated Canisteo soils have free carbonates in that horizon. They have a thinner A horizon than the associated Glencoe soils. Webster soils have more sand and less silt in all horizons than the similar Maxfield and Maxcreek soils, which formed in multiple glacial materials.

**Webster clay loam** (0 to 2 percent slopes) (We).—This soil occupies areas of 5 to 500 acres. It is in broad tracts that are broken by a few gentle rises, and it also is in broad, winding, lower lying tracts within areas of gently rolling to rolling soils in uplands.

Included with this soil in mapping are a few small depressions of Rolfe soils near the crests of the drainage divides. These soils have a grayish surface layer and a dark-colored, clayey subsoil. A few small areas of Canisteo soils on rims of depressions and in drainageways also are included, and so are a few areas of Cordova soils.

This soil is wet. Improved drainage is needed for most crops presently grown. Properly designed and installed drainage systems effectively remove excess water. This soil is used mostly for crops, and in the southern half of the county, most areas have been drained. Capability unit IIw–1; woodland group 7; building site group 10.

## Zumbro Series

The Zumbro series consists of nearly level, moderately well drained soils that formed in recent sandy alluvial sediment in which the sand size is mostly fine and medium. These soils are on broad flats, 5 to 30 acres in size, along streams. Slopes are uniform. The native vegetation was tall prairie grasses and a few thin stands of oak and brush.

In a representative profile the surface layer is about 9 inches of very dark gray sandy loam and about 27 inches of very dark gray and very dark grayish-brown loamy sand. The underlying material is dark grayish-brown, loose sand.

Permeability is rapid. Runoff is slow to medium, depending on slope. Depth to the water table is variable. Available water capacity is moderate. Organic-matter content is moderate, and natural fertility is medium.

Some areas of these soils are farmed with other soils in the field. Some areas are kept in permanent or long-term vegetative cover. The hazard of flooding is a major limitation to the use of these soils.

Representative profile of Zumbro sandy loam, in Cannon City Township, 120 feet west and 900 feet north of southeast corner of sec. 31, T. 110 N., R. 20 W.

A11—0 to 9 inches, very dark gray (10YR 3/1) sandy loam; weak, very fine, subangular blocky structure; friable; neutral; diffuse, wavy boundary.
A12—9 to 14 inches, very dark gray (10YR 3/1) loamy sand; weak, medium and coarse, subangular blocky structure; loose; neutral; diffuse, wavy boundary.
A13—14 to 36 inches, very dark gray (10YR 3/1) and very dark grayish-brown (10YR 3/2) loamy sand grading to sand in lower part; weak, medium and coarse, subangular blocky structure; loose; neutral; diffuse, wavy boundary.
C—36 to 64 inches, dark grayish-brown (10YR 4/2) sand; single grained; loose; neutral.

The solum ranges from 30 to 60 inches in thickness. The A horizon is black, very dark gray, very dark brown, very dark grayish-brown, or dark-brown sandy loam, fine sandy loam, loamy fine sand, loamy sand, or fine sand. Reaction is neutral to medium acid. A thin, dark-brown B horizon is in some profiles. The C horizon is mainly loamy sand, loamy fine sand, fine sand, or sand, but a few, thin, discontinuous bands of sandy loam, fine sandy loam, loamy fine sand, or loamy sand occur in some profiles. Reaction ranges from medium acid to mildly alkaline, but lime generally is leached to a depth of more than 60 inches. Depth of leaching of carbonates is limited by seams of coarse sand and finer textured seams that occur in some of the underlying material.

Zumbro soils have a thicker dark-colored A horizon than the similar Dickman soils.

**Zumbro sandy loam** (0 to 2 percent slopes) (Zu).—This soil is in areas of 5 to 30 acres on slight rises, where it is associated with other alluvial soils. Included with it in mapping are areas of soils that have loamy till material at a depth of 4 to 6 feet. The subsoil is grayer in areas where there is a loamy substratum. Small areas of soils that have slopes of more than 2 percent are also included.

This soil is subject to occasional flooding. It is moderately droughty. Wind erosion is a slight hazard. Some areas of this soil are in crops, and other areas are in permanent pasture or long-term vegetation. Capability unit IIw–3; woodland group 6; building site group 13.

# *Use and Management of the Soils*

This section discusses the use and management of soils in Rice County for crops, explains the system of capability grouping used by the Soil Conservation Service, and discusses the management of the soils by capability units. Predicted yields of principal crops are given. Also discussed are use of the soils for woodland and windbreaks, for wildlife habitat, and for community development. Limitations that affect the use of soils for recreational development and the properties and features that affect engineering practices are given, mainly in tables.

## Use and Management for Crops

In Rice County, a given field may have both level, wet soils and naturally well-drained, sloping soils. Another field can have droughty or moderately droughty soils that are intermingled with wet soils and sloping soils that have a high available water capacity. The wet soils need a drainage system that helps to control the

perched water table. The sloping soils need protection from soil and water loss. The droughty soils respond to irrigation.

The climate generally limits field operations to the period April 15 to November 15. The opportunity for timely field operations is limited.

The crops on most soils respond efficiently to additions of fertilizer. Nitrogen, phosphorus, and potassium are the principal elements added. Minor elements are used on some truck crops. The need for fertilizer depends on the kind of soil, the past and present management, and the crop that is grown. Soil tests provide part of the information needed to choose the best kinds and amounts of fertilizer.

*Tillage practices.*—Frequent tillage or tilling when the soils are too wet or too dry damages the structure of the soils. Frequent tillage makes the surface layer powdery so that water is not absorbed readily and runoff increases. This limits the amount of moisture available to plants, and erosion becomes more serious. Tilling when the soil does not contain the proper amount of moisture also makes the surface layer cloddy and unsuitable as a seedbed. In addition, it destroys the possible benefit to be derived from other practices that improve tilth.

The soils should be tilled only enough to prepare a good seedbed, to control the growth of weeds, or to control the volunteer growth of crops from the previous year. By applying chemicals to control weeds and by using machinery that provides only minimum tillage, the amount of tillage needed can be reduced.

Plowing in fall is a common practice on the nearly level to gently undulating soils. The freezing and thawing in winter can then break the clods and make tillage easier in spring. Soils plowed in fall can also be tilled earlier in spring than soils not plowed the previous fall. As a result, a better seedbed is generally prepared, and the potential for a good stand of plants is increased.

The practice of plowing in fall is suited to the precipitation pattern of this county. The average monthly low-intensity precipitation between October and March ranges from about 1.5 inches to less than 1 inch. Beginning in March or April, there is a rapid increase in the amount of rainfall. This disrupts the timeliness of spring plowing and often causes the soils to be tilled when they are too wet.

The nearly level to gently undulating soils dry out slowly in spring. Fall plowing is therefore more suitable for these soils than spring plowing. Tillage other than rough plowing, however, should be avoided in fall. A rough surface holds the moisture from melting snow and reduces the hazard of erosion.

Sloping soils can be protected by using minimum tillage and rough tillage and by properly managing all crop residue. These practices help to control erosion and also provide a better seedbed for crops that are adapted to minimum tillage. The hazard of erosion increases as the slope increases. Therefore, sloping soils should be cultivated on the contour. Fall plowing is suitable if such soils are terraced and if manure or some other protective mulch is used.

*Erosion control.*—Controlling erosion and conserving water are necessary on erodible soils to reduce losses of soil and water. Among the practices that help to control water are contour cultivation, terracing, stripcropping, sodding of waterways, mulch tillage, rough tillage, and minimum tillage. Practices that help to control soil blowing include stripcropping, mulch tillage, rough tillage, and minimum tillage. Sloping soils can be protected against water erosion by maintaining the content of organic matter and a good level of fertility. A high content of organic matter increases the infiltration of water and, along with a high level of fertility, enables the soil to support crops that improve soil structure.

Soil blowing is generally not a problem in this county, except in a few of the larger areas of muck. Blowing of sandy soils and of organic soils can be prevented, however, by stripcropping, rough tillage, maintaining a cover of plants or crop residue, wind stripcropping, and providing windbreaks for exposed areas.

*Drainage.*—About 38 percent of the acreage in the county is made up of wet soils. Many farmers have installed tile, but many areas still need artificial drainage. Artificial drainage has been one of the most important factors contributing to the development of farming in this county.

A tile drainage system will function properly in most of the soils. In local areas that are underlain by sandy or gravelly material, however, it is difficult to install tile and to maintain open drains.

Root development is good in soils that are adequately drained because the movement of air and water is not restricted. Soils that are adequately drained generally warm up earlier in spring and are less susceptible to frost heaving than poorly drained soils. Effective drainage also facilitates the use of larger farm equipment and permits more timely field operations than are possible in undrained areas.

Areas to be drained should be inspected by someone who knows the soils, because the depth and spacing of the tile depend on the kind of soil and the pattern of occurrence of the various soils. Open ditches are commonly used to remove excess surface water and to provide an outlet for other drainage systems.

*Liming.*—The requirements for lime depend on the natural acidity of the soils, the previous management, and the cropping system that is planned. Originally, the soils of the county were high in calcium. Now, in some of them the calcium has been leached out of the surface layer. After the calcium has been leached out, the soils need periodic applications of lime to correct acidity. The need for lime and the response to it vary considerably. The The soils of this county are generally so intermingled that the soils in one part of the field may need lime and those in another part may not. Soil tests should be made to determine the requirements for lime.

Correcting the acidity in the surface layer helps to make other plant nutrients available to crops. Where the acidity has been corrected, there is better response to the inoculation of legumes.

### *Capability grouping*

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are so 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 apply 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 range, for forest trees, or engineering.

In the capability system, the kinds of soils are grouped at three levels: the capability class, subclass, and unit. These are discussed 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.

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, woodland, or wildlife habitat. (None in Rice County)
Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture, woodland, or wildlife habitat.
Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture, woodland, or wildlife habitat.
Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, 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, woodland, or wildlife habitat, 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–4 or IIIe–3. 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.

### *Management by capability units*

In the following pages the capability units in Rice County are described. The names of the soil series represented are mentioned in the description of each capability unit, but the listing of the series name does not necessarily indicate that all the soils of a series are in the capability unit. The capability classification of each soil is given in the "Guide to Mapping Units" at the back of this survey.

#### CAPABILITY UNIT I-1

This unit consists of well-drained to somewhat poorly drained, medium-textured and moderately fine textured, nearly level soils in the Klinger, Le Sueur, Merton, Nicollet, Ostrander, and Port Byron series and the Fairhaven series, loamy subsoil variant. These soils have few limitations that restrict their use. Erosion is not a significant concern. Available water capacity is high to very high. Permeability is moderate and moderately slow. Corn, soybeans, oats, and alfalfa-brome are the principal crops. Sweet corn and peas are other important crops.

Return of residue from high-yielding crops, limited tillage, and tillage at proper moisture content helps to keep good tilth and to control compaction. Crops on these soils respond well to additions of fertilizer.

#### CAPABILITY UNIT IIe-1

This unit consists of well drained and moderately well drained soils that have irregularly shaped, gently undulating slopes. These soils are in the Clarion, Lester, Moland, Ostrander, Port Byron, and Terril series and the Fairhaven series, loamy subsoil variant. Permeability is moderate, and the available water capacity is high to very high. The hazard of erosion is slight to moderate.

Corn, soybeans, oats, alfalfa, and brome are the principal crops.

The practices commonly used to help control erosion and to maintain good tilth and a high level of fertility are using residue from crops that have a large amount of residue, limiting the amount of tillage, tilling only within the proper range of moisture content, and applying fertilizer. In the larger areas of soils that have smooth slopes, cultivating on the contour and terracing can be used. Waterways should be properly designed and be kept in grass.

The response to lime varies. Unless extra management is used, eroded soils in which the plow layer contains part of the subsoil are less suited to crops than the other soils.

#### CAPABILITY UNIT IIe-2

This unit consists of well-drained, gently undulating soils in the Hayden and Renova series. Available water capacity is high. Permeability is moderate to moderately slow. The hazard of water erosion is moderate. These soils can be properly tilled only within a narrow range of moisture content. The surface layer tends to slake and settle on wetting and to crust on drying. This reduces infiltration of air and water into the plow layer.

Corn, soybeans, oats, alfalfa and brome are the principal crops.

The practices commonly used to control erosion and to maintain good tilth and a high level of fertility are re-

turning residue from crops that have a large amount of residue, limiting the amount of tillage, tilling at a proper moisture content, and applying fertilizer. On the Renova soils and in selected areas of the Hayden soils, contour cultivation and terracing are helpful.

Waterways need to be properly designed and kept in grass. A long-term liming program is essential on these soils, particularly on the Renova soils. Crops respond well to additions of nitrogen, phosphorous, and potassium. Unless extra management is used, crop growth is less on soils in which the plow layer contains part of the subsoil than it is on the other soils.

#### CAPABILITY UNIT IIe-3

This unit consists of well-drained to somewhat poorly drained, medium-textured to moderately fine textured, nearly level to gently sloping and gently undulating soils in the Erin, Kasson, Kilkenny, Lerdal, and Vlasaty series. Available water capacity is high. Permeability is moderately slow to slow. The hazard of erosion is slight to moderate. The soils of this unit are farmed in fields with soils of other units. They can be easily tilled only within a narrow range of moisture content. If they are worked when wet, the soils generally remain cloddy for the balance of the growing season.

Corn, soybeans, oats, alfalfa, and brome are the principal crops.

Practices that control erosion and maintain good tilth and a high level of fertility are using sod crops, returning residue from crops that have a large amount of residue, limiting the amount of tillage, tilling at a proper moisture content, and applying fertilizer. The high clay content in the upper part of the subsoil markedly increases the effects of erosion. Caution must be used in terrace construction. If the grade is too nearly level, wetness may develop in and below the channel. Spring plowing produces a cloddy seedbed.

The waterways need to be properly designed and kept in grass. Soils in this unit need regular liming.

Eroded soils in which part of the subsoil has been mixed into the plow layer are less suited to crops than the other soils.

#### CAPABILITY UNIT IIe-4

This unit consists of well-drained, gently sloping soils that are underlain by sand and gravel. These soils are in the Fairhaven and Waukegan series. They have moderate available water capacity. Permeability is moderate or moderately rapid in the upper part and rapid in the underlying material. The hazard of erosion is slight.

Corn, soybeans, oats, and alfalfa-brome are the principal crops. Canning peas and sweet corn are other important crops.

Controlling erosion, applying fertilizer, and adjusting plant population to the available water and irrigation are the major management needs. Crop growth is directly related to the amount and timeliness of rainfall. Cropping programs should combine short-season crops with long-season crops to adjust to these variations in available water. All waterways should be properly designed and kept in grass.

Where these soils are in permanent pasture, periodic applications of nitrogen, phosphorus, and potassium will sustain adequate plant growth. Generally, neither permanent nor rotation pasture provides adequate quantities of forage for grazing in dry periods.

#### CAPABILITY UNIT IIw-1

This unit consists of poorly drained, moderately fine textured, nearly level soils on broad flats and in wide draws. These soils are in the Canisteo, Colo, Cordova, Garwin, Maxcreek, Maxfield, Mazaska, and Webster series. Available water capacity is high. Permeability is moderate to slow.

Corn and soybeans are the principal crops where these soils are dominant in a field. Where the soils occur as smaller tracts within larger areas of more sloping soils, they are farmed with the dominant soils.

Removing excess water and maintaining good tilth and a high level of fertility are the major management needs. Most areas of these soils are in crops, but good crop growth generally cannot be expected unless properly designed waterways and outlet ditches are constructed and drain tile is installed. Open inlets or French drains are needed in places to prevent ponding in small depressions. Closer tile spacing is needed in the Cordova, Maxfield, and Mazaska soils than in the other soils because the content of clay is higher in the subsoil. The coarse-textured seams in some areas of the Maxcreek and Maxfield soils cave and slough during ditch construction and tile installation. Protection against flooding is needed for Colo soils. If the soils in this unit are adequately drained and managed, row crops can be grown year after year.

Returning residue from crops that have a large amount of residue, limiting the amount of tillage, and tilling at the proper moisture content help to maintain good tilth and to keep compaction at a minimum. Where the soils are adequately drained, crops respond well to applications of fertilizer.

#### CAPABILITY UNIT IIw-2

This unit consists of poorly drained, medium-textured and moderately fine textured soils in the Biscay and Kato series. These soils are on broad flats and in wide draws. Most of them are nearly level, but the Biscay soil, seepy variant, is gently sloping to moderately steep. Available water capacity is moderate to high. Permeability is moderate in the upper part and rapid in the underlying material.

Corn and soybeans are the principal crops grown where these soils are dominant in a field. Large acreages of sweet corn are grown in some areas. Where the soils occur as smaller tracts within areas of more sloping soils, they are farmed with the dominant soils.

Removing excess water and maintaining good tilth and a high level of fertility are the major management needs. Most areas of these soils are in crops, but good crop growth cannot be expected unless properly designed waterways and outlet ditches are constructed and drain tile are installed. Open inlets or French drains are needed in some places to prevent ponding in small depressions. Wider tile spacing is used because the underlying material is coarse textured. This coarse-textured material caves and sloughs during ditch construction and tile installation. If these soils are adequately drained and managed, row crops can be grown year after year.

Using residue from crops that have a large amount of residue limiting the amount of tillage, and tilling at the proper moisture content help to maintain good tilth and to keep compaction at a minimum. Where the soils are

adequately drained, crops respond well to applications of fertilizer.

#### CAPABILITY UNIT IIw-3

This unit consists of well-drained to poorly drained, moderately coarse textured, nearly level soils on broad flats and in wide draws adjacent to streams. These soils are in the Zumbro series and Alluvial land. Available water capacity is low to high and permeability is rapid in the Zumbro soils, but these properties are variable in Alluvial land.

These soils are occasionally flooded, but some areas of them are used for crops. Corn and soybeans are grown where water is kept from the field by dikes or diversions. Where the soils occur as smaller tracts within areas of more sloping soils, they are farmed with the dominant soils.

Removing excess water, protecting the soil against flooding, and maintaining good tilth and a high level of fertility are the major management needs.

Using residue from crops that have a large amount of residue and limiting tillage help to maintain good tilth and to keep compaction at a minimum. Crops respond well to applications of fertilizer if the soils are adequately protected against flooding.

#### CAPABILITY UNIT IIs-1

This unit consists of well-drained, nearly level soils that are underlain by sand and gravel. These soils are in the Fairhaven and Waukegan series. Available water capacity is moderate. Permeability is moderate or moderately rapid in the upper part and rapid in the underlying material. The hazards of water erosion and soil blowing are slight.

Corn and soybeans are the principal crops. Canning peas and sweet corn are other important crops.

Protecting the soils from blowing, applying fertilizer, using irrigation water, and adjusting plant populations to the available water are the major management needs. Crop growth is directly related to the amount and timeliness of rainfall. Cropping systems should combine short-season crops and long-season crops to adjust to variations in available water.

Periodic applications of nitrogen, phosphorous, and potassium sustain satisfactory growth of pasture plants. Ordinarily, neither permanent pasture nor rotation pasture provides adequate quantities of forage for grazing in dry periods.

#### CAPABILITY UNIT IIIe-1

This unit consists mostly of well drained and moderately well drained, medium-textured, sloping and rolling soils in the Clarion, Judson, Lester, Moland, Ostrander, Port Byron, and Terril series. Also in the unit are small tracts of the well-drained Bold soils and the somewhat excessively drained Storden soils. The available water capacity is high. Permeability is moderate, and the hazard of erosion is moderate to severe.

Corn, soybeans, oats, and alfalfa-brome are the principal crops.

Practices that help to control erosion and to maintain good tilth and a high level of fertility are returning residue from crops that have a large amount of residue, limiting the amount of tillage, tilling only at proper moisture content, and applying fertilizer. Contour cultivation and terracing can be applied to the larger tracts where slopes are smooth. Waterways need to be properly designed and kept in grass.

Response to lime and the need for it vary. Crops grown on these soils respond well to applications of nitrogen, phosphorous, and potassium.

Unless extra management is used, eroded soils in which the plow layer contains part of the subsoil are less well suited to crops than other soils in the unit. Many small areas of these soils are farmed with larger areas of less sloping soils. In these small areas, extra manure or special use of crop residue is needed to reduce erosion and to maintain good tilth.

#### CAPABILITY UNIT IIIe-2

This unit consists of well-drained, medium-textured, rolling and sloping soils in the Hayden and Renova series. Available water capacity is high. Permeability is moderate or moderately slow, and the hazard of water erosion is moderate to severe. Soils in this unit can be properly tilled only within a narrow range of moisture content. The surface layer tends to slake and settle on wetting and to crust on drying. The Renova soils are less permeable than the Hayden soils, and their cultivated layer becomes very cloddy if worked above the proper moisture level. The higher content of silt in the Renova soils increases the effect of erosion.

Corn, oats, and alfalfa-brome are the principal crops.

Practices that commonly help to control erosion and to maintain good tilth and a high level of fertility are returning residue from crops that have a large amount of residue, limiting the amount of tillage, tilling at proper moisture content, and applying fertilizer. Contour cultivation and terracing can be applied to the Renova soils and selected areas of the Hayden soils. Waterways need to be properly designed and kept in grass. A long-term liming program is essential on these soils, particularly on the Renova soils. Crops respond well to additions of nitrogen, phosphorous, and potassium. Unless extra management is applied to soils in which the plow layer contains part of the subsoil, these soils are less well suited to crops than other soils.

#### CAPABILITY UNIT IIIe-3

This unit consists of well-drained to somewhat poorly drained, medium-textured and moderately fine textured, sloping and rolling soils in the Erin, Kilkenny, and Lerdal series. Available water capacity is high. Permeability is moderately slow or slow, and the hazard of erosion is severe. Soils in this unit can be properly tilled only within a narrow range of moisture content. The surface layer of the Erin silt loam tends to slake and settle on wetting and to crust on drying. The Kilkenny soils become very cloddy if they are worked above the proper moisture level. The higher content of clay in the subsoil increases the effect of erosion. Soils of this unit occur in fields with soils of other units.

Corn, oats, and alfalfa-brome are the principal crops.

Practices that commonly help to control erosion and to maintain good tilth and a high level of fertility are returning residue from crops that have a large amount of residue, limiting the amount of tillage, tilling at proper moisture content, and applying fertilizer. Contour cultivation and terracing can be applied to selected tracts of these soils. Waterways need to be properly designed and kept in grass. The soils of this unit commonly need applications of lime. Crops respond well to additions of

nitrogen, phosphorus, and potassium. Unless extra management is used, eroded soils in which the plow layer contains part of the subsoil are less suited to crops than the other soils.

#### CAPABILITY UNIT IIIe-4

This unit consists of somewhat excessively drained and well-drained, moderately coarse textured and medium-textured, gently sloping and gently undulating to rolling soils in the Clarion, Dickman, Dodgeville, Estherville, Etter, and Storden series. Available water capacity is low to moderate in most of these soils, but it is high in the Clarion and Storden soils. Permeability is moderate to rapid. The hazard of soil blowing is slight to moderate, and there is also a slight hazard of water erosion.

Corn, oats, and alfalfa-brome are the principal crops. Early season peas and sweet corn are important crops. A few areas of these soils are irrigated for potatoes and sweet corn.

Controlling erosion, applying proper fertilizer, adjusting plant populations to the available water capacity, and irrigating are the major management needs. Crop growth is directly related to the amount and timeliness of rainfall. Cropping systems should combine short-season crops and long-season crops to adjust to variations of available water. Proper management of crop residue is the main practice needed to help control erosion. Periodic topdressing with nitrogen, phosphorus, and potassium increases growth of pasture plants in spring and fall. Generally, neither permanent nor rotation pasture provides enough forage for grazing in dry periods.

#### CAPABILITY UNIT IIIw-1

This unit consists of very poorly drained and poorly drained, moderately fine textured soils that are in low-gradient drainageways and depressions. These soils are in the Canisteo, Glencoe, Maxcreek, Maxfield, and Rolfe series. Available water capacity is high. Permeability is moderate to slow. Soils of this unit are in fields with soils of other units. Timeliness of field operations is affected where these soils are inadequately drained.

Removing excess water and maintaining good tilth and a high level of fertility are the major management needs. Unless waterways or ditches are constructed and drain tile is installed, the soils of this unit are seldom suited to crops. Many areas have been drained and are used for crops. If these soils are adequately drained and managed, row crops can be grown year after year. Open inlets or French drains are needed in places to remove ponded water in closed depressions. Closer tile spacing is needed in the Rolfe soils than in the other soils. The coarse-textured seams in some areas of the Maxcreek and Maxfield soils cave and slough during ditch construction and tile installation.

Returning residue from crops that have a large amount of residue, using a mimimum amount of tillage, and tilling at the proper moisture content help to maintain good tilth and keep compaction at a minimum. If these soils are adequately drained, crops respond well to applications of fertilizer. Lime is not needed. Areas of excess lime occur in Canisteo soils and occasionally in other soils. Such areas need specific fertility treatment.

Some areas of the soils in this unit that have not been brought under cultivation provide wildlife habitat.

#### CAPABILITY UNIT IIIw-2

This unit consists of very poorly drained muck soils in the Caron, Muskego, and Palms series. Available water capacity is very high. The adequacy of the drainage system determines use of these soils and the crop growth.

Removing excess water and maintaining fertility are the main management needs. Removing surface water through drains and outlets ditches is essential in areas used for crops. Where bogs are large, installation of diversion terraces and interceptor ditches on the surrounding higher lying soils helps to control runoff that would otherwise flood the bogs. A tile line near the base of the surrounding mineral soils helps to control seepage. The rate of subsidence varies with the thickness of the muck, the intensity of cropping, the level of the water table, and the natural wetness of the site. Controlling the water table reduces oxidation of the organic matter and the subsidence. In bogs that have a rapid rate of subsidence after they are drained by outlet ditches, the installation of tile should be delayed a year or two.

All the soils in this unit are high in calcium content, but they generally are very low in phosphate and potash. The nitrogen content is high, but some bogs recently drained or under cultivation a long time respond well to additions of nitrogen. Some bogs, particularly those used for truck crops, require additions of trace elements.

Fire is a constant hazard. After a fire becomes established, the effort and cost of extinguishing it is high. These soils neither absorb nor conduct heat as rapidly as do mineral soils. The possibility of frost is a hazard except late in June, in July, and early in August. The degree of hazard varies with the amount of air drainage of the surrounding area (fig. 10). Heat transfer is higher from a moist surface.

Farm crops commonly are limited to soybeans, silage corn, sweet corn, and, in places, early maturing field corn. Truck crops are potatoes, carrots, onions, red beets, and mint.

Practices that help to control soil blowing are planting windbreaks, irrigating, rough tillage, and use of cover crops.

Suitability of the soils to pasture plants varies widely and depends on drainage and types of grasses. Where some drainage improvement is possible and areas are seeded to desirable grasses and properly fertilized, excellent growth of pasture plants can be expected.

Some undeveloped areas of the soils in this unit provide excellent habitat for waterfowl and, in selected areas, provide winter cover for upland birds.

#### CAPABILITY UNIT IIIw-3

This unit consists of somewhat poorly drained, medium-textured, nearly level soils in the Dundas, Shields, and Skyberg series. Available water capacity is high. Permeability is moderately slow or slow.

Corn, soybeans, oats, and alfalfa-brome are the principal crops.

Soils of this unit are slow in drying out and warming up in spring. In cultivated areas the surface layer is weakly aggregated and loses tilth easily. Crops grown on these soils respond well to applications of fertilizer, particularly nitrogen. A liming program must be considered. Proper fertilizing, minimum amount of tilling, using crops that produce a large amount of residue, and tilling at the proper

*Figure 10.*—**Area of Caron muck. On slopes in the background are Kilkenny and Lerdal soils.**

moisture content help to maintain good tilth. The prepared seedbed tends to slake and settle on wetting, and the soil crusts on drying. This reduces aeration and slows the emergence of seedlings. If worked above optimum moisture content, the cultivated layer becomes persistently cloddy for the balance of the crop season.

Water is slow to leave the surface layer because the subsoil is high in content of clay. The perched water table is at a depth of 2 to 3 feet in seasons of high rainfall and near a depth of 5 feet in the drier seasons. Tile drainage, though generally not installed in these soils, would be effective in controlling the water table. Surface waterways remove excess water. Closer tile spacing is needed in the Shields and Skyberg soils than in the Dundas soils. An adequate outlet is needed for the proper functioning of tile drains.

The high shrink-swell potential of the Shields soil, and the waterlogging of the surface layer in all the soils, increase winter damage to plants having a taproot.

#### CAPABILITY UNIT IIIe-1

This unit consists of somewhat excessively drained and well-drained, moderately coarse textured and moderately fine textured, nearly level soils in the Copaston, Dickman, and Estherville series. These soils are underlain by sand, sand and gravel, or bedrock. Available water capacity is low to moderate. Permeability is moderate to rapid in the upper part and rapid in the coarse-textured underlying material. Soil blowing is a hazard. Rodents do some damage to crops on these soils.

Corn, oats, and alfalfa-brome are the principal crops. Early canning peas and sweet corn also are grown. Sweet corn and potatoes are grown under irrigation in a few places.

Controlling soil blowing, proper fertilizing, irrigation, and adjusting plant populations to the available water capacity are the major management needs. Cropping systems should combine short-season crops with long-season crops to meet variations in available water. Soil blowing can be controlled by the proper management of residue.

Where these soils are in permanent pasture or long-term meadow, periodic topdressing with nitrogen, phosphorus and potassium increases forage growth in spring and fall. Generally, neither permanent nor rotation pasture provides adequate forage for grazing in dry periods.

#### CAPABILITY UNIT IVe-1

This unit consists of medium-textured, moderately steep and hilly soils in the Bold, Clarion, Lester, Moland, Ostrander, Port Byron and Storden soils. All of these soils are well drained, except for the Storden soils, which are somewhat excessively drained. The soils in this unit have high to very high available water capacity and moderate permeability. The hazard of erosion is severe.

Corn, oats, and alfalfa-brome are the principal crops. Many small areas are farmed with larger areas of less sloping soils.

Controlling erosion in cultivated fields and improving forage for hay and pasture are the major management needs.

Soil and water loss can be controlled in cultivated fields through the use of contouring, residue management, and limited tillage. Slopes are commonly too steep for terracing and too irregular for contouring. Additions of manure and special use of crop residue are the principal erosion control methods.

Long-term meadow or pasture needs periodic topdressings of nitrogen, phosphorus, and potassium. There is less growth on south- and west-facing slopes during hot summer months than on slopes facing north and east.

#### CAPABILITY UNIT IVe-2

This unit consists of well-drained, medium-textured, moderately steep and hilly soils in the Hayden and Renova series. Available water capacity is high. Permeability is moderate or moderately slow. The hazard of erosion is severe. Soils in this unit can be properly tilled only within a narrow range of moisture content. The surface layer tends to slake and settle on wetting, and it crusts on drying. The Renova soils are less permeable than the Hayden soils, and their cultivated layer becomes very cloddy if it is worked above the proper moisture level. The higher content of silt in the Renova soils increases the effects of erosion. The soils in this unit occur in fields with soils of other units.

Corn, oats, and alfalfa-brome are the principal crops.

Practices that control erosion and that maintain good tilth and a high level of fertility commonly are the return of residue from crops that have a large amount of residue, limiting the amount of tillage, tilling at proper moisture content, and applying fertilizer. Contour cultivation can be applied to the Renova soils and to selected areas of the Hayden soils. Waterways need to be properly designed and kept in grass. A long-term liming program is essential on these soils, particularly on the Renova soils. Crops respond well to applications of nitrogen, phosphorus, and potassium. Unless extra management is used, eroded soils in which the plow layer contains part of the subsoil are less suited to crops than are other soils.

#### CAPABILITY UNIT IVe-3

This unit consists of well-drained to somewhat poorly drained, medium-textured and moderately fine textured, hilly soils in the Erin, Kilkenny, and Lerdal soils. Available water capacity is high. Permeability is moderately slow to slow. The hazard of erosion is severe. Soils in this unit can be properly tilled only within a narrow range of moisture content. The surface layer of the Erin silt loam tends to slake and settle on wetting, and it crusts on drying. In cultivated areas the Kilkenny soils become very cloddy if they are worked above the proper moisture content. If worked when too wet, the soils generally remain cloddy the balance of the cropping season. The higher content of clay in the subsoil increases the effects of erosion.

Corn, oats, and alfalfa-brome are the principal crops.

Practices that control erosion and maintain good tilth and a high level of fertility commonly are the return of residue from crops that have a large amount of residue, limiting the amount of tillage, tilling at the proper moisture content, and applying fertilizer. Waterways need to be properly designed and kept in grass. The soils of this unit commonly need applications of lime. These soils respond well to applications of nitrogen, phosphorus, and potassium. Unless extra management is used, eroded soils in which the plow layer contains part of the subsoil are less suited to crops than other soils.

#### CAPABILITY UNIT IVe-4

This unit consists of well-drained and somewhat excessively drained, moderately coarse textured to medium-textured, sloping soils in the Dickman, Dodgeville, and Estherville series. These soils are underlain by sand, sand and gravel, or bedrock. Available water capacity is moderate or low. Permeability is moderate to rapid in the upper part and rapid in the underlying material. The hazards of soil blowing and water erosion are moderate in cultivated fields.

Corn, oats, and alfalfa are the common crops grown on the soils in this unit.

Controlling erosion and adjusting crops to the available water capacity are the major management needs. The soils of this unit occur as small areas within larger areas of other soils that have a higher available water capacity. Long-term production of grasses and legumes is sustained or increased by topdressing with nitrogen, phosphorus and potassium.

Contour tillage and residue management are effective erosion control practices.

Generally, neither permanent nor rotation pasture provides sufficient forage for grazing in dry periods.

#### CAPABILITY UNIT VIe-1

This unit consists of steep to very steep, medium-textured and moderately fine textured soils in the Clarion, Erin, Hayden, Kilkenny, Lester, Ostrander, Renova, and Storden series. These soils are well drained, except for the Storden soils, which are somewhat excessively drained. The available water capacity is high. Permeability is moderate to moderately slow. The hazard of water erosion is severe to very severe.

Improving pasture and improving woodlots are the major management needs. Larger areas are better suited to a permanent cover of vegetation than to other plants. Woodland and wildlife plantings can be established in smaller areas. Applications of lime, nitrogen, phosphorus, and potassium help to increase the growth of pasture plants. Production on south- and west-facing slopes is low during the hot summer months. A few areas are included that are so steep that they cannot be safely seeded and fertilized.

#### CAPABILITY UNIT VIe-2

This unit consists of well-drained, medium-textured and moderately coarse textured, sloping to moderately steep soils in the Dodgeville and Etter series. These soils

are underlain by bedrock or sandstone. Available water capacity is moderate. Permeability is moderate, and the hazard of erosion is severe. Most areas of these soils are in permanent vegetation.

Controlling erosion and maintaining satisfactory stands of forage and other kinds of permanent vegetation are the main management needs. Growth is reduced in many places by limited or untimely rainfall, high winds, or high temperatures. Many areas of the soils in this unit occur as small tracts associated with larger areas of less sloping soils. Applications of fertilizer need to be adjusted to the available water capacity. Long-term crops of grasses and legumes are sustained or increased by topdressing with nitrogen, phosphorus, and potassium.

Residue management helps to control erosion.

Generally, neither permanent nor rotation pasture provides sufficient forage for grazing in dry periods.

#### CAPABILITY UNIT VIw-1

This unit consists of Alluvial land, frequently flooded, and Lake beaches. These land types are variable in available water capacity and permeability.

Most areas are in permanent vegetation. The land types are poorly suited to cultivated crops because of wetness and the hazard of flooding. Improved permanent pasture, wildlife habitat, and recreation are suitable uses. Alluvial land, frequently flooded, is occasionally cropped if dikes, levees, or diversions are used. Lake beaches are occasionally cropped if adjacent organic soils are drained, but in many places they become droughty if the water table is lowered.

#### CAPABILITY UNIT VIw-2

This unit consists of Biscay loam, seepy variant, and Faxon clay loam. These soils have moderate available water capacity and moderate permeability. The Faxon soil has bedrock at a depth of 20 to 40 inches, and Biscay loam, seepy variant, has slopes of 4 to 18 percent.

Most areas of these soils are in permanent vegetation. The soils are poorly suited to cultivated crops because of wetness. Improving drainage is difficult or impractical because of the depth to bedrock in the Faxon soil and the slope of the Biscay variant. Improved permanent pasture, wildlife habitat, and recreation are suitable uses. Soils of this unit are cultivated in some areas where they are adjacent to soils that have been artificially drained.

#### CAPABILITY UNIT VIs-1

This unit consists of excessively drained, coarse textured and moderately coarse textured, gently sloping to sloping soils in the Boone and Salida series. Available water capacity is very low. These soils have very rapid permeability. They commonly occur as small areas within larger areas of more fertile soils. The hazards of soil blowing and water erosion are moderate in cultivated areas.

Controlling erosion and maintaining permanent vegetative cover are the main management needs. Growth is reduced in many places by limited or untimely rainfall, high winds, or high temperatures. Applications of fertilizer need to be adjusted to the available water capacity of these soils. Long-term crops of grasses and legumes are sustained or increased by topdressings of nitrogen, phosphorous, and potassium. Woodland is commonly the best general use of these soils.

Ordinarily, neither permanent nor rotation pasture provides sufficient forage for grazing during dry periods.

#### CAPABILITY UNIT VIIe-1

This unit consists of well-drained, medium-textured, steep to very steep soils in the Dodgeville series and of Rough broken land. The Dodgeville soils are underlain by bedrock. Available water capacity is moderate. Permeability is moderate. The soil materials, available water capacity, and permeability are variable in Rough broken land. The hazard of erosion is severe to very severe.

Controlling erosion and maintaining satisfactory stands of permanent vegetation are the major management needs. Growth is often reduced by limited or untimely rainfall, high winds, or high temperatures.

Generally, permanent pasture does not provide enough forage for grazing in dry periods.

#### CAPABILITY UNIT VIIs-1

This unit consists of well-drained to excessively drained, moderately coarse textured and coarse textured, moderately steep to very steep soils in the Boone, Salida, and Sogn series. Available water capacity is very low. Permeability is moderate to very rapid. In places the soils of this unit occur as small tracts within larger areas of more fertile soils. The hazards of soil blowing and water erosion are moderate to very severe.

Maintaining a permanent cover of vegetation is the principal management need. Growth is often reduced by limited or untimely rainfall, high winds, or high temperatures. Commonly, the best general use of the soils in this unit is woodland.

#### CAPABILITY UNIT VIIIw-1

This unit consists only of Marsh. Generally, this land type is unsuited to cultivated crops and is poorly suited to pasture because the water level is so high.

The management needed for Marsh is related mostly to the wildlife that is adapted to this kind of an environment. Areas of Marsh can be improved by level ditching or by controlling the water level. Selected areas provide winter cover for upland birds.

### *Predicted yields*

The yields of principal crops shown in table 2 can be obtained in Rice County if the following management is applied—

1. Lime needs are corrected.
2. Special fertility treatments are applied to the calcareous soils.
3. Tillage operations maintain optimum tilth.
4. Erosion is controlled on sloping soils.
5. Pesticides and herbicides are used.
6. Soils are adequately drained.
7. Plant populations are adjusted to available water capacity of soils.
8. Fertilizer is applied according to results of soil tests.

The yield predictions were based on information obtained from the following sources: records of measured yields obtained by experiments made on specific soils, records of yields and soil management practices reported by farmers for crops on specific soils, observations of crops and interviews with farmers during the course of the survey, knowledge of soil properties that are known to affect crop growth, consultation with county agents and personnel of the Soil Conservation Service, and average yield values published in agricultural census data.

TABLE 2.—*Predicted average yields per acre of principal crops grown under a high level of management*

[ Absence of a yield figure indicates that the yield is too variable to predict or that the crop is not suited to the soil or ordinarily is not grown on it]

| Soil | Corn | Oats | Soybeans | Alfalfa or alfalfa-brome mixture |
|---|---|---|---|---|
| | *Bu.* | *Bu.* | *Bu.* | *Tons* |
| Alluvial land [1] | 70 | 55 | 27 | 3.0 |
| Alluvial land, frequently flooded | | | | |
| Biscay loam [1] | 80 | 70 | 32 | 3.0 |
| Biscay loam, seepy variant [1] | 75 | 60 | 30 | 3.0 |
| Boone fine sand, 2 to 12 percent slopes | | 30 | | 1.5 |
| Boone fine sand, 12 to 25 percent slopes | | | | |
| Boone fine sand, 25 to 40 percent slopes | | | | |
| Canisteo clay loam [1] | 110 | 75 | 36 | 4.5 |
| Canisteo clay loam, depressional [1] | 95 | 65 | 30 | 4.0 |
| Caron muck [1,2] | 70 | | 28 | |
| Clarion loam, 2 to 6 percent slopes | 120 | 85 | 40 | 4.5 |
| Clarion loam, 6 to 12 percent slopes | 95 | 65 | 30 | 4.0 |
| Clarion-Estherville-Storden complex, 4 to 12 percent slopes, eroded | 65 | 50 | 20 | 2.5 |
| Clarion-Storden loams, 6 to 12 percent slopes | 75 | 60 | 25 | 3.0 |
| Clarion-Storden loams, 12 to 18 percent slopes | 60 | 40 | | 2.5 |
| Clarion-Storden loams, 18 to 25 percent slopes | | | | 2.0 |
| Colo silty clay loam [1] | 90 | 60 | 30 | 3.0 |
| Copaston sandy clay loam, 0 to 2 percent slopes | 50 | 45 | 20 | 2.5 |
| Cordova clay loam [1] | 90 | 65 | 33 | 3.0 |
| Dickman sandy loam, 0 to 2 percent slopes | 60 | 55 | 22 | 2.5 |
| Dickman sandy loam, 2 to 6 percent slopes | 55 | 50 | 20 | 2.5 |
| Dickman sandy loam, 6 to 12 percent slopes | 50 | 45 | 18 | 2.5 |
| Dickman sandy loam, benches, 0 to 2 percent slopes | 60 | 55 | 22 | 2.5 |
| Dickman sandy loam, benches, 2 to 6 percent slopes | 55 | 50 | 20 | 2.5 |
| Dodgeville silt loam, 2 to 6 percent slopes | 70 | 65 | 30 | 3.0 |
| Dodgeville silt loam, 6 to 12 percent slopes | 65 | 60 | 20 | 2.5 |
| Dodgeville silt loam, 12 to 18 percent slopes | | | | 2.5 |
| Dodgeville silt loam, 18 to 25 percent slopes | | | | |
| Dundas silt loam [1] | 85 | 65 | 30 | 3.5 |
| Erin silt loam, 2 to 6 percent slopes | 85 | 75 | 30 | 3.5 |
| Erin silt loam, 6 to 12 percent slopes, eroded | 75 | 65 | 25 | 3.5 |
| Erin silt loam, 12 to 18 percent slopes, eroded | 60 | 60 | | 3.0 |
| Erin silt loam, 18 to 30 percent slopes | | | | 2.5 |
| Estherville sandy loam, 0 to 2 percent slopes | 60 | 50 | 24 | 2.7 |
| Estherville sandy loam, 2 to 6 percent slopes | 60 | 50 | 22 | 2.5 |
| Estherville sandy loam, 6 to 12 percent slopes | 50 | 45 | 20 | 2.2 |
| Etter fine sandy loam, 2 to 6 percent slopes | 60 | 55 | 22 | 3.0 |
| Etter fine sandy loam, 6 to 15 percent slopes | | | | 2.5 |
| Fairhaven silt loam, 0 to 2 percent slopes | 100 | 75 | 40 | 4.5 |
| Fairhaven silt loam, 2 to 6 percent slopes | 95 | 70 | 30 | 3.5 |
| Fairhaven silt loam, loamy subsoil variant, 0 to 2 percent slopes | 100 | 70 | 30 | 3.5 |
| Fairhaven silt loam, loamy subsoil variant, 2 to 6 percent slopes | 95 | 70 | 30 | 3.5 |
| Faxon clay loam | | | | 1.5 |
| Garwin silty clay loam [1] | 120 | 80 | 35 | 4.5 |
| Glencoe clay loam [1] | 95 | 75 | 35 | 4.0 |
| Hayden loam, 2 to 6 percent slopes | 100 | 85 | 35 | 4.5 |
| Hayden loam, 6 to 12 percent slopes | 80 | 65 | 23 | 4.0 |
| Hayden loam, 12 to 18 percent slopes | 65 | 60 | 20 | 3.0 |
| Hayden loam, 18 to 30 percent slopes | | | | 2.5 |
| Judson silt loam, 4 to 12 percent slopes | 85 | 75 | 30 | 3.0 |
| Kasson silt loam, 1 to 3 percent slopes | 85 | 75 | 32 | 3.0 |
| Kato silty clay loam [1] | 95 | 75 | 35 | 4.0 |
| Kilkenny clay loam, 2 to 6 percent slopes | 90 | 75 | 35 | 4.5 |
| Kilkenny clay loam, 6 to 12 percent slopes, eroded | 80 | 65 | 30 | 4.0 |
| Kilkenny clay loam, 12 to 18 percent slopes, eroded | | 55 | | 2.5 |
| Kilkenny clay loam, 18 to 25 percent slopes | | | | 2.0 |
| Klinger silt loam, 1 to 3 percent slopes | 110 | 75 | 35 | 4.0 |

See footnotes at end of table.

TABLE 2.—*Predicted average yields per acre of principal crops grown under a high level of management*—Continued

| Soil | Corn | Oats | Soybeans | Alfalfa or alfalfa-brome mixture |
|---|---|---|---|---|
| | *Bu.* | *Bu.* | *Bu.* | *Tons* |
| Lake beaches | | | | |
| Lerdal silt loam, 1 to 6 percent slopes | 90 | 75 | 35 | 4.5 |
| Lerdal clay loam, 6 to 12 percent slopes, eroded | 80 | 65 | 25 | 3.0 |
| Lerdal clay loam, 12 to 18 percent slopes, eroded | 60 | 45 | 15 | 2.0 |
| Lester loam, 2 to 6 percent slopes | 120 | 85 | 40 | 4.5 |
| Lester loam, 6 to 12 percent slopes | 95 | 65 | 30 | 3.7 |
| Lester loam, 6 to 12 percent slopes, eroded | 85 | 60 | 28 | 3.5 |
| Lester loam, 12 to 18 percent slopes, eroded | 70 | 55 | | 3.0 |
| Lester loam, 18 to 25 percent slopes | | | | 2.5 |
| Le Sueur clay loam, 1 to 3 percent slopes | 120 | 80 | 40 | 4.5 |
| Marsh | | | | |
| Maxcreek silty clay loam [1] | 120 | 80 | 40 | 4.5 |
| Maxcreek silty clay loam, swales [1] | 85 | 65 | 30 | 4.0 |
| Maxfield silty clay loam [1] | 110 | 70 | 30 | 4.0 |
| Maxfield silty clay loam, swales [1] | 80 | 60 | 25 | 3.5 |
| Mazaska silty clay loam [1] | 85 | 65 | 35 | 3.0 |
| Merton silt loam, 1 to 3 percent slopes | 120 | 80 | 40 | 4.5 |
| Moland silt loam, 2 to 6 percent slopes | 100 | 80 | 40 | 4.5 |
| Moland silt loam, 6 to 12 percent slopes | 90 | 75 | 30 | 4.5 |
| Moland silt loam, 12 to 18 percent slopes, eroded | 75 | 65 | | 3.5 |
| Muskego muck [1,2] | 70 | | 28 | |
| Nicollet clay loam, 1 to 3 percent slopes | 120 | 80 | 40 | 4.5 |
| Ostrander loam, 12 to 18 percent slopes, eroded | 60 | 45 | | 2.2 |
| Ostrander loam, 18 to 30 percent slopes, eroded | | | | 2.2 |
| Ostrander silt loam, 2 to 6 percent slopes | 80 | 65 | 32 | 3.5 |
| Ostrander silt loam, 6 to 12 percent slopes, eroded | 65 | 45 | 22 | 2.7 |
| Ostrander silt loam, bedrock substratum, 0 to 2 percent slopes | 80 | 65 | 32 | 3.5 |
| Palms muck [1,2] | 70 | | 28 | |
| Port Byron silt loam, 0 to 2 percent slopes | 120 | 75 | 40 | 4.5 |
| Port Byron silt loam, 2 to 6 percent slopes | 110 | 75 | 35 | 4.5 |
| Port Byron silt loam, 6 to 12 percent slopes | 100 | 70 | 25 | 4.0 |
| Port Byron silt loam, 12 to 18 percent slopes | 80 | 70 | | 3.5 |
| Port Byron-Bold silt loams, 6 to 12 percent slopes | 90 | 70 | 25 | 3.0 |
| Port Byron-Bold silt loams, 12 to 18 percent slopes | 80 | 60 | | 3.0 |
| Renova silt loam, 2 to 6 percent slopes | 85 | 65 | 30 | 3.5 |
| Renova silt loam, 6 to 12 percent slopes | 80 | 60 | 25 | 3.0 |
| Renova silt loam, 12 to 18 percent slopes, eroded | 75 | 60 | | 3.0 |
| Renova silt loam, 18 to 30 percent slopes | | | | 2.0 |
| Rolfe silty clay loam [1] | 80 | 65 | 25 | 3.0 |
| Rough broken land | | | | |
| Salida gravelly sandy loam, 4 to 12 percent slopes | | 30 | | 1.8 |
| Salida gravelly sandy loam, 12 to 30 percent slopes | | | | |
| Shields silt loam [1] | 80 | 60 | 25 | 3.5 |
| Skyberg silt loam [1] | 80 | 60 | 28 | 4.0 |
| Sogn stony loam, 18 to 35 percent slopes | | | | |
| Terril loam, 1 to 6 percent slopes | 120 | 80 | 36 | 4.5 |
| Terril loam, 6 to 12 percent slopes | 95 | 70 | 33 | 4.0 |
| Vlasaty silt loam, 1 to 4 percent slopes | 75 | 65 | 25 | 3.0 |
| Waukegan silt loam, 0 to 2 percent slopes | 100 | 75 | 35 | 3.5 |
| Waukegan silt loam, 2 to 6 percent slopes | 95 | 70 | 30 | 3.5 |
| Webster clay loam [1] | 120 | 75 | 40 | 4.0 |
| Zumbro sandy loam | 50 | 40 | 20 | 2.0 |

[1] Yields can be obtained where the soil has a complete drainage system.

[2] Corn is grown for grain on a minor acreage of this soil. Silage corn or soybeans are the principal crops. Hay grown on this soil is brome or reed canarygrass, but not alfalfa.

The use of improved varieties of seed, of new and improved farming practices, and of larger amounts of fertilizer make it possible to obtain higher average yields than those given in table 2. Yields vary from year to year because of disease and insect infestations and variations in climate, especially rainfall. Therefore, the predicted yields are averages that can be expected for a 5- to 10-year period and not for any 1 year.

## Woodland and Windbreaks [2]

Rice County lies along the edge of the region known as the Big Woods on maps of presettlement vegetation in the northern United States. The northern upland hardwoods and oak types were dominant. Full-canopy growth

[2] JOHN HULTGREN, woodland conservationist, Soil Conservation Service, helped prepare this section.

was common west and north of the Cannon River, east of the Straight River, and astride Prairie Creek and its branches. Oak groves and brush were typical of eastern Webster Township and north of Heath Creek in Bridgewater Township. Small groves and hazel thickets persisted in areas that were dominantly prairie in Northfield, Wheeling, Richland, Walcott, Warsaw, and Morristown Townships.

The woodland in Rice County is mostly in small woodlots and along streams. Wood production is a minor enterprise; many wooded areas are grazed; and a few tracts produce maple syrup. Windbreaks have been planted mainly around farmsteads.

Trees and shrubs are planted for windbreaks in Rice County. Field windbreaks are necessary to retard soil blowing, to distribute and control snow, and to reduce crop damage and moisture loss.

### *Soils in the woodland groups*

Woodland groups are determined by species adaptability, site index or potential productivity, species preferred for planting, and soil-related hazards and limitations. Each group consists of soils that are suited to the same species of trees and that have similar hazards, limitations, and production potential. The ratings are based on the experience and judgment of local soil scientists and foresters. Measurements of tree growth in natural stands were made on some modal soils.

The soils of Rice County have been placed in eight woodland groups, and these are described in the following pages. To learn the woodland group for any given soil, refer to the "Guide to Mapping Units" at the back of this survey.

#### WOODLAND GROUP 1

This group consists of soils in the Bold, Clarion, Hayden, Judson, Klinger, Lester, Le Sueur, Merton, Moland, Nicollet, Ostrander, Port Byron, Renova, Storden, and Terril series and the Fairhaven series, loamy subsoil variant. All of these soils are medium textured to moderately fine textured and are well drained to somewhat poorly drained. Natural fertility is medium to high. The organic-matter content ranges from moderate to high. Available water capacity is very high or high, and permeability is moderate to moderately slow. Slopes are dominantly 2 to 12 percent but range from 0 to 35 percent.

#### WOODLAND GROUP 2

This group consists of soils in the Dundas, Erin, Kasson, Kilkenny, Lerdal, Shields, Skyberg, and Vlasaty series. These are well-drained to somewhat poorly drained, medium-textured and moderately fine textured soils. The subsoil is moderately fine textured and fine textured. Slopes are dominantly 2 to 6 percent but range from 0 to 30 percent. Natural fertility is medium to high. The organic-matter content is moderate. Available water capacity is high, and permeability is moderately slow to slow.

#### WOODLAND GROUP 3

This group consists of soils in the Copaston, Dodgeville, Etter, Fairhaven, and Waukegan series. These are well-drained, moderately coarse textured and medium-textured soils over sand, sand and gravel, or bedrock.

These soils have moderate available water capacity and medium natural fertility. The organic-matter content is moderate to high. Permeability is moderate to moderately rapid in the surface layer and subsoil and is rapid in the underlying sand and gravel. Slopes are dominantly 0 to 6 percent but range to 25 percent.

#### WOODLAND GROUP 4

This group consists of soils in the Boone, Dickman, Estherville, and Salida series. These soils are coarse textured to moderately coarse textured and are excessively drained to somewhat excessively drained. They have very low to moderate available water capacity and very rapid to moderately rapid permeability. The organic-matter content is low to moderate. Natural fertility is low to medium. Slopes range from 0 to 12 percent.

#### WOODLAND GROUP 5

This group consists of soils in the Boone, Salida, and Sogn series and Rough broken land. These are medium-textured and coarse-textured soils that are underlain by sand or sand and gravel within a depth of 12 inches or by bedrock within a depth of 20 inches. Slopes range from 12 to 35 percent. All the soils have very low available water capacity and moderate to very rapid permeability. The organic-matter content is low to moderate, and natural fertility is low. Stones are a common limitation on the Sogn soils. Rough broken land is a land type that has variable properties; therefore, each individual site should be evaluated for woodland treatment.

#### WOODLAND GROUP 6

This group consists of Alluvial land and soils in the Zumbro series. These are mostly medium-textured to coarse-textured, moderately well drained, nearly level soils on bottom lands that are subject to occasional flooding. The available water capacity is low to moderate, but after trees are established, they are not adversely affected, because the water table is usually within 2 to 5 feet of the surface. Permeability ranges from moderate to rapid. Natural fertility ranges from medium to high, and organic-matter content is moderate to high.

#### WOODLAND GROUP 7

This group consists of soils in the Biscay, Canisteo, Colo, Cordova, Garwin, Kato, Maxcreek, Maxfield, Mazaska, and Webster series and the Biscay series, seepy variant. Also in the group is the land type Lake beaches. Except for the Biscay soil, the Biscay seepy variant, and Lake beaches, these soils are moderately fine textured. The Biscay soil and the Biscay seepy variant have a moderately fine textured surface layer but are underlain by sand or sand and gravel at a depth of 24 to 40 inches. Texture is variable in Lake beaches. All the soils are poorly drained, except for Lake beaches, in which drainage is variable. The water table is at a depth of 0 to 3 feet in wet periods.

The available water capacity is high in most of the soils but is moderate to high in the soils that have more sandy materials. Natural fertility generally is medium to high, though it is variable in Lake beaches.

WOODLAND GROUP 8

This group consists of Alluvial land, frequently flooded; Marsh; and soils in the Canisteo, Caron, Faxon, Glencoe, Maxcreek, Maxfield, Muskego, Palms, and Rolfe series. These range from moderately fine textured soils in small depressions to extensive areas of organic soils, marshy areas, and old river channels. The poorly drained to very poorly drained soils in the group are normally considered too wet for trees or shrubs unless they are drained. The water table is near the surface much of the year. Some of the soils are subject to flooding.

### *Factors affecting woodland management*

Species productivity can be estimated by site index. Site index is the average height in feet that the dominant and codominant trees of a given species will attain at 50 years of age. Table 3 indicates potential productivity, seedling mortality, plant competition, and other factors affecting management for each woodland group. These factors are discussed in the following paragraphs.

Seedling mortality is the expected loss of natural or planted seedlings resulting from unfavorable soil characteristics, degree of wetness, or topographic position. Mortality is *slight* if the loss is less than 25 percent; *moderate* if it is between 25 and 50 percent; and *severe* if it is more than 50 percent.

Plant competition refers to the encroachment of competing vegetation on a desired species. Competition is *slight* if competing vegetation does not restrict the growth of seedlings. It is *moderate* if plant invaders delay but do not prevent the establishment of a normal, fully stocked stand of a desired species. Competition is *severe* if grass, brush, or undesired trees prevent adequate regeneration, and where intensive site preparation and maintenance are needed until a desired species is well established.

Equipment limitation is *slight* where there are few restrictions on the type of equipment or on the time of the year that the equipment can be used. The limitation is *moderate* where the use of equipment is restricted by soil, slope, or wetness for more than three months or where indiscriminate use of equipment could create soil erosion or damage tree roots. The limitation is *severe* where the use of normal equipment is restricted or limited more than six months per year.

The hazard of erosion is the degree of soil loss by wind or water action. Vegetative establishment and cover, slope, and soil properties are important factors. The hazard is *slight* where erosion is no hazard. It is *moderate* where normal conservation measures are needed to control soil loss. It is *severe* where special measures or restrictions are needed to control soil loss.

### *Estimated yields by site index*

The following paragraphs list estimated yields of various species by site index for well-stocked, unmanaged, even-aged stands of trees on about a 50-year rotation. These yields are given in cords per acre per year. The estimates are only for trees that are more than 6 inches in diameter at breast height.

For red pine and white spruce, the annual yield per acre is 0.7 cord or more if the site index is 60 or higher; 0.6 to 0.7 cord if the site index is 55; 0.5 to 0.6 cord if the site index is 50; and less than 0.5 cord if the site index is 45 or lower.

For white pine, balsam fir, upland oaks, ash, and elm, the annual yield per acre is 0.7 cord or more if the site index is 65 or higher; 0.6 to 0.7 cord if the site index is 60; 0.5 to 0.6 cord if the site index is 55; and less than 0.5 cord if the site index is 50 or lower.

For jack pine, northern hardwoods, poplar, and white birch, the annual yield per acre is 0.7 cord or more if the site index is 70 or higher; 0.6 to 0.7 cord if the site index is 65; 0.5 to 0.6 cord if the site index is 60; and less than 0.5 cord if the site index is 55 or lower.

### *Windbreak plantings*

Windbreaks help reduce soil blowing, block out severe wind, improve human comfort, protect livestock, control snow drifting, and provide food and cover for wildlife. The esthetic value is improved, dust and wind damage is reduced, and outdoor activity is more enjoyable.

Trees and shrubs that are suggested for windbreaks are listed in table 4. Each tree and shrub is given one of the following performance ratings: *Preferred* species are those that are vigorous and healthy, have good survival, and are easily managed. *Suitable* species are those that lack certain qualities required for a rating of preferred. *Unsuitable* species are those that normally will not survive without special care or treatment or are not recommended.

Texture, drainage, depth, reaction, stoniness, steepness, and aspect of slopes are important soil characteristics that affect survival and growth of trees and shrubs. The ratings are based largely on the experience and judgment of local soil scientists, district conservationists, and foresters.

## Wildlife [3]

The soils of Rice County have the potential to provide excellent habitat for various kinds and species of wildlife. Table 5 shows the suitability of the soil associations as habitat for specified kinds of wildlife.

Different soils have different suitabilities for producing various types of habitat components, and there is a distinct interrelationship between different kinds of plants on various soils and the animals associated with these plants. For example, the Clarion-Webster-Nicollet soil association has a high potential to produce habitat elements that are favorable to the ring-necked pheasant. The Clarion and Nicollet soils can produce high-quality grasses that the pheasant uses for nesting and escape cover. This association can produce food plants of high quality and woody cover needed by the pheasant.

Undrained, the Webster soils produce high-quality cattail areas, sedges, and water-tolerant grasses that provide escape cover, nesting cover, and a source of food. If drained, these soils produce high-quality row crops, such as corn and soybeans, which are an excellent source of food for the pheasant.

At the present time, the pheasant populations are larger in the southeastern part of the county, in the Clarion-Webster-Nicollet, the Lester-Hayden-Le Sueur, the Moland-Maxcreek-Merton, the Ostrander-Maxfield-Klinger, and the Maxfield-Klinger soil associations.

[3] JOHN W. BEDISH, biologist, Soil Conservation Service, helped prepare this section.

TABLE 3.—*Woodland groups and*

| Woodland group | Potential productivity | | Seedling mortality | Plant competition |
|---|---|---|---|---|
| | Important trees | Site index | | |
| Group 1. | Black walnut | 55–65 | Slight | Severe |
| | Basswood | 65–75 | | |
| | Sugar maple | 55–65 | | |
| | Oak | 65–75 | | |
| | Cottonwood | 85–95 | | |
| | Spruce and pine | 60–70 | | |
| Group 2. | Black walnut | 50–60 | Slight to moderate | Severe |
| | Cottonwood | 70–80 | | |
| | Silver maple | 60–75 | | |
| | Ash | 55–65 | | |
| | Sugar maple | 50–60 | | |
| Group 3. | Oak | 55–65 | Slight | Moderate |
| | Spruce | 50–55 | | |
| | Pine | 55–60 | | |
| | Silver maple | 60–70 | | |
| | Basswood | 60–70 | | |
| Group 4. | Oak | 45–50 | Moderate | Slight to moderate |
| | Pine | 50–55 | | |
| | Spruce | 45–50 | | |
| Group 5. | Bur oak | 35–45 | Moderate to severe | Slight |
| | Redcedar | 10–30 | | |
| | Pine | 40–50 | | |
| Group 6. | Black walnut | 50–65 | Slight to moderate | Severe |
| | Oak | 55–75 | | |
| | Elm, ash | 55–75 | | |
| | Silver maple | 55–75 | | |
| | Cottonwood | 80–100 | | |
| Group 7. | Elm, ash | 55–60 | Moderate to severe | Severe |
| | Silver maple | 55–60 | | |
| | Aspen | 60–80 | | |
| | Cottonwood | 60–80 | | |
| Group 8. | None | | Severe | Severe |

Waterfowl populations are more concentrated in the Lester-Hayden-Le Sueur and the Kilkenny-Shields-Lerdal soil associations (fig. 11) in the western two-thirds of Rice County, where the network of lakes and wetlands is extensive. They also are concentrated in the Colo-Estherville-Waukegan soil association, which makes up the bottom lands along the Straight, Cannon, and Zumbro Rivers.

Numerous upland game and songbirds are distributed throughout the county. Hungarian partridge are mainly in the northwestern part of the county in the Kilkenny-Shields-Lerdal soil association.

The deer population is good throughout the county, but deer tend to concentrate near the more heavily wooded areas in the Lester-Hayden-Le Sueur, the Renova-Kasson-Skyberg, and the Colo-Estherville-Waukegan soil associations.

## Use of the Soils for Recreational Development

Knowledge of soils is necessary in planning, developing, and maintaining areas used for recreation. In table 6 the soils are rated according to limitations that affect their suitability for camp areas, playgrounds, picnic areas, and paths and trails.

In table 6 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, freedom from flooding during periods of heavy use, and a surface that is firm after rains but not dusty when dry.

*factors in woodland management*

| Erosion hazard | Equipment limitations | Windthrow hazard | Preferred species for planting |
|---|---|---|---|
| Slight to severe | Slight to moderate | Slight | Black walnut, basswood, silver maple, oak, pine, and spruce. On south- and west-facing slopes of more than 12 percent: red pine, redcedar, jack pine, green ash, and white pine. |
| Slight to moderate | Slight to moderate | Slight | Cottonwood, silver maple, black walnut, and ash. |
| Slight to moderate | Slight to moderate | Slight | Silver maple, basswood, oak, red pine, white pine and spruce. On south- and west-facing slopes o, more than 12 percent: red pine, jack pine, redcedar, and ponderosa pine. |
| Slight | Slight | Slight | Oak, ponderosa pine, white pine, spruce, red pine, and redcedar. |
| Moderate to severe | Slight to severe | Slight to moderate | Jack pine, ponderosa pine, and redcedar. |
| Slight | Slight | Slight | Cottonwood, silver maple, black walnut, and oak. |
| Slight | Moderate to severe | Moderate to severe | Cottonwood, silver maple, and black ash. |
| Slight | Severe | Severe | None without special land treatment. |

Playgrounds are areas used intensively for baseball, football, badminton, and similar organized games. Soils suitable for this use need to withstand intensive foot traffic. The best soils have a nearly level surface that is free of coarse fragments and rock outcrops, have good drainage, are free of flooding during periods of heavy use, and have a surface layer that is firm after rains but not dusty when dry. If grading and leveling are required, depth to rock is important.

Picnic areas are attractive natural or landscaped tracts used primarily for preparing meals and eating outdoors. These areas are subject to heavy foot traffic. Most of the vehicular traffic, however, is confined to access roads. The best soils are firm when wet but not dusty when dry; are free of flooding during the season of use; and do not have slopes or stoniness that greatly increase cost of leveling sites or of building access roads.

Paths and trails are used for local and cross-country travel by foot or 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 not 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.

Rice County has lakes, streams, hardwood groves, and landscape vistas that provide a wide choice of recreation uses. Boating, fishing, swimming, hiking, and picnic sites are plentiful. Many sites have been developed; many more sites have good potential.

Soils that have a wide range in slope may have all three degrees of limitation given in an evaluation, depending on the slope. Steep slopes may be a severe limitation to a particular use even though other features may be favorable. For example, Lester soils have slight limitations for picnic areas where slopes are 2 to 6 percent. Where slopes are 6 to 12 percent, however, the soils are less desirable and limitations are moderate. Limitations for picnic areas are severe on slopes of more than 12 percent because the soils would have to be made more nearly level to use for this purpose.

Some soils that have severe limitations for a particular use because of certain soil properties may also have some moderate limitations that may remain even though the

TABLE 4.—*Suitability of specified trees and shrubs for windbreaks*

[Woodland groups 5 and 8 are not shown, because generally they are not suited to windbreaks and onsite investigation is needed]

| Species | Suitability in— | | | | | |
|---|---|---|---|---|---|---|
| | Woodland group 1 | Woodland group 2 | Woodland group 3 | Woodland group 4 | Woodland group 6 | Woodland group 7 |
| Coniferous trees: | | | | | | |
| European larch | Preferred | Preferred | Unsuitable | Unsuitable | Preferred | Unsuitable. |
| Pine | Preferred | Preferred | Preferred | Preferred | Preferred | Unsuitable. |
| Redcedar | Suitable | Suitable | Suitable | Preferred | Suitable | Suitable. |
| Spruce | Preferred | Preferred | Preferred | Suitable | Preferred | Preferred. |
| White-cedar | Preferred | Preferred | Preferred | Preferred | Preferred | Preferred. |
| Deciduous trees: | | | | | | |
| American elm | Suitable | Suitable | Suitable | Suitable | Suitable | Suitable. |
| Boxelder | Unsuitable | Unsuitable | Unsuitable | Unsuitable | Unsuitable | Suitable. |
| Bur oak | Suitable | Suitable | Preferred | Preferred | Suitable | Unsuitable. |
| Cottonwood | Suitable | Suitable | Suitable | Unsuitable | Suitable | Preferred. |
| Green ash | Preferred | Preferred | Preferred | Preferred | Preferred | Preferred. |
| Hackberry | Preferred | Preferred | Preferred | Preferred | Preferred | Suitable. |
| Honeylocust | Preferred | Preferred | Preferred | Preferred | Preferred | Preferred. |
| Siberian elm | Unsuitable | Unsuitable | Suitable | Suitable | Unsuitable | Suitable. |
| Silver maple | Suitable | Suitable | Suitable | Suitable | Suitable | Preferred. |
| Willow, laurel-leaf | Suitable | Suitable | Suitable | Unsuitable | Suitable | Suitable. |
| Willow, white and golden | Suitable | Suitable | Suitable | Unsuitable | Suitable | Suitable. |
| Small trees and shrubs: | | | | | | |
| American plum | Suitable | Suitable | Preferred | Preferred | Suitable | Preferred. |
| Amur maple | Preferred | Preferred | Suitable | Unsuitable | Preferred | Preferred. |
| Buffaloberry | Unsuitable | Unsuitable | Suitable | Preferred | Unsuitable | Unsuitable. |
| Caragana | Unsuitable | Unsuitable | Suitable | Preferred | Unsuitable | Suitable. |
| Chokecherry | Suitable | Suitable | Suitable | Suitable | Suitable | Suitable. |
| Cotoneaster | Suitable | Suitable | Suitable | Suitable | Suitable | Unsuitable. |
| Dogwood | Preferred | Preferred | Preferred | Unsuitable | Preferred | Preferred. |
| Honeysuckle | Preferred | Preferred | Preferred | Preferred | Preferred | Preferred. |
| Lilac | Preferred | Preferred | Preferred | Preferred | Preferred | Preferred. |
| Purple-osier willow | Suitable | Suitable | Suitable | Suitable | Suitable | Preferred. |
| Russian-olive | Unsuitable | Unsuitable | Preferred | Preferred | Unsuitable | Suitable. |
| Siberian crab apple | Preferred | Preferred | Preferred | Preferred | Preferred | Suitable. |

TABLE 5.—*Suitability of soil associations as habitat for specified kinds of wildlife*

| Name of association | Suitability as habitat for— | | | | |
|---|---|---|---|---|---|
| | Pheasant, Hungarian partridge, and other upland game | Duck, mink, beaver, muskrat, and other waterfowl and furbearers | Squirrel, rabbit, and other small game | Deer and other big game | Bluebird, field sparrow, and other songbirds |
| Clarion-Webster-Nicollet association | Good | Good | Good | Fair | Fair. |
| Lester-Hayden-Le Sueur association | Fair to good. | Good | Good | Good | Good. |
| Kilkenny-Shields-Lerdal association | Fair to good. | Good | Good | Good | Good. |
| Moland-Maxcreek-Merton association | Good | Fair | Fair | Good | Good. |
| Ostrander-Maxfield-Klinger association | Fair | Fair to good in undrained, poorly drained, and very poorly drained areas. Poor in other areas. | Fair | Fair | Good. |
| Maxfield-Klinger association | Fair | Fair to good in undrained, poorly drained, and very poorly drained areas. Poor in other areas. | Fair | Fair | Good. |
| Renova-Kasson-Skyberg association | Fair to poor. | Fair to good in undrained, poorly drained, and very poorly drained areas. Poor in other areas. | Good | Good | Good. |
| Colo-Estherville-Waukegan association | Poor | Fair | Fair to good. | Good | Good. |

*Figure 11.*—**Wildlife habitat that has been developed in an area of the Kilkenny-Shields-Lerdal soil association.**

severe limitations are overcome. For this reason, on some soils both severe and moderate limitations are given.

Table 6 can serve as a general guide for selecting recreational sites and designing recreational developments. Evaluations are based on soil features only and serve as preliminary information to further investigation on the site. For more specific information regarding the feasibility and potential for recreation enterprises refer to "An Appraisal of Potentials for Outdoor Recreational Developments", published by the Rice County Soil and Water Conservation District.

In table 6, all soils were treated as having suitable width, depth, and uniformity. However, in many landscapes the size, shape, or pattern of a soil in relation to other soils may change its limitations greatly. The planner should consider these relationships in making his final decision.

All soils were considered to be in their natural condition. Drainage, diking, and other practices can greatly alter limitations. Such manmade alterations should be considered during onsite evaluations.

Sewage disposal and other engineering considerations are not considered in this table. See the section "Use of Soils for Community Development" for ratings for onsite sewage disposal systems and for other evaluations.

## Use of the Soils for Community Development

Rice County is on the edge of a region of rapid urban expansion and a rapidly increasing population. Groups of houses are being built in wooded areas, near lakes, and along all-weather roads.

The suitability or limitations of the soils must be considered before selecting a site for a home or factory. The main factors considered are those properties and qualities of undisturbed soils that affect the support of foundations of buildings less than three stories high. Only the underlying material is evaluated. The main factors are depth to water table, bearing capacity, volume change (shrink-swell potential), frost heave, and flooding.

Limitations of the soils for use as septic tank filter fields are important in areas beyond existing sewer lines. These limitations are based on percolation tests and evaluation of texture, structure, and internal drainage. In general, effective filter fields require soils not subject to

TABLE 6.—*Degree and kind of limitations for recreational development*

[An asterisk in the first column indicates that at least one mapping unit is made up of two or more kinds of soil. The soils in such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for referring to other series that appear in the first column of this table]

| Series name and mapping unit | Camp areas | Playgrounds | Picnic areas | Paths and trails |
|---|---|---|---|---|
| Alluvial land: | | | | |
| Ad | Moderate: occasional flooding. | Moderate: occasional flooding. | Moderate: occasional flooding. | Moderate: occasional flooding. |
| Af | Severe: frequent flooding. | Severe: frequent flooding. | Severe: frequent flooding. | Severe: frequent flooding. |
| Biscay: Bc | Moderate: surface layer is soft and sticky when wet. Severe when water table is seasonally high. | Moderate: surface layer is soft and sticky when wet. Severe when water table is seasonally high. | Moderate: surface layer is soft and sticky when wet. Severe when water table is seasonally high. | Moderate: surface layer is soft and sticky when wet. Severe when water table is seasonally high. |
| Biscay, seepy variant: Bk | Severe: seasonal high water table; slopes of 4 to 18 percent. | Severe: downslope seeps caused by seasonal high water table; slopes of 4 to 18 percent. | Severe: seasonal high water table; slopes of 4 to 18 percent. | Severe: seasonal high water table. |
| Bold. Mapped only in complexes with Port Byron soils. For Bold part of these complexes, see mapping units PoC and PoD under the Port Byron series. | | | | |
| Boone: | | | | |
| BoC | Moderate: soft, loose surface layer. | Severe: difficult to vegetate; soft, loose surface layer. | Severe: difficult to vegetate; soft, loose surface layer. | Moderate: soft, loose surface layer. |
| BoD, BoF | Severe: slope | Severe: slope | Severe: slope | Moderate to severe: slope. |
| Canisteo: | | | | |
| Ca | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. | Moderate: surface layer is soft and sticky when wet. Severe when water table is seasonally high. | Moderate: surface layer is soft and sticky when wet. Severe when water table is seasonally high. | Moderate: surface layer is soft and sticky when wet. Severe when water table is seasonally high. |
| Cd | Severe: seasonal high water table; frequently ponded. | Moderate: surface layer is sticky and ponded when wet. Severe when water table is seasonally high. | Moderate: surface layer is sticky and ponded when wet. Severe when water table is seasonally high; frequently ponded. | Severe: seasonal high water table; frequently ponded. |
| Caron: Ck | Severe: high water table; seasonally ponded; soft, organic surface layer. | Severe: high water table; seasonally ponded; soft, organic surface layer. | Severe: high water table; seasonally ponded; soft, organic surface layer. | Severe: high water table; seasonally ponded; soft, organic surface layer. |
| *Clarion: | | | | |
| ClB | Slight | Moderate: slope | Slight | Slight. |
| ClC, CnC2, CsC | Moderate: slope | Severe: slope | Moderate: slope | Slight. |
| CsD, CsE | Severe: slope | Severe: slope | Severe: slope | Moderate: slope. |
| Ratings are also for Estherville and Storden soils in CnC2, CsC, CsD, and CsE. | | | | |
| Colo: Ct | Severe when water table is seasonally high; occasional flooding. | Moderate to severe when water table is seasonally high; occasional flooding; surface layer is soft and sticky when wet. | Moderate when water table is seasonally high; occasional flooding; surface layer is soft and sticky when wet. | Moderate when water table is seasonally high: occasional flooding. |

TABLE 6.—*Degree and kind of limitations for recreational development*—Continued

| Series name and mapping unit | Camp areas | Playgrounds | Picnic areas | Paths and trails |
|---|---|---|---|---|
| Copaston: CvA | Moderate: stones and boulders on the surface in places. | Severe: bedrock at a depth of 12 to 20 inches. | Slight: stones and boulders on the surface in places. | Slight: stones and boulders on the surface in places. |
| Cordova: Cy | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. | Moderate: surface layer is soft and sticky when wet. Severe when water table is seasonally high. | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. |
| Dickman: | | | | |
| DcA, DkA | Slight | Slight | Slight | Slight. |
| DcB, DkB | Slight | Moderate: slope | Slight | Slight. |
| DcC | Moderate: slope | Severe: slope | Moderate: slope | Slight. |
| Dodgeville: | | | | |
| DoB | Slight | Moderate: bedrock at a depth of 20 to 40 inches. | Slight | Slight. |
| DoC | Moderate: slope | Severe: slope | Moderate: slope | Slight. |
| DoD, DoE | Severe: slope | Severe: slope | Severe: slope | Moderate: slope. |
| Dundas: Du | Moderate: surface layer is sticky and soft when wet. | Moderate: surface layer is sticky and soft when wet. | Moderate: surface layer is sticky and soft when wet. | Moderate: surface layer is sticky and soft when wet. |
| Erin: | | | | |
| ErB | Slight | Moderate: slope | Slight | Slight. |
| ErC2 | Moderate: slope | Severe: slope | Moderate: slope | Slight. |
| ErD2 | Severe: slope | Severe: slope | Severe: slope | Slight. |
| Estherville: | | | | |
| EsA | Slight | Slight | Slight | Slight. |
| EsB | Slight | Moderate: slope | Slight | Slight. |
| EsC | Moderate: slope | Severe: slope | Moderate: slope | Slight. |
| Etter: | | | | |
| EtB | Slight | Moderate: slope | Slight | Slight. |
| EtC | Moderate: slope | Severe: slope | Moderate: slope | Slight. |
| Fairhaven: | | | | |
| FaA | Slight | Slight | Slight | Slight. |
| FaB | Slight | Moderate: slope | Slight | Slight. |
| Fairhaven, loamy subsoil variant: | | | | |
| FlA | Slight | Slight | Slight | Slight. |
| FlB | Slight | Moderate: slope | Slight | Slight. |
| Faxon: Fx | Severe when water table is seasonally high. | Severe when water table is seasonally high. | Severe when water table is seasonally high. | Moderate when water table is seasonally high. |
| Garwin: Ga | Severe when water table is seasonally high. | Severe when water table is seasonally high. | Severe when water table is seasonally high. | Severe when water table is seasonally high. |
| Glencoe: Gc | Severe: high water table; frequently ponded. | Moderate: surface layer is sticky and soft when wet. Severe when water table is high; frequently ponded. | Moderate: surface layer is sticky and soft when wet. Severe when water table is high; frequently ponded. | Moderate: surface layer is sticky and ponded when wet. Severe when water table is high; frequently ponded. |
| Hayden: | | | | |
| HaB | Slight | Moderate: slope | Slight | Slight. |
| HaC | Moderate: slope | Severe: slope | Moderate: slope | Slight. |
| HaD, HaE | Severe: slope | Severe: slope | Severe: slope | Moderate: slope. |
| Judson: JuC | Moderate: slope | Moderate to severe: slope. | Moderate: slope | Slight. |
| Kasson: KaA | Moderate: moderately well drained. | Moderate: moderately well drained. | Slight | Slight. |

TABLE 6.—*Degree and kind of limitations for recreational development*—Continued

| Series name and mapping unit | Camp areas | Playgrounds | Picnic areas | Paths and trails |
|---|---|---|---|---|
| Kato: Kc | Severe when water table is seasonally high. | Severe when water table is seasonally high. | Severe when water table is seasonally high. | Severe when water table is seasonally high. |
| Kilkenny: | | | | |
| KkB | Slight | Moderate: slope | Slight | Slight. |
| KkC2 | Moderate: slope | Severe: slope | Moderate: slope | Slight. |
| KkD2, KkE | Severe: slope | Severe: slope | Severe: slope | Moderate: slope. |
| Klinger: KlA | Moderate: moderately well drained. | Moderate: moderately well drained. | Slight | Slight. |
| Lake beaches: La | Severe: high water table. | Severe: high water table. | Severe: high water table. | Severe: high water table. |
| Lerdal: | | | | |
| LbB | Moderate: moderately well drained. | Moderate: slope | Slight | Slight. |
| LeC2 | Moderate: slope | Severe: slope | Moderate: slope | Slight. |
| LeD2 | Severe: slope | Severe: slope | Severe: slope | Slight. |
| Lester: | | | | |
| LlB | Slight | Moderate: slope | Slight | Slight. |
| LlC, LlC2 | Moderate: slope | Severe: slope | Moderate: slope | Slight. |
| LlD2, LlE | Severe: slope | Severe: slope | Severe: slope | Slight to moderate: slope. |
| Le Sueur: LuA | Slight | Slight | Slight | Slight. |
| Marsh: Ma | Severe: high water table; ponded most of the year. | Severe: high water table; ponded most of the year. | Severe: high water table; ponded most of the year. | Severe: high water table; ponded most of the year. |
| Maxcreek: | | | | |
| Mb | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. |
| Mc | Severe: high water table; occasionally ponded. | Severe: high water table; occasionally ponded. | Severe: high water table; occasionally ponded. | Severe: high water table; occasionally ponded. |
| Maxfield: | | | | |
| Mf | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. |
| Mh | Severe: high water table; occasionally ponded. | Severe: high water table; occasionally ponded. | Severe: high water table; occasionally ponded. | Severe: high water table; occasionally ponded. |
| Mazaska: Mk | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. |
| Merton: MnA | Slight | Slight | Slight | Slight. |
| Moland: | | | | |
| MoB | Slight | Moderate: slope | Slight | Slight. |
| MoC | Moderate: slope | Severe: slope | Moderate: slope | Slight. |
| MoD2 | Severe: slope | Severe: slope | Severe: slope | Slight. |
| Muskego: Mu | Severe: high water table; seasonally ponded; soft, organic surface layer. | Severe: high water table; seasonally ponded: soft, organic, surface layer. | Severe: high water table; seasonally ponded; soft, organic surface layer. | Severe: high water table; seasonally ponded; soft, organic surface layer. |

TABLE 6.—*Degree and kind of limitations for recreational development*—Continued

| Series name and mapping unit | Camp areas | Playgrounds | Picnic areas | Paths and trails |
|---|---|---|---|---|
| Nicollet: NcA | Moderate: moderately well drained to somewhat poorly drained. | Moderate: moderately well drained to somewhat poorly drained. | Slight | Slight. |
| Ostrander: | | | | |
| OsD2, OsE2 | Severe: slope | Severe: slope | Severe: slope | Moderate: slope. |
| OtB | Slight | Moderate: slope | Slight | Slight. |
| OtC2 | Moderate: slope | Severe: slope | Moderate: slope | Slight. |
| OuA | Slight | Slight | Slight | Slight. |
| Palms: Pa | Severe: high water table; seasonally ponded; soft, organic surface layer. | Severe: high water table; seasonally ponded; soft, organic surface layer. | Severe: high water table; seasonally ponded; soft, organic surface layer. | Severe: high water table; seasonally ponded; soft, organic surface layer. |
| Port Byron: | | | | |
| PbA | Slight | Slight | Slight | Slight. |
| PbB | Slight | Moderate: slope | Slight | Slight. |
| PbC, PoC | Moderate: slope | Severe: slope | Moderate: slope | Slight. |
| PbD, PoD | Severe: slope | Severe: slope | Severe: slope | Slight. |
| Renova: | | | | |
| RnB | Slight | Moderate: slope | Slight | Slight. |
| RnC | Moderate: slope | Severe: slope | Moderate: slope | Slight. |
| RnD2, RnE | Severe: slope | Severe: slope | Severe: slope | Moderate: slope. |
| Rolfe: Ro | Severe: high water table; occasionally ponded. | Severe: high water table; occasionally ponded. | Severe: high water table; occasionally ponded. | Severe: high water table; occasionally ponded. |
| Rough broken land: Ru | Severe: slope | Severe: slope | Severe: slope | Severe: slope. |
| Salida: | | | | |
| SaC | Moderate: gravelly sandy surface layer. | Severe: sandy and gravelly surface layer. | Moderate: sandy and gravelly surface layer. | Slight. |
| SaD | Severe: slope | Severe: slope | Severe: slope | Slight. |
| Shields: Sh | Moderate: surface layer is sticky and soft when wet. | Moderate: surface layer is sticky and soft when wet. | Moderate: surface layer is sticky and soft when wet. | Moderate: surface layer is sticky and soft when wet. |
| Skyberg: Sk | Moderate: surface layer is sticky and soft when wet. | Moderate: surface layer is sticky and soft when wet. | Moderate: surface layer is sticky and soft when wet. | Moderate: surface layer is sticky and soft when wet. |
| Sogn: SoE | Severe: stony surface; less than 12 inches to rock. | Severe: stony surface; less than 12 inches to rock. | Severe: stony surface; less than 12 inches to rock. | Severe: stony surface; less than 12 inches to rock. |
| Storden: Mapped only in complexes with Clarion and Estherville soils. For Storden part of these complexes, see mapping units CnC2, CsC, CsD, and CsE under the Clarion series. | | | | |
| Terril: | | | | |
| TeB | Moderate: moderately well drained. | Moderate: slope | Slight | Slight. |
| TeC | Moderate: slope | Severe: slope | Moderate: slope | Slight. |
| Vlasaty: VlA | Moderate: moderately well drained. | Moderate: moderately well drained. | Slight | Slight. |

TABLE 6.—*Degree and kind of limitations for recreational development—Continued*

| Series name and mapping unit | Camp areas | Playgrounds | Picnic areas | Paths and trails |
|---|---|---|---|---|
| Waukegan: | | | | |
| WaA | Slight | Slight | Slight | Slight. |
| WaB | Slight | Moderate: slope | Slight | Slight. |
| Webster: We | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. | Moderate: surface layer is sticky and soft when wet. Severe when water table is seasonally high. |
| Zumbro: Zu | Severe: occasionally flooded. | Moderate: occasionally flooded. | Moderate: occasionally flooded. | Slight: occasionally flooded. |

flooding, in which the water table remains 4 feet below the drain field trench in all seasons. Percolation rates slower than 60 minutes per inch may cause effluent to rise to the surface and overflow. High percolation rates may permit contamination of ground water in certain areas. If septic tank filter fields are installed in poorly drained or slowly permeable soils, drain field problems develop. In sandy soils, high-density use increases the hazard of contaminating wells, lakes, shallow aquifers, and streams.

In selecting sites for drain fields, it is essential to examine each site and determine the capacity of the soil to absorb and filter effluent. A percolation test is needed in some places to determine the percolation rate and the drain field size. Percolation design rates are suggested for the soils in each building site group where percolation tests are not available. These design rates are useful chiefly in calculating the drain field size that is generally needed for a particular soil.

Limitations for the sanitary landfill are based on soil properties that affect capability of the soil to filter leachate and to serve as refuse cover. Leachate refers to the liquid product that results from the decomposition of organic refuse. The important soil properties are permeability, internal drainage, depth to coarse material, and shrink-swell potential. Slope and flood hazard are also considered.

The best location for a sanitary landfill is one above flood levels, far removed from lakes, wells, or drainage channels, and having a substantial depth of relatively impervious surface soil above the water table. Undesirable locations for sanitary landfills are river flood plains, areas that drain into lakes and streams, areas where the water table is high, and areas that are near water supplies.

The soils of Rice County have been placed into 13 building site groups on the basis of having similar effects on the use of a particular soil for (1) residential, commercial, and industrial construction with public sewers, (2) septic tank filter fields, and (3) sanitary landfills. The soils were examined to a depth of 5 feet. Such economic factors as the distance to roads and streets were not considered.

Descriptions of the 13 building site groups follow. The limitations are expressed as slight, moderate and severe. The limitation is slight if it is easy to overcome. It is moderate if good management and careful design are needed. Severe limitations are difficult to overcome; special designs are generally needed to overcome the limitation or major reclamation work is required; and costs generally are high.

Using the soil map to identify the soils, the interpretations reported here can be useful in selecting suitable locations for residences, stores, factories, schools, and similar facilities. It is emphasized that these interpretations do not eliminate the need for detailed onsite investigation. Engineers and others should not apply specific values to the estimates given for bearing capacity of soils.

The names of soil series represented are mentioned in the description of each group, but this does not mean that all the soils of a given series are in the group. To find the classification for any given soil, refer to the "Guide to Mapping Units" at the back of this survey.

### BUILDING SITE GROUP 1

This group consists of well-drained soils in the Fairhaven and Waukegan series. These soils are underlain by sand and gravel at a depth of 24 to 36 inches. They have moderately rapid permeability. The water table is at a depth below 6 feet throughout the season in all places and at a depth below 10 feet in most places. Slopes range from 0 to 6 feet. Included with these soils are areas of somewhat poorly drained and poorly drained soils in the 1- to 2-acre depressions and in the narrow drainageways.

Soils of this group have only slight limitations for large residential developments, shopping centers, and industrial parks. Because slopes are only 0 to 6 percent, the cost of excavating and grading is generally low. The bearing capacity for low buildings is good, and the change in volume with change in moisture content in the upper 2 or 3 feet of soil is only low to moderate. Susceptibility to frost heave is moderate (fig. 12).

The soils in this group have only slight limitations to use as septic tank filter fields. The percolation rate in the loamy subsoil is near 20 minutes per inch, but the high percolation rate in the coarse underlying material creates a severe hazard of polluting the ground water as well as nearby lakes and streams. This hazard can be reduced by placing the drain tile of the filter field on a bed of loamy material.

These soils have severe limitations for trench-type sanitary landfills because of shallowness to underlying sand and gravel. The leachate that is produced as the refuse decomposes can easily move long distances and contaminate the ground water and nearby lakes and

*Figure 12.*—**In foreground is a nearly level field of Waukegan soils. Etter soils are above the fence row; Sogn soils are on the sides of the mesas; and Dodgeville soils are on the tops.**

streams. The contamination can be prevented by covering the underlying beds of sand and gravel with 3 or 4 feet of impervious fill.

Lawns, trees, and shrubs are relatively easy to establish and maintain on the soils of this group.

#### BUILDING SITE GROUP 2

This group consists of excessively drained and somewhat excessively drained soils in the Boone, Dickman, Estherville, and Salida series. These soils are underlain by deep sand or sand and gravel at a depth of 12 to 24 inches. In most places the water table is at a depth below 10 feet throughout the year. Slopes range from 0 to 40 percent but, in most places are 0 to 12 percent.

Where slopes are 0 to 6 percent, these soils have only slight limitations for commerical and residential developments that use public sewers. Where slopes are 6 to 12 percent, limitations are moderate because grading and construction costs are higher. Where slopes are more than 12 percent, limitations are severe because the costs of building streets and developing homesites generally are high.

These soils have good bearing capacity for foundations. Volume change as a result of changes in soil moisture is low. Susceptibility to frost heave is low. Where slopes are less than 6 percent, excavations for foundations are not difficult, and construction costs for roads and streets are relatively low.

Soils of this group have slight limitations for absorbing septic tank effluent. Percolation rates are generally less than 10 minutes per inch, but this high percolation rate increases the risk of pollution to wells, lakes, and streams in areas of high-density population. The severe hazard of pollution is reduced if the filter field is constructed on a thick bed of loamy fill. Where slopes are more than 12 percent, downslope seepage of effluent is a severe hazard and filter fields are difficult to lay out.

Limitations for trench-type sanitary landfills are severe because these soils are shallow over sand and gravel. Leachate produced by the decomposing refuse can easily move long distances and contaminate the ground water as well as the nearby lakes and streams. This pollution can be avoided by covering the underlying beds of sand and gravel with 3 or 4 feet of impervious fill, which will prevent movement of the leachate through the coarse material below.

Vegetation is difficult to establish and maintain on these soils. Frequent watering and fertilizing are necessary

to maintain a good, vigorous lawn. It is desirable to top-dress these soils with 12 to 18 inches of loamy soil material that will hold moisture.

Selected areas of Estherville and Salida soils generally are good sources of gravel and sand for construction purposes.

#### BUILDING SITE GROUP 3

This group consists of Rough broken land and soils in the Copaston, Dodgeville, Etter, Ostrander, and Sogn series. Rough broken land is very steep and so variable in all properties that no reliable estimates can be made. The soils in this group are well drained and moderately permeable. Slopes range from 0 to 35 percent. All the soils have bedrock within a depth of 5 feet. Copaston and Sogn soils have bedrock at a depth of 20 inches or less, Dodgeville and Etter soils at a depth of 20 to 40 inches, and Ostrander soils at a depth of about 5 feet.

Shallowness to bedrock and slope are moderate to severe limitations to commercial or residential uses. Limitations are moderate on the Ostrander soils, moderate to severe on the Dodgeville and Etter soils, and severe on the Copaston and Sogn soils.

Shallowness to bedrock and the hazard of polluting water supplies through cracks in the limestone bedrock, or as a result of porosity of the sandstone bedrock, are severe limitations to use as septic tank filter fields.

Soil texture and depth to bedrock are severe limitations to use as trench-type sanitary landfills.

#### BUILDING SITE GROUP 4

This group consists only of Clarion-Estherville-Storden complex, 4 to 12 percent slopes, eroded. The soil materials in this complex commonly vary widely within distances of 5 to 10 feet. Permeability ranges from moderate in the Clarion and Storden soils to rapid in the material that underlies the Estherville soils. The water table commonly is at a depth below 10 feet.

Where slopes are less than 6 percent, these soils have slight to moderate limitations for commercial or residential developments that use central sewer systems. Where slopes are 6 to 12 percent, limitations are moderate. As the slope increases, the cost of grading roads, streets, and homesites increases. These soils are well suited to developments that have large lots.

The soils in this group have low to moderate volume change as a result of changes in soil mositure. Susceptibility to frost heave is low to moderate. Except for the included areas in small drainageways, wetness is not a limitation. The bearing capacity is fair to good, but where large buildings are constructed, differential settling can be a concern because of wide differences in soil texture within short distances. It is a good practice either to compact the fill around foundations or to allow the fill material to settle before seeding or sodding lawns. In warm seasons, soaking the fill with water hastens settling.

Limitations for septic tank filter fields on the soils in this group are slight to moderate. As slope increases, filter fields are more difficult to construct and the hazard of seepage on side slopes increases. It is important to place the drain field in undisturbed natural soils.

Graded and filled areas of this soil material generally absorb effluent very slowly. Percolation rates are quite variable because of the variations in soil texture. Percolation rates range from 75 minutes per inch to less than 10 minutes per inch at the depth at which tile trenches are generally constructed. The hazard of contaminating the ground water is moderate. These soils contain pockets of sand and gravel that can allow effluent to move long distances and to pollute nearby wells and lakes.

Limitations for trench-type sanitary landfills are moderate because the soils contain many pockets and veins of sand and gravel that may allow the leachate to move long distances and to contaminate nearby wells and lakes.

In places these soils contain sand and gravel of good quality for construction purposes. In other places the larger veins and pockets of sand and gravel are at a depth of 5 to 20 feet or more. In other areas only a meager supply of sand and gravel is available.

#### BUILDING SITE GROUP 5

This group consists of soils in the Bold, Clarion, Hayden, Lester, Moland, Port Byron and Storden series and the Fairhaven series, loamy subsoil variant. These are deep, moderately permeable, somewhat excessively drained and well-drained, silty and loamy soils. The water table generally is below a depth of 10 feet. Slopes range from 0 to 30 percent. The Hayden and Lester soils are in convex positions that are intermingled with shallow, concave drainageways occupied by the poorly drained Cordova and Dundas soils.

Where slopes are 2 to 12 percent, the soils in this group have moderate limitations for urban and commercial developments that use public sewers. Where slopes are more than 12 percent, limitations are severe. Grading and leveling costs for homesites and street development are high. Where the steeper slopes are extensive, developments that have large lots are generally better suited to these soils.

These soils have fair bearing capacity and fair shear strength. Their volume change with changes in moisture is moderate. Fairly wide footings are needed for foundations. Roads, driveways, and other concrete structures need careful design, especially on the Lester and Hayden soils, to prevent breakup as a result of volume changes in the soil.

Where foundations are backfilled, air pockets generally form and the fill settles unevenly. It is good practice to compact the fill or allow it to settle before establishing a lawn.

In warm seasons, soaking the fill with water during backfill operations hastens settling. The low areas can then be refilled before seeding or sodding these areas.

During unusually wet periods, side-slope seepage occurs on these soils where slope is more than 2 percent. It is therefore good practice to place tile around foundation footings to intercept water that might seep into the basement, but an adequate outlet is needed. On the poorly drained soils in drainageways, the high risk of frost heave and the high seasonal water table need to be considered.

Where slopes are 2 to 12 percent, the soils have a moderate limitation to use for septic tank filter fields for private homes. Limitations for drain fields are severe where slopes are more than 12 percent. Slide-slope seepage is a hazard, and filter fields are difficult to lay out. The design percolation rate for Hayden and Lester soils in most places is 60 minutes per inch, but the rate ranges from about 45 to 75 minutes per inch.

The absorbing capacity in the life of a drain field can be increased by constructing trenches 40 to 48 inches deep and using gravel under the tile. Large lots, one-half acre or more in size, are advisable on these soils to allow sufficient area for drain fields. It is important to place the drain field in undisturbed natural soils. Graded and filled areas of this soil material generally absorb effluent very slowly.

The Hayden and Lester soils have percolation rates that are not suited to absorbing effluent from schools, hospitals, and other large institutions. A sewage lagoon or a central sewer system is commonly needed for these facilities.

These soils are well suited to trench-type sanitary landfills. The water table is deep, the soils are moderately permeable, and the hazard of pollution is relatively low. The Hayden and Lester soils are sticky and plastic when wet and are somewhat difficult to use for refuse cover.

Trees, shrubs, and sod are easy to establish in most areas of these soils. On the Hayden soils, however, tilth is generally poorer and seeded lawns are harder to establish.

#### BUILDING SITE GROUP 6

This group consists of soils in the Judson, Le Sueur, Merton, Nicollet, and Terril series. These are deep, loamy, moderately well drained soils that occupy convex positions and are intermingled with poorly drained soils in shallow drainageways and depressions. Slopes are 1 to 3 percent. A seasonal water table occurs at a depth of 2 to 5 feet.

These soils have moderate limitations for residential and commercial developments because foundations require installation of drain tile around basement footings to control the water table. In addition, an adequate outlet is needed or the foundation needs to be placed above the waterline.

These soils have fair bearing capacity for foundations, and moderately wide footings are needed. The soils are highly susceptible to frost action and have a moderate volume change with changes in soil moisture. Streets, roads, and sidewalks tend to heave unless they are carefully designed and have a thick subbase of sand.

If foundations are backfilled on these soils, air pockets generally form and the fill settles unevenly. It is a good practice to compact the fill or allow it to settle before establishing a lawn. In warm seasons, soaking the fill with water during backfill operations hastens settling.

Soils of this group have moderate limitations for septic tank filter fields. The percolation design rates are near 75 minutes per inch of soil, through percolation rates range mostly from 45 to 75 minutes per inch. Deep absorption trenches are desirable so that the absorption area per lineal foot of drain field is increased. It is important to place the drain fields in undisturbed, natural soils. The soil material in graded and filled areas generally absorbs effluent very slowly, and such areas are poor sites for filter fields.

These soils have severe limitations for sanitary landfills because of the high water table.

Sod, shrubs, and trees are easily established.

#### BUILDING SITE GROUP 7

This group consists of soils in the Erin, Kilkenny, and Lerdal series. These are deep soils that have moderately slow and slow permeability. The Erin and Kilkenny soils are well drained and have convex slopes of 2 to 35 percent. The water table commonly is below a depth of 10 feet, except for the Lerdal soils. These soils are intermingled with shallow, concave drainageways and depressions occupied by poorly drained Cordova and Dundas soils (see building site group 10). These poorly drained soils need to be considered when developing the soils in this group for urban uses. The Lerdal soils have slopes of 1 to 18 percent and are moderately well drained to somewhat poorly drained. They have a seasonally high water table at a depth of 2 to 5 feet.

Where slopes are less than 12 percent, the soils in this group have moderate limitations for residential and commercial developments that use public sewers. Where slopes are more than 12 percent, the soils generally have severe limitations for these purposes because costs of grading streets and building sites are high. The bearing capacity and shear strength of the soils are fair. The change in volume with moisture changes is moderate to moderately high. Fairly wide foundation footings are needed. Unless streets, roads, and concrete slabs are carefully designed, they are subject to heaving and cracking.

If foundations are backfilled, air pockets generally form. As a result, the fill settles unevenly. In warm seasons it is good practice to compact the fill or allow it to settle before establishing a lawn. Soaking the fill with water during backfill operations hastens the settling action.

These soils have severe limitations for residential or commercial developments that do not use central sewers. Percolation design rates are near 120 minutes per inch. Graded and filled areas of this soil material generally absorb effluent very slowly.

Drain fields are difficult to construct where slopes are 12 to 35 percent, and side slope seepage is severe.

These soils have moderate limitations for trench-type sanitary landfills. Leachate moves slowly through the soil. These soils are sticky and plastic when wet and are somewhat difficult to use as cover for refuse. The moderate to high volume change with change in moisture causes cracks to form on the surface.

Sod and shrubs are fairly easy to establish on these soils. Establishing lawns from seed is difficult because the soils are plastic and sticky, are hard to work, and are easily eroded.

#### BUILDING SITE GROUP 8

This group consists of soils in the Kasson, Klinger, Ostrander, Renova, and Vlasaty series. These are deep, well drained and moderately well drained soils. The water table commonly is at a depth of 2 to 5 feet in the Kasson, Klinger, and Vlasaty soils but is below a depth of 10 feet in the Ostrander and Renova soils. Slopes range from 0 to 30 percent but are dominantly near 2 to 4 percent and are 200 to 400 feet long. The soils have in common a silty mantle over a stone line or coarse-textured layer that is underlain by firm till. In places the underlying till has seams and wedges of sand. Permeability ranges from moderate to moderately slow.

Where slopes are 2 to 12 percent, these soils have moderate limitations for urban and commercial developments. Where slopes are more than 12 percent, the limitations are severe.

These soils have fair bearing capacity and fair shear strength. Their volume change with changes in moisture is

moderate. Fairly wide footings are needed for foundations. If foundations are backfilled, air pockets generally form and the fill settles unevenly. In warm seasons it is a good practice to compact the fill or allow it to settle before establishing a lawn. Soaking the fill with water during the backfill operation hastens the settling action.

Seepage occurs in these soils along the stone line where slopes are more than 2 percent. Tile should be placed around foundation footings to intercept seepage and to lower the water table. In addition, an adequate outlet for the tile is needed. These soils are crossed by wet drainageways.

Where slopes are 2 to 12 percent, limitations are moderate for septic tank filter fields for private homes. Where slopes are more than 12 to 30 percent, limitations are severe.

The design percolation rate is near 60 minutes per inch, but the percolation rate ranges from about 45 to 75 minutes per inch. Absorption capacity in the life of a drainfield can be increased by constructing trenches 40 to 48 inches deep and by using gravel under the tile. Lots that are one-half acre or more in size generally allow sufficient area for drain fields. The drain field should be placed in undisturbed natural soil because graded and filled areas of this soil material generally absorb sewage very slowly. Percolation rates are not well suited for schools, hospitals, and other large institutions. The long slopes, generally low relief, and downslope seepage place severe limitations on use of the soils for trench-type sanitary landfills.

Trees, shrubs, and sod are easily established on these soils.

#### BUILDING SITE GROUP 9

This group consists of soils in the Biscay and Kato series and the Biscay series, seepy variant. The Biscay and Kato soils are nearly level, but the Biscay seepy variant is on foot slopes of 4 to 18 percent. These soils are poorly drained and have a water table at a depth of 0 to 3 feet.

The soils of this group have moderate to severe limitations for residential and commercial developments that use a central sewer system because the soils are wet. Unless the water table is lowered or the foundation is placed above the waterline, wet basements result.

These soils are highly susceptible to frost heave unless the water table is lowered. Their underlying material has good bearing capacity for buildings of less than three stories. The soils have a moderate volume change with changes in soil moisture in the upper 2 or 3 feet.

These soils have severe limitations for drainfields because the water table is high and nearby wells, streams, and lakes could be polluted. Drain field performance is severely reduced during wet periods unless the water table is controlled by regional drainage. Percolation rate in the sand and gravel substratum is less than 5 minutes per inch, but the percolation rate ranges from 30 to 120 minutes per inch in the upper loamy and silty layers. Where septic tank filter fields must be constructed in the soils in this group, placing the filter fields in a 3- to 5-foot-thick bed of loamy material above the waterline helps to reduce the risk of pollution and to overcome wetness.

The soils in this group have severe limitations for trench-type sanitary landfills because the water table is high and the underlying material is porous. Leachate from landfills can move a long distance in the sand and pollute nearby wells, lakes, and streams.

#### BUILDING SITE GROUP 10

This group consists of soils in the Canisteo, Cordova, Garwin, Maxcreek, Maxfield, and Webster series. These are deep, nearly level, poorly drained, loamy soils. In undrained areas a water table occurs at a depth of 0 to 3 feet during wet periods. The water table may be high for 90 or more consecutive days in a year.

Because of wetness, these soils have moderate to severe limitations for residential and commercial developments that use central sewers. If the soils are to be used for building sites, tile must be placed around foundation footings and connected to an adequate outlet to control the water table, or the foundations need to be placed above the waterline.

If foundations are backfilled on these soils, air pockets are generally formed and the fill settles unevenly. It is a good practice to compact the fill or allow it to settle before establishing a lawn. In warm seasons, soaking the fill with water during backfill operations hastens settling.

The susceptibility to frost heave is high on these soils. Bearing capacity and shear strength are fair to poor, and volume change with changes in moisture content is moderate.

These soils have severe limitations for residential developments that use septic tank filter fields because the water table is high and permeability is moderate to moderately slow.

Where filter fields must be used, they should be constructed in a thick bed of specified loamy material or the water table in the filter field should be controlled through the installation of drain tile 3½ to 4 feet deep about 50 feet apart. A free-flowing outlet is needed. Drain tile can then be placed between the tile that control the water table. Trenches should be deep and narrow. These procedures should be approved by public health officials before adoption. Percolation rates generally range from 45 to 90 minutes per inch of soil.

Because of wetness, these soils have severe limitations for trench-type sanitary landfills.

#### BUILDING SITE GROUP 11

This group consists of soils in the Dundas, Mazaska, Shields, and Skyberg series. These are deep, nearly level, poorly drained to somewhat poorly drained soils. Permeability is moderately slow or slow. The Mazaska and Shields soils consist of 30 to 72 inches of clay sediment that is high in content of shale and overlies loam. In places, silty sediment as much as 4 feet thick occurs between the clay and the loam. Dundas soils have less clay than Mazaska and Shields soils. The Skyberg soils have a silty mantle over a firm loamy subsoil and substratum. All of these soils are in broad, level areas and in shallow drainageways. The water table is at a depth of 0 to 5 feet for periods as long as 90 consecutive days or more during wet periods.

These soils have severe limitations to use as sites for residential and commercial developments. Where they are used as building sites, artificial drainage is needed to control the water table, or the foundation needs to be built on fill to raise it above the waterline. These soils are sticky when wet and have poor trafficability if used for roads.

Foundations constructed on the Mazaska and Shields soils need to be reinforced to prevent cracking caused by large changes in volume with changes in soil moisture. Roads, driveways, and parking lots are subject to cracking and heaving unless they are carefully designed. The bearing capacity, which ranges from fair to poor, needs to be carefully investigated when designing foundations on these soils.

If foundations are backfilled on these soils, air pockets generally form and the fill settles unevenly. The fill should be carefully compacted or it should be allowed to settle before a lawn is established. Soaking the fill with water during backfill operations hastens settling.

These soils have severe limitations to use as septic tank filter fields because of wetness and moderately slow and slow permeability. Percolation rates generally are more than 120 minutes per inch. Where filter fields must be constructed in these soils, one method would be to place a 4- to 5-foot-thick bed of loamy fill above the waterline. The drain field area needs to be protected against runoff from surrounding higher areas.

The soils in this group have severe limitations for trench-type sanitary landfills because the water table is high and the clayey soil material is plastic when wet. Landfills need to be built to a level above the waterline to prevent anaerobic decomposition. The clayey upper 3 to 6 feet of the Mazaska and Shields soils makes poor covering for refuse. This soil material forms cracks as it dries.

Sod, trees, and shrubs are easy to establish on these soils. Seedbeds for lawns are hard to prepare.

#### BUILDING SITE GROUP 12

The group consists of Marsh and soils in the Canisteo, Caron, Colo, Faxon, Glencoe, Maxcreek, Maxfield, Muskego, Palms, and Rolfe series. These are poorly drained and very poorly drained, loamy, silty, or organic soils that are subject to ponding or flooding. The Faxon soils have bedrock at a depth of 20 to 40 inches and are subject to seepage. Unless the soils of this group are drained, the water table is near the surface much of the year.

These soils have severe limitations to use for community development because of wetness and flooding. The risk of frost heave is high.

Where these soils are used for building sites, drainage is needed or the foundations must be placed above the waterline.

Muskego and Palms soils have severe limitations to use as foundations. Foundations must be placed on pilings in many places. If practical, organic material should be completely removed before fill is added, or otherwise the fill may settle and draw away from the foundation.

The degree of limitation on these soils is severe for septic tank filter fields because the water table is very high and effluent can easily contaminate the ground water as well as the nearby lakes and streams.

These soils have severe limitations for trench-type sanitary landfills because of the risk of polluting the ground water.

Many areas of these soils are suitable for special habitat. Some areas are suitable for use as parks and other recreational areas.

#### BUILDING SITE GROUP 13

This group consists of Alluvial land; Alluvial land, frequently flooded; Lake beaches; and soils in the Zumbro series. All of these are sandy to loamy soils that occur on bottom lands along streams and lake beaches. They are subject to flooding. The soils are well drained to somewhat poorly drained, but in places they have a water table at a depth of 1 to 5 feet when the river is high.

Flooding is a severe limitation to the use of these soils for residential and commercial developments. Limitations for trench-type sanitary landfills are severe because the soils are subject to flooding. During floods the refuse pollutes nearby lakes and streams.

These soils are suited to use as parks, recreation areas, and wildlife sanctuaries. In areas that are seldom flooded, the soils are suited to campsites and picnic areas. Flooding is not so hazardous to these uses, because peak use generally occurs after floodwaters have receded.

## Engineering Uses of the Soils [4]

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 soil 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. Table 7 shows several estimated soil properties that are significant to engineering, and table 8 gives interpretations for various engineering uses.

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 7 and 8, and can be used to make other useful maps.

[4] THEODORE THORSON, engineer, Soil Conservation Service, helped prepare this section.

TABLE 7.—*Estimated 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. The soils for referring to other series that appear in the first column of this

| Soil series and map symbols | Depth to— | | Depth from surface | USDA texture | Classification | | Coarse fraction greater than 3 inches |
|---|---|---|---|---|---|---|---|
| | Bedrock | Seasonal high water table | | | Unified | AASHO | |
| | *Feet* | *Feet* | *Inches* | | | | *Percent* |
| Alluvial land: Ad, Af. Most properties too variable to be estimated. | | | | | | | |
| Biscay: Bc | >5 | 0–3 | 0–15 | Loam | CL or ML | A–7 or A–6 | |
| | | | 15–25 | Loam | CL or ML | A–6 or A–7 | |
| | | | 25–33 | Sandy loam | SM or SC | A–2 or A–4 | |
| | | | 33–64 | Gravelly coarse sand | SP or SW | A–1 | |
| Biscay, seepy variant: Bk | >5 | 0–3 | 0–17 | Loam | CL or ML | A–7 or A–6 | |
| | | | 17–28 | Loam | CL or ML | A–7 or A–6 | |
| | | | 28–35 | Sandy loam | SM or SC | A–2 or A–4 | |
| | | | 35–68 | Sand and gravel | SW or SP | A–1 | |
| Bold. Mapped only in complexes with Port Byron soils. | >5 | >10 | 0–8 | Silt loam | ML | A–4 | |
| | | | 8–60 | Silt loam | ML | A–4 | |
| Boone: BoC, BoD, BoF | 1.5–3.5 | >10 | 0–30 | Fine sand | SM | A–2 | |
| | | | 30–68 | Weakly cemented sandstone, dominantly fine sand size. | | | |
| Canisteo: Ca, Cd | >5 | 0–3 | 0–19 | Clay loam | MH, OH, or CL | A–7 | |
| | | | 19–30 | Clay loam | CL | A–7 or A–6 | |
| | | | 30–60 | Clay loam | CL | A–6 | |
| Caron: Ck. Some estimates are not shown because properties are too variable. | >5 | 0–3 | 0–46 | Muck or mucky peat (sapric or hemic). | Pt | A–8 | |
| | | | 46–84 | Muck (Limnic) | MH | A–5 | |
| | | | 84–96 | Silty clay loam | MH or ML | A–7 or A–6 | |
| *Clarion: ClB, ClC, CnC2, CsC, CsD, CsE. For Estherville part of CnC2, see Estherville series. For Storden part of CnC2, CsC, CsD, and CsE, see Storden series. | >5 | >10 | 0–13 | Loam | ML–CL | A–4 or A–6 | |
| | | | 13–34 | Loam | ML–CL or CL | A–7 or A–6 | |
| | | | 34–60 | Loam | ML–CL or CL | A–6 or A–4 | |
| Colo: Ct | >5 | 2–5 | 0–60 | Silty clay loam | MH, CL, or OH | A–7 or A–6 | |
| Copaston: CvA | 1–2 | >10 | 0–7 | Sandy clay loam | SM or SC | A–4 | |
| | | | 7–11 | Fine sandy loam | SM | A–2 or A–4 | |
| | | | 11–18 | Sandy loam | SM | A–2 | 0–5 |
| | | | 18 | Bedrock. | | | |
| Cordova: Cy | >5 | 0–3 | 0–13 | Clay loam | OL, OH, or CL | A–7 | |
| | | | 13–36 | Clay loam | CL | A–7 | |
| | | | 36–60 | Loam | CL or ML | A–7 or A–6 | |
| Dickman: DcA, DcB, DcC, DkA, DkB. | >5 | >10 | 0–19 | Sandy loam | SM | A–2 or A–4 | |
| | | | 19–27 | Loamy sand | SM | A–2 | |
| | | | 27–60 | Sand | SP–SM | A–2 or A–3 | |
| Dodgeville: DoB, DoC, DoD, DoE. | 1.5–4.5 | >10 | 0–10 | Silt loam | ML | A–4 | |
| | | | 10–28 | Silt loam and loam | ML | A–4 | |
| | | | 28 | Bedrock. | | | |

See footnotes at end of table.

*significant in engineering*

in such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions table. The symbol > means greater than; the symbol < means less than]

| Percentage less than 3 inches passing sieve— | | | | Liquid limit | Plasticity index | Permeability | Available water capacity | Reaction | Shrink-swell potential |
|---|---|---|---|---|---|---|---|---|---|
| No. 4 (4.7 mm.) | No. 10 (2.0 mm.) | No.40 (0.42 mm.) | No. 200 (0.074 mm.) | | | | | | |
| | | | | | | *Inches per hour* | *Inches per inch of soil* | *pH value* | |
| | | | | | | | | 6. 6–7. 3 | Low. |
| 95–100 | 95–100 | 70–90 | 50–60 | 35–50 | 10–20 | 0. 6–2. 0 | 0. 20–0. 22 | 6. 1–7. 8 | Moderate. |
| 90–100 | 90–100 | 70–90 | 50–60 | 35–60 | 15–25 | 0. 6–2. 0 | 0. 17–0. 19 | 6. 6–7. 3 | Moderate. |
| 90–100 | 90–100 | 55–75 | 20–40 | 25–40 | 8–15 | 2. 0–6. 0 | 0. 12–0. 14 | 6. 6–7. 3 | Moderate. |
| 65–90 | 60–80 | 20–45 | 2–5 | (1) | (1) | 6. 0–20. 0 | 0. 02–0. 04 | 7. 4–7. 8 | Low. |
| 95–100 | 95–100 | 70–90 | 50–60 | 35–50 | 10–20 | 0. 6–2. 0 | 0. 20–0. 22 | 6. 1–7. 8 | Moderate. |
| 90–100 | 90–100 | 70–90 | 50–60 | 35–50 | 15–25 | 0. 6–2. 0 | 0. 17–0. 19 | 6. 6–7. 3 | Moderate. |
| 90–100 | 90–100 | 55–75 | 20–40 | 25–40 | 8–15 | 2. 0–6. 0 | 0. 12–0. 14 | 6. 6–7. 3 | Moderate. |
| 65–90 | 60–80 | 20–45 | 2–5 | (1) | (1) | 6. 0–20. 0 | 0. 02–0. 04 | 7. 4–7. 8 | Low. |
| 100 | 100 | 90–100 | 70–90 | 25–30 | 0–4 | 0. 6–2. 0 | 0. 22–0. 24 | 7. 4–7. 8 | Low. |
| 100 | 100 | 90–100 | 70–90 | 20–30 | 0–3 | 0. 6–2. 0 | 0. 20–0. 22 | 7. 4–7. 8 | Low. |
| 100 | 100 | 65–80 | 20–35 | (1) | (1) | >20. 0 | 0. 07–0. 09 | 5. 1–6. 0 | Very low. |
| 98–100 | 95–100 | 85–98 | 70–90 | 45–55 | 15–20 | 0. 6–2. 0 | 0. 17–0. 19 | 7. 4–7. 8 | Moderate. |
| 98–100 | 90–100 | 85–95 | 65–85 | 35–50 | 20–30 | 0. 6–2. 0 | 0. 15–0. 19 | 7. 4–7. 8 | Moderate. |
| 95–100 | 90–100 | 80–95 | 60–75 | 35–40 | 12–20 | 0. 6–2. 0 | 0. 14–0. 16 | 7. 4–7. 8 | Moderate. |
| | | | | | | 2. 0–6. 0 | 0. 35–0. 58 | 6. 1–7. 3 | High. |
| 100 | 95–100 | 80–90 | 55–75 | | | 2. 0–6. 0 | 0. 22–0. 35 | 6. 6–7. 8 | High. |
| 100 | 100 | 98–100 | 75–90 | 45–60 | 20–30 | 0. 2–0. 6 | 0. 16–0. 19 | 7. 4–7. 8 | High. |
| 95–100 | 95–100 | 80–95 | 55–70 | 35–45 | 15–20 | 0. 6–2. 0 | 0. 20–0. 22 | 5. 6–6. 5 | Moderate. |
| 95–100 | 95–100 | 80–95 | 55–75 | 35–45 | 15–20 | 0. 6–2. 0 | 0. 17–0. 19 | 5. 6–7. 3 | Moderate. |
| 95–100 | 85–95 | 80–95 | 60–75 | 30–40 | 8–20 | 0. 6–2. 0 | 0. 17–0. 19 | 7. 4–7. 8 | Moderate. |
| 100 | 100 | 95–100 | 95–100 | 45–60 | 20–30 | 0. 2–0. 6 | 0. 18–0. 22 | 6. 6–7. 3 | High. |
| 100 | 90–100 | 80–90 | 35–50 | 25–30 | 4–10 | 0. 6–2. 0 | 0. 18–0. 20 | 5. 6–7. 3 | Low. |
| 90–100 | 90–100 | 70–85 | 30–40 | (1) | (1) | 0. 6–2. 0 | 0. 15–0. 17 | 5. 6–6. 5 | Low. |
| 90–100 | 90–100 | 40–70 | 20–35 | (1) | (1) | 2. 0–6. 0 | 0. 12–0. 14 | 5. 6–6. 5 | Low. |
| 98–100 | 98–100 | 90–98 | 70–85 | 40–50 | 10–20 | 0. 2–0. 6 | 0. 17–0. 19 | 5. 6–7. 3 | Moderate. |
| 98–100 | 95–100 | 85–95 | 65–80 | 40–50 | 15–25 | 0. 2–0. 6 | 0. 15–0. 19 | 5. 6–6. 5 | Moderate. |
| 95–100 | 90–100 | 80–95 | 55–70 | 30–45 | 10–20 | 0. 6–2. 0 | 0. 17–0. 19 | 7. 4–7. 8 | Moderate. |
| 95–100 | 90–100 | 55–75 | 20–40 | (1) | (1) | 6. 0–20. 0 | 0. 13–0. 15 | 5. 6–6. 5 | Low. |
| 95–100 | 95–100 | 50–75 | 15–30 | (1) | (1) | 6. 0–20. 0 | 0. 09–0. 11 | 5. 6–6. 5 | Low. |
| 95–100 | 95–100 | 50–70 | 5–15 | (1) | (1) | 6. 0–20. 0 | 0. 05–0. 07 | 5. 6–7. 3 | Low. |
| 100 | 100 | 90–100 | 70–90 | 25–35 | 0–6 | 0. 6–2. 0 | 0. 22–0. 24 | 5. 6–7. 3 | Moderate. |
| 100 | 100 | 90–100 | 60–90 | 25–35 | 0–6 | 0. 6–2. 0 | 0. 17–0. 22 | 5. 6–6. 5 | Moderate. |

TABLE 7.—*Estimated soil properties*

| Soil series and map symbols | Depth to— | | Depth from surface | USDA texture | Classification | | Coarse fraction greater than 3 inches |
|---|---|---|---|---|---|---|---|
| | Bedrock | Seasonal high water table | | | Unified | AASHO | |
| | *Feet* | *Feet* | *Inches* | | | | *Percent* |
| Dundas: Du | >5 | 2–5 | 0–15 | Silt loam and loam | MH or ML | A–4 | |
| | | | 15–40 | Loam and clay loam. | MH or CH | A–7 or A–6 | |
| | | | 40–64 | Loam | ML or CL | A–6 or A–7 | |
| Erin: ErB, ErC2, ErD2, ErE | >5 | >10 | 0–12 | Silt loam | ML | A–6 | |
| | | | 12–65 | Clay loam and clay | MH or CH | A–7 | |
| | | | 65–71 | Clay loam | CL | A–7 | |
| Estherville: EsA, EsB, EsC | >5 | >10 | 0–10 | Sandy loam | SM | A–2 | |
| | | | 10–16 | Sandy loam | SM | A–2 | |
| | | | 16–68 | Gravelly coarse sand | SP | A–1 | 5–25 |
| Etter: EtB, EtC | 1. 5–4. 5 | >10 | 0–12 | Fine sandy loam | ML or SM | A–4 | |
| | | | 12–29 | Loam | ML | A–4 | |
| | | | 29–32 | Loamy fine sand | SM | A–2 | |
| | | | 32–68 | Weakly cemented sandstone. | | | |
| Fairhaven: FaA, FaB | >5 | >10 | 0–17 | Silt loam | ML | A–4 | |
| | | | 17–28 | Loam | CL–ML | A–4 or A–6 | |
| | | | 28–32 | Sandy loam | SM | A–2 or A–4 | |
| | | | 32–60 | Gravelly coarse sand | SP or SW | A–1 | |
| Fairhaven, loamy subsoil variant: FlA, FlB. | >5 | >10 | 0–12 | Silt loam | ML | A–4 | |
| | | | 12–44 | Silt loam, loam, and sandy clay loam. | CL or ML | A–4 or A–6 | |
| | | | 44–64 | Very fine sandy loam, loamy coarse sand, and sandy loam. | SM | A–2 or A–4 | |
| Faxon: Fx | 1. 5–3. 5 | 0–3 | 0–15 | Clay loam and loam | CL, ML, or OL | A–7 or A–6 | |
| | | | 15–34 | Loam or fine sandy loam. | CL, ML, or SC | A–4 or A–6 | |
| | | | 34 | Bedrock. | | | |
| Garwin: Ga | >5 | 0–3 | 0–17 | Silty clay loam | MH or OH | A–7 | |
| | | | 17–31 | Silty clay loam | CL | A–7 | |
| | | | 31–70 | Silt loam | ML | A–4 | |
| Glencoe: Gc | >5 | 0–3 | 0–20 | Clay loam | OL or MH | A–7 | |
| | | | 20–27 | Clay loam | MH, ML, or CL | A–7 | |
| | | | 27–64 | Clay loam | CL or ML | A–6 or A–7 | |
| Hayden: HaB, HaC, HaD, HaE | >5 | >10 | 0–8 | Loam | ML or CL | A–4 | |
| | | | 8–40 | Clay loam | CL | A–6 or A–7 | |
| | | | 40–60 | Loam | CL or ML | A–6 or A–4 | |
| Judson: JuC | >5 | 2–5 | 0–30 | Silt loam | ML | A–4 | |
| | | | 30–60 | Silt loam | ML or CL | A–4 or A–7 | |
| | | | 60–94 | Silt loam | ML or CL | A–4 | |
| Kasson: KaA | >5 | 2–5 | 0–10 | Silt loam | ML | A–4 | |
| | | | 10–24 | Silty clay loam | ML or CL | A–6 | |
| | | | 24–78 | Loam | CL | A–6 | |
| Kato: Kc | >5 | 0–3 | 0–20 | Silty clay loam | CL, CH, or MH | A–7 | |
| | | | 20–29 | Silty clay loam | ML or CL | A–7 or A–6 | |
| | | | 29–64 | Sand or sand and gravel. | SM or SP | A–1 | |

See footnotes at end of table.

*significant in engineering*—Continued

| Percentage less than 3 inches passing sieve— | | | | Liquid limit | Plasticity index | Permeability | Available water capacity | Reaction | Shrink-swell potential |
|---|---|---|---|---|---|---|---|---|---|
| No. 4 (4.7 mm.) | No. 10 (2.0 mm.) | No.40 (0.42 mm.) | No. 200 (0.074 mm.) | | | | | | |
| | | | | | | *Inches per hour* | *Inches per inch of soil* | *pH value* | |
| 100 | 98–100 | 85–98 | 65–80 | 30–55 | 0–6 | 0. 6–2. 0 | 0. 20–0. 24 | 5. 6–7. 3 | Moderate. |
| 98–100 | 95–100 | 85–98 | 60–80 | 50–65 | 20–35 | 0. 2–0. 6 | 0. 15–0. 19 | 4. 5–6. 0 | Moderate to high. |
| 98–100 | 90–100 | 80–95 | 55–70 | 35–45 | 15–25 | 0. 6–2. 0 | 0. 17–0. 19 | 7. 4–7. 8 | Moderate. |
| 95–100 | 95–100 | 90–95 | 70–90 | 40–50 | 10–15 | 0. 6–2. 0 | 0. 22–0. 24 | 5. 1–6. 5 | Moderate. |
| 95–100 | 95–100 | 90–95 | 70–95 | 50–60 | 25–35 | 0. 2–0. 6 | 0. 10–0. 19 | 4. 0–7. 3 | High. |
| 95–100 | 95–100 | 80–90 | 70–80 | 40–50 | 20–30 | 0. 2–0. 6 | 0. 14–0. 16 | 7. 4–7. 8 | Moderate. |
| 90–100 | 80–98 | 50–75 | 20–35 | 25–35 | 0–10 | 2. 0–6. 0 | 0. 13–0. 15 | 5. 6–6. 5 | Low. |
| 90–100 | 80–98 | 50–75 | 20–35 | 25–35 | 0–10 | 2. 0–6. 0 | 0. 12–0. 14 | 5. 6–6. 5 | Low. |
| 60–90 | 40–90 | 10–40 | 2–5 | (1) | (1) | 6. 0–20. 0 | 0. 02–0. 05 | 5. 6–7. 8 | Low. |
| 95–100 | 95–100 | 70–95 | 40–65 | 25–30 | 0–8 | 2. 0–6. 0 | 0. 16–0. 18 | 5. 6–6. 5 | Low. |
| 95–100 | 95–99 | 70–95 | 50–65 | 25–35 | 0–8 | 0. 6–2. 0 | 0. 17–0. 19 | 4. 5–5. 5 | Low. |
| 90–98 | 90–98 | 60–90 | 12–35 | (1) | (1) | 6. 0–20. 0 | 0. 08–0. 10 | 4. 5–6. 0 | Low. |
| 95–100 | 95–100 | 80–95 | 70–80 | 30–40 | 3–8 | 2. 0–6. 0 | 0. 22–0. 24 | 6. 1–7. 3 | Low. |
| 95–100 | 95–100 | 85–95 | 50–75 | 28–38 | 5–12 | 2. 0–6. 0 | 0. 17–0. 19 | 6. 1–7. 3 | Low. |
| 95–100 | 90–100 | 55–75 | 20–40 | (1) | (1) | 2. 0–6. 0 | 0. 12–0. 14 | 6. 6–7. 3 | Low. |
| 85–95 | 70–80 | 30–50 | 2–5 | (1) | (1) | 6. 0–20. 0 | 0. 02–0. 04 | 7. 4–7. 8 | Low. |
| 95–100 | 95–100 | 80–95 | 70–80 | 30–40 | 3–8 | 0. 6–2. 0 | 0. 22–0. 24 | 5. 6–7. 3 | Low. |
| 95–100 | 95–100 | 70–90 | 50–75 | 30–40 | 5–12 | 0. 6–2. 0 | 0. 17–0. 20 | 5. 6–7. 3 | Low. |
| 95–100 | 90–100 | 55–80 | 25–50 | 20–30 | 0–8 | 0. 6–6. 0 | 0. 11–0. 16 | 5. 6–7. 3 | Low. |
| 95–100 | 95–100 | 95–100 | 80–95 | 35–45 | 8–15 | 0. 6–2. 0 | 0. 17–0. 22 | 6. 6–7. 8 | Moderate. |
| 95–100 | 95–100 | 70–95 | 40–65 | 30–40 | 8–12 | 2. 0–6. 0 | 0. 15–0. 19 | 6. 6–7. 8 | Moderate. |
| 100 | 100 | 95–100 | 95–100 | 55–65 | 20–25 | 0. 2–0. 6 | 0. 18–0. 22 | 6. 1–7. 8 | High. |
| 100 | 100 | 90–100 | 70–95 | 40–50 | 15–25 | 0. 2–0. 6 | 0. 16–0. 22 | 6. 6–7. 3 | High. |
| 100 | 100 | 95–100 | 85–95 | 25–30 | 2–6 | 0. 6–2. 0 | 0. 20–0. 22 | 6. 6–7. 8 | Moderate. |
| 100 | 100 | 95–100 | 70–90 | 45–55 | 8–12 | 0. 2–0. 6 | 0. 17–0. 19 | 6. 1–7. 8 | Moderate to high. |
| 100 | 95–100 | 85–98 | 75–90 | 45–55 | 15–20 | 0. 2–0. 6 | 0. 15–0. 19 | 6. 6–7. 8 | Moderate to high. |
| 98–100 | 95–100 | 80–98 | 70–85 | 30–45 | 12–20 | 0. 2–0. 6 | 0. 14–0. 16 | 7. 4–7. 8 | Moderate. |
| 95–100 | 90–100 | 80–95 | 50–70 | 20–30 | 1–6 | 0. 6–2. 0 | 0. 20–0. 22 | 5. 6–6. 5 | Moderate. |
| 95–100 | 90–100 | 80–95 | 55–75 | 30–45 | 18–22 | 0. 6–2. 0 | 0. 15–0. 19 | 5. 6–7. 3 | Moderate. |
| 95–100 | 90–100 | 75–90 | 50–70 | 25–35 | 8–12 | 0. 6–2. 0 | 0. 17–0. 19 | 7. 4–7. 8 | Moderate. |
| 100 | 100 | 90–100 | 70–90 | 30–40 | 6–10 | 0. 6–2. 0 | 0. 22–0. 24 | 6. 1–6. 5 | Moderate. |
| 100 | 100 | 90–100 | 70–90 | 35–50 | 8–20 | 0. 6–2. 0 | 0. 20–0. 22 | 5. 6–6. 5 | Moderate. |
| 100 | 100 | 90–100 | 70–90 | 30–40 | 6–12 | 0. 6–2. 0 | 0. 20–0. 22 | 6. 0–7. 3 | Moderate. |
| 95–100 | 95–100 | 90–95 | 85–95 | 30–40 | 6–10 | 0. 6–2. 0 | 0. 22–0. 24 | 5. 6–7. 3 | Moderate. |
| 95–100 | 95–100 | 90–95 | 85–95 | 30–40 | 10–15 | 0. 6–2. 0 | 0. 16–0. 19 | 4. 5–6. 0 | Moderate. |
| 95–99 | 95–99 | 85–95 | 60–75 | 25–35 | 15–20 | 0. 2–0. 6 | 0. 17–0. 19 | 5. 1–7. 8 | Moderate. |
| 100 | 100 | 85–95 | 75–95 | 45–55 | 20–25 | 0. 6–2. 0 | 0. 18–0. 22 | 6. 1–7. 3 | Moderate. |
| 100 | 100 | 70–90 | 85–95 | 35–45 | 10–20 | 0. 6–2. 0 | 0. 16–0. 19 | 6. 6–7. 3 | Moderate. |
| 65–90 | 60–80 | 20–45 | 2–13 | (1) | (1) | 6. 0–20. 0 | 0. 02–0. 04 | 6. 6–7. 8 | Moderate. |

TABLE 7.—*Estimated soil properties*

| Soil series and map symbols | Depth to— | | Depth from surface | USDA texture | Classification | | Coarse fraction greater than 3 inches |
|---|---|---|---|---|---|---|---|
| | Bedrock | Seasonal high water table | | | Unified | AASHO | |
| | *Feet* | *Feet* | *Inches* | | | | *Percent* |
| Kilkenny: KkB, KkC2, KkD2, KkE. | >5 | >10 | 0–11 | Clay loam | ML or CL | A–7 | |
| | | | 11–45 | Clay loam | MH or CH | A–7 | |
| | | | 45–80 | Clay loam | CL | A–7 | |
| Klinger: KlA | >5 | 2–5 | 0–29 | Silt loam | ML | A–6 or A–7 | |
| | | | 29–47 | Loam | ML or CL | A–6 | |
| | | | 47–60 | Loam | CL | A–6 | |
| Lake beaches: La. Properties too variable to be estimated. | | | | | | | |
| Lerdal: | | | | | | | |
| LbB | >5 | 2–5 | 0–6 | Silt loam | ML or CL | A–7 or A–6 | |
| | | | 6–40 | Clay loam and clay | MH or CH | A–7 | |
| | | | 40–64 | Clay loam | CL or ML | A–7 or A–6 | |
| LeC2, LeD2 | >5 | 2–5 | 0–32 | Clay loam and clay | MH or CH | A–7 | |
| | | | 32–60 | Clay loam | CL or ML | A–7 or A–6 | |
| Lester: LlB, LlC, LlC2, LlD2, LlE. | >5 | >10 | 0–8 | Loam | ML or CL | A–4 or A–6 | |
| | | | 8–40 | Clay loam and loam | CL | A–6 or A–7 | |
| | | | 40–64 | Loam | CL or ML | A–4 or A–6 | |
| Le Sueur: LuA | >5 | 2–5 | 0–14 | Clay loam | ML or CL | A–7 | |
| | | | 14–36 | Clay loam | ML or CL | A–7 | |
| | | | 36–64 | Clay loam | CL | A–6 | |
| Marsh: Ma. Properties too variable to be estimated. | | | | | | | |
| Maxcreek: Mb, Mc | >5 | 0–3 | 0–18 | Silty clay loam | MH | A–7 | |
| | | | 18–36 | Silt loam | CL or ML | A–6 or A–7 | |
| | | | 36–68 | Loam | CL | A–6 | |
| Maxfield: Mf, Mh | >5 | 0–3 | 0–20 | Silty clay loam | MH | A–7 | |
| | | | 20–27 | Silt loam | CL or ML | A–7 or A–6 | |
| | | | 27–64 | Loam | CL | A–6 or A–7 | |
| Mazaska: Mk | >5 | 0–3 | 0–22 | Silty clay loam and clay loam. | CL or CH | A–7 | |
| | | | 22–42 | Clay | MH or CH | A–7 | |
| | | | 42–62 | Clay loam | CL | A–6 or A–7 | |
| Merton: MnA | >5 | 2–5 | 0–15 | Silt loam | ML or CL | A–6 or A–7 | |
| | | | 15–28 | Silt loam | ML or CL | A–6 | |
| | | | 28–46 | Loam | ML or CL | A–6 | |
| | | | 46–60 | Loam | CL | A–6 | |
| Moland: MoB, MoC, MoD2 | >5 | >10 | 0–20 | Silt loam | ML or CL | A–6 or A–7 | |
| | | | 20–49 | Loam | CL or ML | A–6 | |
| | | | 49–64 | Loam | CL | A–6 | |
| Muskego: Mu | >5 | 0–3 | 0–33 | Muck (sapric) | Pt | A–8 | |
| | | | 33–71 | Muck (limnic) | MH | A–7 | |
| Some estimates not shown because properties are too variable. | | | 71–104 | Silt loam and sandy clay loam. | MH or ML | A–7 or A–6 | |
| Nicollet: NcA | >5 | 2–5 | 0–19 | Clay loam | ML or CL | A–7 or A–6 | |
| | | | 19–40 | Clay loam | ML or CL | A–7 or A–6 | |
| | | | 40–60 | Clay loam | ML or CL | A–6 | |
| Ostrander: OsD2, OsE2, OtB, OtC2, OuA. Limestone bedrock at a depth of 5 to 8 feet in OuA. | >5 | >10 | 0–11 | Silt loam | ML or CL | A–4 or A–6 | |
| | | | 11–18 | Silt loam | CL or ML | A–6 | |
| | | | 18–42 | Loam | CL | A–6 | |
| | | | 42–60 | Loam | CL | A–6 or A–4 | |

See footnotes at end of table.

*significant in engineering*—Continued

| Percentage less than 3 inches passing sieve— | | | | Liquid limit | Plasticity index | Permeability | Available water capacity | Reaction | Shrink-swell potential |
|---|---|---|---|---|---|---|---|---|---|
| No. 4 (4.7 mm.) | No. 10 (2.0 mm.) | No.40 (0.42 mm.) | No. 200 (0.074 mm.) | | | *Inches per hour* | *Inches per inch of soil* | *pH value* | |
| 95–100 | 95–100 | 80–95 | 70–85 | 40–50 | 10–20 | 0. 2–0. 6 | 0. 17–0. 19 | 5. 6–6. 5 | Moderate to high. |
| 95–100 | 90–98 | 80–95 | 60–80 | 55–65 | 25–35 | 0. 2–0. 6 | 0. 15–0. 19 | 4. 5–6. 5 | High. |
| 95–100 | 90–98 | 75–90 | 60–75 | 40–50 | 20–30 | 0. 2–0. 6 | 0. 14–0. 16 | 7. 4–7. 8 | Moderate to high. |
| 100 | 100 | 90–100 | 90–100 | 35–50 | 10–15 | 0. 6–2. 0 | 0. 20–0. 24 | 5. 6–6. 5 | Moderate. |
| 100 | 100 | 90–100 | 70–90 | 30–40 | 12–18 | 0. 2–0. 6 | 0. 17–0. 19 | 5. 6–7. 3 | Moderate. |
| 100 | 100 | 85–95 | 60–75 | 25–35 | 12–18 | 0. 2–0. 6 | 0. 17–0. 19 | 7. 4–7. 8 | Moderate. |
| 98–100 | 90–98 | 80–95 | 70–85 | 35–50 | 10–18 | 0. 6–2. 0 | 0. 22–0. 24 | 5. 6–6. 5 | Moderate to high. |
| 95–100 | 90–98 | 80–95 | 60–75 | 55–65 | 25–30 | 0. 06–0. 6 | 0. 13–0. 19 | 4. 5–6. 5 | High. |
| 90–98 | 85–95 | 75–95 | 60–75 | 35–45 | 12–18 | 0. 2–0. 6 | 0. 14–0. 16 | 7. 4–7. 8 | Moderate to high. |
| 95–100 | 90–98 | 80–95 | 60–75 | 55–65 | 25–30 | 0. 06–0. 6 | 0. 13–0. 19 | 4. 5–6. 5 | High. |
| 90–98 | 85–95 | 75–95 | 60–75 | 35–45 | 12–18 | 0. 2–0. 6 | 0. 14–0. 16 | 7. 4–7. 8 | Moderate to high. |
| 95–100 | 90–98 | 80–95 | 55–70 | 30–40 | 8–15 | 0. 6–2. 0 | 0. 20–0. 22 | 5. 6–6. 5 | Moderate. |
| 95–100 | 90–98 | 80–95 | 55–75 | 35–45 | 20–25 | 0. 6–2. 0 | 0. 15–0. 19 | 5. 1–7. 3 | Moderate. |
| 95–100 | 90–98 | 75–90 | 55–70 | 30–40 | 8–15 | 0. 6–2. 0 | 0. 17–0. 19 | 7. 4–7. 8 | Moderate. |
| 98–100 | 95–100 | 90–98 | 70–85 | 40–50 | 15–20 | 0. 6–2. 0 | 0. 17–0. 19 | 5. 6–6. 5 | Moderate. |
| 98–100 | 95–100 | 85–98 | 60–80 | 40–50 | 18–22 | 0. 6–2. 0 | 0. 15–0. 19 | 5. 6–7. 3 | Moderate. |
| 95–100 | 90–100 | 85–95 | 60–75 | 30–40 | 15–20 | 0. 6–2. 0 | 0. 14–0. 16 | 7. 4–7. 8 | Moderate. |
| 100 | 100 | 95–100 | 85–95 | 60–65 | 20–25 | 0. 6–2. 0 | 0. 18–0. 22 | 6. 1–7. 8 | High. |
| 100 | 100 | 90–100 | 70–90 | 35–50 | 18–22 | 0. 6–2. 0 | 0. 20–0. 22 | 6. 6–7. 8 | High. |
| 100 | 100 | 85–95 | 60–75 | 25–35 | 12–18 | 0. 6–2. 0 | 0. 17–0. 19 | 7. 4–7. 8 | Moderate. |
| 100 | 100 | 95–100 | 95–100 | 60–65 | 20–25 | 0. 6–2. 0 | 0. 18–0. 22 | 6. 1–7. 3 | High. |
| 100 | 100 | 95–100 | 95–100 | 35–50 | 18–22 | 0. 6–2. 0 | 0. 20–0. 22 | 6. 1–7. 3 | High. |
| 95–100 | 90–95 | 90–95 | 55–75 | 35–45 | 15–25 | 0. 2–0. 6 | 0. 17–0. 19 | 6. 6–7. 8 | Moderate. |
| 98–100 | 95–100 | 90–98 | 85–95 | 45–55 | 20–30 | 0. 2–0. 6 | 0. 17–0. 20 | 4. 5–6. 5 | Moderate. |
| 95–100 | 85–95 | 80–95 | 65–85 | 60–70 | 25–35 | 0. 06–0. 2 | 0. 10–0. 14 | 4. 5–6. 0 | High. |
| 95–100 | 85–95 | 80–95 | 65–85 | 35–50 | 20–30 | 0. 2–0. 6 | 0. 14–0. 16 | 7. 4–7. 8 | Moderate. |
| 100 | 100 | 90–95 | 80–90 | 35–45 | 10–20 | 0. 6–2. 0 | 0. 22–0. 24 | 5. 6–6. 5 | Moderate. |
| 100 | 100 | 80–95 | 75–90 | 30–40 | 15–20 | 0. 6–2. 0 | 0. 20–0. 22 | 5. 6–6. 5 | Moderate. |
| 90–100 | 85–95 | 60–75 | 50–75 | 30–40 | 10–18 | 0. 6–2. 0 | 0. 17–0. 19 | 5. 6–7. 3 | Moderate. |
| 90–100 | 85–95 | 65–85 | 50–75 | 25–35 | 12–20 | 0. 6–2. 0 | 0. 17–0. 19 | 7. 4–7. 8 | Moderate. |
| 100 | 100 | 85–95 | 65–85 | 35–45 | 10–20 | 0. 6–2. 0 | 0. 22–0. 24 | 5. 6–6. 5 | Moderate. |
| 90–100 | 80–90 | 60–75 | 50–65 | 30–40 | 15–20 | 0. 6–2. 0 | 0. 17–0. 19 | 5. 6–7. 3 | Moderate. |
| 90–100 | 80–90 | 65–80 | 50–70 | 25–35 | 12–20 | 0. 6–2. 0 | 0. 17–0. 19 | 7. 4–7. 8 | Moderate. |
| | | | | | | | 0. 35–0. 48 | 5. 6–7. 3 | High. |
| 100 | 95–100 | 80–90 | 55–75 | | | | 0. 25–0. 30 | 5. 6–7. 8 | High. |
| 100 | 100 | 98–100 | 75–90 | | | 0. 6–2. 0 | 0. 15–0. 19 | 8. 5–9. 0 | High. |
| 98–100 | 95–100 | 85–98 | 65–85 | 35–50 | 15–25 | 0. 6–2. 0 | 0. 17–0. 19 | 5. 6–6. 5 | Moderate. |
| 95–100 | 95–100 | 80–95 | 60–80 | 35–50 | 15–25 | 0. 6–2. 0 | 0. 15–0. 19 | 6. 1–7. 3 | Moderate. |
| 95–100 | 85–95 | 75–90 | 60–75 | 30–40 | 10–20 | 0. 6–2. 0 | 0. 17–0. 19 | 7. 4–7. 8 | Moderate. |
| 95–100 | 95–100 | 90–95 | 70–90 | 35–45 | 10–20 | 0. 6–2. 0 | 0. 22–0. 24 | 5. 6–7. 3 | Moderate. |
| 95–100 | 95–100 | 95–100 | 85–95 | 35–45 | 10–20 | 0. 6–2. 0 | 0. 20–0. 22 | 5. 6–6. 5 | Moderate. |
| 85–95 | 75–95 | 65–85 | 50–60 | 30–40 | 15–25 | 0. 6–2. 0 | 0. 17–0. 19 | 5. 6-7. 3 | Moderate. |
| 85–95 | 75–95 | 65–85 | 50–70 | 25–35 | 8–20 | 0. 6–2. 0 | 0. 17–0. 19 | 7. 4–7. 8 | Moderate. |

TABLE 7.—*Estimated soil properties*

| Soil series and map symbols | Depth to— | | Depth from surface | USDA texture | Classification | | Coarse fraction greater than 3 inches |
|---|---|---|---|---|---|---|---|
| | Bedrock | Seasonal high water table | | | Unified | AASHO | |
| Palms: Pa | >5 | 0–3 | 0–35 | Muck (sapric) | Pt | A–8 | |
| | | | 35–60 | Silty clay loam | MH | A–7 | |
| *Port Byron: PbA, PbB, PbC, PbD, PoC, PoD. For Bold part of PoC and PoD, see Bold series. | >5 | >10 | 0–14 | Silt loam | ML | A–4 | |
| | | | 14–42 | Silt loam | ML | A–4 or A–6 | |
| | | | 42–64 | Silt loam | ML | A–4 | |
| Renova: RnB, RnC, RnD2, RnE | >5 | >10 | 0–10 | Silt loam | ML or CL | A–4 or A–6 | |
| | | | 10–19 | Silty clay loam | ML or CL | A–7 | |
| | | | 19–52 | Loam | CL | A–6 | |
| | | | 52–60 | Loam | CL | A–4 or A–6 | |
| Rolfe: Ro | >5 | 0–3 | 0–12 | Silt loam | ML or CL | A–7 or A–6 | |
| | | | 12–40 | Clay and clay loam | CH or MH | A–7 | |
| | | | 40–76 | Clay loam | ML, MH, CH, or CL | A–7 | |
| Rough broken land: Ru. Properties too variable to be estimated. | | | | | | | |
| Salida: SaC, SaD | >5 | >10 | 0–3 | Gravelly sandy loam. | SM | A–2 or A–1 | |
| | | | 3–100 | Sand and gravel | SP, SW, or GW | A–1 | 15–40 |
| Shields: Sh | >5 | 2–5 | 0–11 | Silt loam and silty clay loam. | ML and CL | A–6 or A–7 | |
| | | | 11–38 | Silty clay | MH or CH | A–7 | |
| | | | 38–64 | Clay loam | ML, MH, CH, or CL | A–7 | |
| Skyberg: Sk | >5 | 2–5 | 0–13 | Silt loam | ML | A–6 or A–4 | |
| | | | 13–26 | Silty clay loam | CL | A–6 or A–7 | |
| | | | 26–48 | Clay loam and loam. | CL | A–6 | |
| | | | 48–100 | Loam | CL | A–6 | |
| Sogn: SoE | 0–1 | >10 | 0–8 | Stony loam | GM | A–4 or A–6 | 20–30 |
| | | | 8 | Bedrock. | | | |
| Storden Mapped only in complexes with Clarion and Estherville soils. | >5 | >10 | 0–8 | Loam | ML or CL | A–6 | |
| | | | 8–62 | Loam | CL or ML | A–4 or A–6 | |
| Terril: TeB, TeC | >5 | 2–5 | 0–85 | Loam | CL or ML | A–7 or A–6 | |
| Vlasaty: VlA | >5 | 2–5 | 0–13 | Silt loam | ML | A–4 or A–6 | |
| | | | 13–23 | Silty clay loam | ML or CL | A–6 or A–7 | |
| | | | 23–60 | Clay loam and loam | CL | A–6 | |
| | | | 60–100 | Loam | CL | A–6 | |
| Waukegan: WaA, WaB | >5 | >10 | 0–15 | Silt loam | ML | A–4 | |
| | | | 15–33 | Silt loam | ML or CL | A–4 or A–6 | |
| | | | 33–60 | Gravelly coarse sand | SP, SW, or SP–SW | A–1 | |
| Webster: We | >5 | 0–3 | 0–20 | Clay loam | ML or CL | A–7 | |
| | | | 20–28 | Clay loam | CL or ML | A–7 | |
| | | | 28–64 | Clay loam and loam | CL or ML | A–7 or A–6 | |
| Zumbro: Zu | >5 | (2) | 0–14 | Sandy loam and loamy sand. | SM | A–2 | |
| | | | 14–54 | Loamy sand and sand. | SM or SP | A–2 or A–3 | |

[1] Nonplastic.
[2] Variable.

*significant in engineering*—Continued

| Percentage less than 3 inches passing sieve— | | | | Liquid limit (0.074 mm.) | Plasticity index | Permeability | Available water capacity | Reaction | Shrink-swell potential |
|---|---|---|---|---|---|---|---|---|---|
| No. 4 | No. 10 (4.7 mm.) | No. 40 (2.0 mm.) | No. 200 (0.42 mm.) | | | | | | |
| 100 | 100 | 100 | 100 | | | | 0. 35–0. 48 | 6. 1–7. 3 | High. |
| 100 | 100 | 98–100 | 75–90 | 55–65 | 15–20 | 0. 6–2. 0 | 0. 15–0. 19 | 6. 6–7. 8 | High. |
| 100 | 100 | 100 | 95–100 | 30–35 | 5–10 | 0. 6–2. 0 | 0. 22–0. 24 | 5. 6–7. 3 | Low. |
| 100 | 100 | 100 | 95–100 | 35–40 | 8–14 | 0. 6–2. 0 | 0. 20–0. 22 | 5. 6–7. 3 | Low. |
| 100 | 100 | 100 | 95–100 | 30–35 | 5–10 | 0. 6–2. 0 | 0. 20–0. 22 | 7. 4–7. 8 | Low. |
| 95–100 | 95–100 | 95–100 | 80–95 | 35–45 | 8–20 | 0. 6–2. 0 | 0. 22–0. 24 | 5. 6–6. 5 | Moderate. |
| 95–100 | 95–100 | 95–100 | 85–95 | 40–50 | 10–20 | 0. 2–2. 0 | 0. 16–0. 19 | 5. 6–6. 0 | Moderate. |
| 85–95 | 75–95 | 65–85 | 50–65 | 30–40 | 15–20 | 0. 6–2. 0 | 0. 17–0. 19 | 5. 1–7. 3 | Moderate. |
| 85–95 | 75–95 | 65–85 | 50–70 | 25–35 | 8–20 | 0. 2–2. 0 | 0. 17–0. 19 | 7. 4–7. 8 | Moderate. |
| 100 | 90–100 | 85–98 | 65–95 | 35–45 | 18–25 | 0. 6–2. 0 | 0. 22–0. 24 | 5. 1–6. 5 | Moderate. |
| 100 | 100 | 90–98 | 85–95 | 60–70 | 25–35 | 0. 06–0. 2 | 0. 10–0. 19 | 4. 5–6. 0 | High. |
| 98–100 | 95–100 | 80–98 | 80–95 | 45–55 | 15–25 | 0. 2–0. 6 | 0. 14–0. 16 | 6. 6–7. 8 | High to moderate. |
| 80–90 | 70–85 | 30–60 | 12–20 | (1) | (1) | >20. 0 | 0. 10–0. 15 | 6. 1–7. 8 | Low. |
| 45–80 | 40–80 | 10–30 | 2–5 | (1) | (1) | >20. 0 | 0. 04–0. 06 | 6. 1–7. 8 | Low. |
| 100 | 98–100 | 85–98 | 65–95 | 35–45 | 18–25 | 0. 2–2. 0 | 0. 18–0. 24 | 5. 6–6. 5 | Moderate. |
| 100 | 100 | 90–98 | 85–95 | 60–70 | 25–35 | 0. 06–0. 2 | 0. 13–0. 16 | 4. 5–6. 0 | High. |
| 98–100 | 95–100 | 80–98 | 80–95 | 45–55 | 15–25 | 0. 2–0. 6 | 0. 14–0. 16 | 7. 4–7. 8 | Moderate to high. |
| 95–100 | 95–100 | 95–100 | 85–95 | 30–40 | 5–20 | 0. 6–2. 0 | 0. 20–0. 24 | 5. 6–7. 3 | Moderate. |
| 95–100 | 95–100 | 95–100 | 85–95 | 35–45 | 20–25 | 0. 6–2. 0 | 0. 16–0. 19 | 4. 5–6. 0 | Moderate. |
| 90–100 | 85–95 | 85–95 | 55–70 | 30–40 | 15–25 | 0. 2–0. 6 | 0. 15–0. 19 | 4. 5–6. 5 | Moderate. |
| 90–100 | 85–95 | 85–95 | 55–70 | 30–40 | 15–25 | 0. 2–0. 6 | 0. 17–0. 19 | 6. 6–7. 8 | Moderate. |
| 50–90 | 50–80 | 50–80 | 50–60 | (1) | (1) | 0. 6–2. 0 | 0. 20–0. 22 | 6. 6–7. 8 | Low. |
| 95–100 | 95–100 | 70–85 | 55–70 | 30–40 | 10–20 | 0. 6–2. 0 | 0. 20–0. 22 | 7. 4–7. 8 | Moderate. |
| 95–100 | 85–95 | 70–85 | 55–70 | 30–40 | 8–20 | 0. 6–2. 0 | 0. 17–0. 19 | 7. 4–7. 8 | Moderate. |
| 98–100 | 95–100 | 85–98 | 60–80 | 35–45 | 15–20 | 0. 6–2. 0 | 0. 20–0. 22 | 6. 1–7. 8 | Moderate. |
| 100 | 100 | 95–100 | 85–95 | 30–40 | 5–15 | 0. 6–2. 0 | 0. 22–0. 24 | 5. 1–7. 3 | Moderate. |
| 100 | 100 | 95–100 | 85–95 | 35–45 | 15–30 | 0. 2–0. 6 | 0. 16–0. 19 | 4. 5–6. 0 | Moderate. |
| 95–99 | 95–99 | 85–95 | 55–70 | 30–40 | 15–25 | 0. 2–2. 0 | 0. 15–0. 19 | 5. 1–7. 3 | Moderate. |
| 95–99 | 95–99 | 85–95 | 55–70 | 30–40 | 15–25 | 0. 6–2. 0 | 0. 17–0. 19 | 6. 6–7. 8 | Moderate. |
| 95–100 | 95–100 | 95–100 | 85–95 | 30–40 | 3–8 | 0. 6–2. 0 | 0. 22–0. 24 | 5. 6–7. 3 | Low. |
| 95–100 | 95–100 | 95–100 | 85–95 | 25–35 | 5–12 | 0. 6–2. 0 | 0. 20–0. 22 | 5. 6–6. 5 | Low. |
| 85–95 | 65–85 | 30–50 | 3–10 | (1) | (1) | 6. 0–20. 0 | 0. 02–0. 04 | 6. 6–7. 8 | Low. |
| 98–100 | 95–100 | 85–98 | 70–85 | 40–50 | 15–25 | 0. 6–2. 0 | 0. 17–0. 19 | 6. 1–7. 8 | Moderate. |
| 98–100 | 95–100 | 85–95 | 65–80 | 40–50 | 15–25 | 0. 6–2. 0 | 0. 15–0. 19 | 6. 6–7. 8 | Moderate. |
| 95–100 | 90–100 | 80–95 | 60–75 | 35–45 | 15–20 | 0. 6–2. 0 | 0. 14–0. 19 | 7. 4–7. 8 | Moderate. |
| 90–100 | 90–100 | 60–90 | 15–30 | (1) | (1) | 6. 0–20. 0 | 0. 10–0. 12 | 5. 6–7. 3 | Low. |
| 80–100 | 70–90 | 50–70 | 5–15 | (1) | (1) | 6. 0–20. 0 | 0. 06–0. 08 | 5. 6–7. 8 | Low. |

TABLE 8.—*Interpretations of 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. The soils in referring to other series that appear

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings without basements | Sanitary landfill [1] (trench type) | Local roads and streets |
| Alluvial land: Ad, Af | Severe: subject to flooding. | Severe: subject to flooding. | Severe: subject to flooding. | Severe: subject to flooding. | Severe: subject to flooding. | Severe: subject to flooding. |
| Biscay: Bc | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. |
| Biscay, seepy variant: Bk. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. |
| Bold (mapped only in complexes with Port Byron soils): | | | | | | |
| Bold part of PoC | Moderate: slope. | Severe: slope. | Moderate: slope. | Moderate: slope. | Slight | Moderate: slope; very erodible. |
| Bold part of PoD | Severe: slope. | Severe: slope. | Severe: slope; very erodible. | Severe: slope. | Moderate: slope. | Severe: slope; very erodible. |
| Boone: | | | | | | |
| BoC | Moderate: [2] slope. | Severe: slope; very rapid permeability. | Severe: sand | Moderate: slope. | Severe: [1] very rapid permeability; sandy. | Moderate: slope. |
| BoD | Severe: [2] slope | Severe: slope; very rapid permeability. | Severe: sand; slope. | Severe: slope | Severe: [1] sandy; very rapid permeability. | Severe: slope |
| BoF | Severe: [2] slope | Severe: slope; very rapid permeability. | Severe: sand; slope. | Severe: slope | Severe: [1] sandy; very rapid permeability; slope. | Severe: slope |

See footnotes at end of table.

*properties of the soils*

such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions for in the first column of this table]

| Suitability as source of— | | | Soil features affecting— | | | | |
|---|---|---|---|---|---|---|---|
| Road fill | Sand | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terraces and diversions |
| Poor to fair: variable; onsite investigation required. | Unsuited: no sand. | Fair to poor: onsite investigation required. | Subject to flooding. | Variable | Outlets difficult to obtain; needs surface drainage; subject to flooding. | Variable; subject to flooding. | Not needed; nearly level. |
| Poor: seasonal high water table. | Good: seasonal high water table. | Poor: seasonal high water table. | Seasonal high water table. | Fair to good stability; seasonal high water table. | Seasonal high water table; hazard of caving during excavation. | Generally not irrigated; seasonal high water table. | Not needed; nearly level. |
| Poor: seasonal high water table. | Good: seasonal high water table. | Poor: seasonal high water table. | Seasonal high water table. | Fair to good stability; seasonal high water table. | Seasonal high water table; hazard of sloughing and caving during excavation. | Generally not irrigated; seasonal high water table. | Not needed; nearly level. |
| Fair: ML material. | Unsuited: no sand. | Poor: less than 8 inches of suitable material. | Piping hazard; moderate permeability. | Poor stability; piping hazard. | Not needed | Moderate: permeability. | Moderate permeability. |
| Fair: ML material; slope. | Unsuited: no sand. | Poor: less than 8 inches of suitable material. | Moderate permeability; piping hazard. | Poor stability; piping hazard. | Not needed | Moderate: permeability. | Moderate permeability. |
| Good | Fair to good | Poor: sandy | Very rapid permeability. | Poor stability and compaction. | Not needed | Very rapid permeability; very low available water capacity. | Difficult to establish vegetation; hazard of erosion caused by wind and water. |
| Fair: slope | Fair to good | Poor: sandy; slope. | Very rapid permeability; slope. | Poor stability | Not needed | Very rapid permeability; very low available water capacity. | Difficult to establish vegetation; hazard of erosion caused by wind and water; slope. |
| Fair to poor: slope. | Fair to good | Poor: sandy; slope. | Very rapid permeability; slope. | Poor stability | Not needed | Very rapid permeability; very low available water capacity. | Difficult to establish vegetation; hazard of erosion caused by wind and water; slope. |

TABLE 8.—*Interpretations of engineering*

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings without basements | Sanitary landfill[1] (trench type) | Local roads and streets |
| Canisteo: Ca, Cd | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. |
| Caron: Ck | Severe: high organic-matter content; high water table. | Severe: high water table. | Severe: high water table. | Severe: high water table. | Severe: high water table. | Severe: high water table; high organic-matter content. |
| *Clarion: | | | | | | |
| ClB | Slight | Moderate: moderate permeability; slope. | Slight | Slight | Slight | Slight |
| ClC, CnC2, CsC | Moderate: slope. | Severe: slope | Moderate: slope. | Moderate: slope. | Slight | Moderate: moderate shrink-swell potential. |
| For Estherville part of CnC2, see unit EsC in the Estherville series; for Storden part of CnC2, see Storden series. | | | | | | |
| CsD, CsE | Severe: slope | Severe: slope | Severe: slope | Severe: slope | Moderate: slope. | Severe: slope |
| For Storden part, see Storden series. | | | | | | |
| Colo: Ct | Severe: seasonal high water table; subject to flooding. | Severe: seasonal high water table; subject to flooding. | Severe: seasonal high water table; subject to flooding. | Severe: seasonal high water table; subject to flooding. | Severe: seasonal high water table; subject to flooding. | Severe: seasonal high water table; subject to flooding. |
| Copaston: CvA | Severe: bedrock at depth of 1 to 2 feet. | Severe: bedrock at depth of 1 to 2 feet. | Severe: bedrock at depth of 1 to 2 feet. | Severe: bedrock at depth of 1 to 2 feet. | Severe: bedrock at depth of 1 to 2 feet. | Severe: bedrock at depth of 1 to 2 feet. |
| Cordova: Cy | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. |
| Dickman: | | | | | | |
| DcA, DcB, DkA, DkB. | Slight[2] | Severe: rapid permeability. | Severe: sand | Slight | Severe: rapid permeability; sand. | Slight |

See footnotes at end of table.

*properties of the soils*—Continued

| Suitability as source of— | | | Soil features affecting— | | | | |
|---|---|---|---|---|---|---|---|
| Road fill | Sand | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terraces and diversions |
| Poor: seasonal high water table. | Unsuited: no sand. | Poor: seasonal high water table. | Seasonal high water table. | Fair to good stability; seasonal high water table. | Seasonal high water table; moderate permeability; tile required for crops. | Generally not irrigated; seasonal high water table. | Not needed; nearly level. |
| Poor: high shrink-swell potential. | Unsuited: no sand. | Poor: high water table. | High water table. | High water table; organic material. | High water table; poor stability; tile required for crops. | Generally not irrigated; high water table. | Not needed; nearly level. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Good | Moderate permeability. | Fair to good stability. | Not needed | Moderate permeability. | Short, uneven slopes. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Good | Moderate permeability. | Fair to good stability. | Not needed | Moderate permeability. | Short, uneven slopes. |
| Fair: moderate shrink-swell potential; slope. | Unsuited: no sand. | Fair: slope | Moderate permeability; slope. | Fair to good stability. | Not needed | Moderate permeability. | Short, uneven slopes in places. |
| Poor: seasonal high water table; subject to flooding; high shrink-swell potential. | Unsuited: no sand. | Poor: seasonal high water table. | Seasonal high water table; subject to flooding. | Seasonal high water table; subject to flooding; fair to poor stability. | Seasonal high water table; outlets difficult to obtain; subject to flooding; moderately slow permeability; tile needed for crops. | Generally not irrigated; seasonal high water table; subject to flooding. | Not needed; nearly level; subject to flooding. |
| Poor: bedrock at depth of 1 to 2 feet. | Unsuited: bedrock at depth of 1 to 2 feet. | Poor: bedrock at depth of 1 to 2 feet. | Bedrock at depth of 1 to 2 feet. | Bedrock at depth of 1 to 2 feet. | Not needed | Bedrock at depth of 1 to 2 feet. | Bedrock at depth of 1 to 2 feet. |
| Severe: seasonal high water table. | Unsuited: no sand. | Poor: seasonal high water table. | Seasonal high water table. | Fair to good stability; seasonal high water table. | Seasonal high water table; moderately slow permeability; tile required for crops. | Generally not irrigated; seasonal high water table. | Not needed; nearly level. |
| Good | Good to poor: poorly graded sand. | Fair: very low available water capacity after removal. | Rapid permeability; piping hazard. | Fair stability; piping hazard. | Not needed | Rapid permeability. | Rapid permeability; short, uneven slopes. |

TABLE 8.—*Interpretations of engineering*

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings without basements | Sanitary landfill [1] (trench type) | Local roads and streets |
| Dickman—Continued | | | | | | |
| DcC | Moderate: slope. | Severe: rapid permeability. | Severe: sand | Moderate: slope. | Severe: rapid permeability; sand. | Moderate: slope. |
| Dodgeville: | | | | | | |
| DoB | Severe: bedrock at depth of 1.5 to 3.5 feet. | Severe: bedrock at depth of 1.5 to 3.5 feet. | Severe: bedrock at depth of 1.5 to 3.5 feet. | Moderate to severe: bedrock at depth of 1.5 to 3.5 feet. | Severe: bedrock at depth of 1.5 to 3.5 feet. | Moderate: bedrock at depth of 1.5 to 3.5 feet. |
| DoC | Severe: bedrock at depth of 1.5 to 3.5 feet. | Severe: bedrock at depth of 1.5 to 3.5 feet. | Severe: bedrock at depth of 1.5 to 3.5 feet. | Moderate to severe: bedrock at depth of 1.5 to 3.5 feet. | Severe: bedrock at depth of 1.5 to 3.5 feet. | Moderate: bedrock at depth of 1.5 to 3.5 feet. |
| DoD, DoE | Severe: bedrock at depth of 1.5 to 3.5 feet; slope. | Severe: bedrock at depth of 1.5 to 3.5 feet; slope. | Severe: bedrock at depth of 1.5 to 3.5 feet; slope. | Severe: bedrock at depth of 1.5 to 3.5 feet; slope. | Severe: bedrock at depth of 1.5 to 3.5 feet; slope. | Severe: bedrock at depth of 1.5 to 3.5 feet; slope. |
| Dundas: Du | Severe: moderately slow permeability; seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate to severe: seasonal high water table at depth of 2 to 5 feet. | Severe: seasonal high water table at depth of 2 to 5 feet. | Severe: seasonal high water table at depth of 2 to 5 feet. |
| Erin: | | | | | | |
| ErB | Severe: moderately slow to slow permeability. | Moderate: slope. | Moderate: clay loam. | Severe: high shrink-swell potential in subsoil. | Moderate: clay loam. | Severe: high shrink-swell potential in subsoil; high frost-action potential. |
| ErC2 | Severe: moderately slow to slow permeability. | Severe: slope | Moderate: clay loam. | Severe: high shrink-swell potential in subsoil. | Moderate: clay loam. | Severe: high shrink-swell potential in subsoil; high frost-action potential. |
| ErD2 | Severe: moderately slow to slow permeability; slope. | Severe: slope | Severe: slope | Severe: slope | Moderate: slope; clay loam. | Moderate: moderate to high shrink-swell potential; slope. |
| ErE | Severe: moderately slow to slow permeability; slope. | Severe: slope | Severe: slope | Severe: slope | Moderate: slope. | Severe: slope |

See footnotes at end of table.

*properties of the soils*—Continued

| Suitability as source of— | | | Soil features affecting— | | | | |
|---|---|---|---|---|---|---|---|
| Road fill | Sand | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terraces and diversions |
| Good | Good to poor: poorly graded sand. | Fair: very low available water capacity after removal. | Rapid permeability; piping hazard. | Fair stability; piping hazard. | Not needed | Rapid permeability. | Rapid permeability; short, uneven slopes. |
| Fair: bedrock at depth of 1.5 to 3.5 feet. | Unsuited: no sand. | Good: bedrock at depth of 1.5 to 3.5 feet. | Bedrock at depth of 1.5 to 3.5 feet. | Poor to fair stability; bedrock at depth of 1.5 to 3.5 feet. | Not needed | Bedrock at depth of 1.5 to 3.5 feet. | Bedrock at depth of 1.5 to 3.5 feet. |
| Fair: bedrock at depth of 1.5 to 3.5 feet. | Unsuited: no sand. | Fair: slope | Bedrock at depth of 1.5 to 3.5 feet. | Poor to fair stability; bedrock at depth of 1.5 to 3.5 feet. | Not needed | Bedrock at depth of 1.5 to 3.5 feet. | Bedrock at depth of 1.5 to 3.5 feet. |
| Fair: bedrock at depth of 1.5 to 3.5 feet; slope. | Unsuited: no sand. | Poor: slope; bedrock at depth of 1.5 to 3.5 feet. | Bedrock at depth of 1.5 to 3.5 feet. | Poor to fair stability; bedrock at depth of 1.5 to 3.5 feet. | Not needed | Bedrock at depth of 1.5 to 3.5 feet. | Bedrock at depth of 1.5 to 3.5 feet. |
| Fair: moderate to high shrink-swell potential. | Unsuited: no sand. | Fair: less than 16 inches of suitable material. | Moderately slow permeability; seasonal high water table at depth of 2 to 5 feet. | Fair to poor stability; seasonal high water table at depth of 2 to 5 feet. | Seasonal high water table at depth of 2 to 5 feet; moderately slow permeability. | Moderately slow permeability; seasonal high water table at depth of 2 to 5 feet. | Not needed; nearly level. |
| Fair: moderate to high shrink-swell potential. | Unsuited: no sand. | Fair: less than 16 inches of suitable material. | Moderately slow to slow permeability. | Fair to poor stability. | Not needed | Moderately slow to slow permeability. | Moderately slow to slow permeability. |
| Fair: moderate to high shrink-swell potential. | Unsuited: no sand. | Fair: less than 16 inches of suitable material. | Moderately slow to slow permeability. | Fair to poor stability. | Not needed | Moderately slow to slow permeability. | Moderately slow to slow permeability. |
| Fair: moderate to high shrink-swell potential. | Unsuited: no sand. | Poor: slope; less than 16 inches of suitable material. | Moderately slow to slow permeability. | Fair to poor stability. | Not needed | Moderately slow to slow permeability. | Moderately slow to slow permeability. |
| Fair: moderate to high shrink-swell potential. | Unsuited: no sand. | Poor: slope | Moderately slow to slow permeability. | Fair to poor stability. | Not needed | Moderately slow to slow permeability; slope. | Moderately slow to slow permeability. |

TABLE 8.—*Interpretations of engineering*

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings without basements | Sanitary landfill [1] (trench type) | Local roads and streets |
| Estherville: EsA, EsB | Slight [2] | Severe: moderately rapid to rapid permeability. | Severe: coarse-textured underlying material. | Slight | Severe: rapid permeability in underlying material. | Slight: slope |
| EsC | Moderate: [2] slope. | Severe: moderately rapid to rapid permeability. | Severe: coarse textured underlying material. | Moderate: slope. | Severe: rapid permeability in underlying material. | Moderate: slope. |
| Etter: EtB | Slight [2] | Severe to moderate: rapid permeability. | Moderate: sandstone at depth of 1.5 to 4.5 feet. | Slight | Severe: rapid permeability in underlying material. | Slight |
| EtC | Moderate: [2] slope. | Severe: moderate to rapid permeability. | Moderate: sandstone at depth of 1.5 to 4.5 feet. | Moderate: slope. | Severe: rapid permeability in underlying material. | Slight |
| Fairhaven: FaA, FaB | Slight [2] | Severe: rapid permeability in underlying material. | Severe: coarse-textured underlying material. | Slight | Severe: rapid permeability in underlying material. | Slight |
| Fairhaven, loamy subsoil variant: FlA, FlB. | Slight | Moderate: moderate permeability. | Slight | Slight | Slight | Slight |
| Faxon: Fx | Severe: high water table; bedrock at depth of 1.5 to 3.5 feet. | Severe: high water table; bedrock at depth of 1.5 to 3.5 feet. | Severe: high water table; bedrock at depth of 1.5 to 3.5 feet. | Severe: high water table. | Severe: high water table; bedrock at depth of 1.5 to 3.5 feet. | Severe: high water table; bedrock at depth of 1.5 to 3.5 feet. |
| Garwin: Ga | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. |
| Glencoe: Gc | Severe: high water table. | Severe: high water table. | Severe: high water table. | Severe: high water table. | Severe: high water table. | Severe: high water table. |

See footnotes at end of table.

*properties of the soils*—Continued

| Suitability as source of— | | | Soil features affecting— | | | | |
|---|---|---|---|---|---|---|---|
| Road fill | Sand | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terraces and diversions |
| Good | Good: sand | Poor: difficult to vegetate; underlain by coarse material. | Moderately rapid to rapid permeability. | Good stability; high compacted permeability. | Not needed | Moderately rapid to rapid permeability. | Short, uneven slopes in places. |
| Good | Good: sand | Poor: difficult to vegetate; underlain by coarse material. | Moderately rapid to rapid permeability. | Good stability; high compacted permeability. | Not needed | Moderately rapid to rapid permeability. | Short, uneven slopes in places. |
| Good | Poor to fair: poorly graded fine sands. | Fair: less than 16 inches of suitable material. | Moderate to rapid permeability. | Fair stability; weakly cemented sandstone below a depth of 20 to 40 inches. | Not needed | Moderate to rapid permeability. | Short slopes. |
| Good | Poor to fair: poorly graded fine sands. | Fair: less than 16 inches of suitable material. | Moderate to rapid permeability. | Fair stability; weakly cemented sandstone below a depth of 20 to 40 inches. | Not needed | Moderate to rapid permeability. | Short slopes. |
| Good | Good | Good | Moderately rapid to rapid permeability. | Fair to poor stability; piping hazard. | Not needed | Moderately rapid to rapid permeability. | Sand and gravel at depth of 20 to 40 inches; short slopes. |
| Good | Good | Good | Moderate permeability. | Fair to poor stability; piping hazard. | Not needed | Moderate: permeability. | Sand and gravel at depth of 20 to 40 inches; short slopes. |
| Poor: high water table; bedrock at depth of 1.5 to 3.5 feet. | Unsuited: no sand. | Poor: high water table; bedrock at depth of 1.5 to 3.5 feet. | Bedrock at depth of 1.5 to 3.5 feet; high water table. | Poor stability; bedrock at depth of 1.5 to 3.5 feet; high water table. | Bedrock at depth of 1.5 to 3.5 feet prevents adequate drainage in places; high water table. | Generally not irrigated; high water table. | Not needed; nearly level. |
| Poor: seasonal high water table. | Unsuited: no sand. | Poor: seasonal high water table. | Seasonal high water table. | Poor to fair stability; seasonal high water table. | Seasonal high water table; tile needed for crops. | Generally not irrigated; seasonal high water table. | Not needed; nearly level. |
| Poor: high water table. | Unsuited: no sand. | Poor: high water table. | High water table. | Poor stability; high water table. | High water table; moderately slow permeability; tile needed for crops. | Generally not irrigated; high water table. | Not needed; nearly level. |

TABLE 8.—*Interpretations of engineering*

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings without basements | Sanitary landfill[1] (trench type) | Local roads and streets |
| Hayden: | | | | | | |
| HaB | Moderate: moderate permeability. | Moderate: slope. | Slight | Moderate: moderate shrink-swell potential. | Slight | Moderate: moderate shrink-swell potential. |
| HaC | Moderate: moderate permeability; slope. | Severe: slope | Moderate: slope. | Moderate: slope. | Slight | Moderate: moderate shrink-swell potential; slope. |
| HaD, HaE | Severe: slope | Severe: slope | Severe: slope | Severe: slope | Moderate: slope. | Severe: slope |
| Judson: JuC | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate permeability; seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate shrink-swell potential; seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet; moderate shrink-swell potential. |
| Kasson: KaA | Severe: moderately slow permeability; seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate shrink-swell potential; seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate shrink-swell potential; seasonal high water table at depth of 2 to 5 feet. |
| Kato: Kc | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. |
| Kilkenny: | | | | | | |
| KkB | Severe: moderately slow permeability. | Moderate: slope. | Moderate: clay loam. | Moderate: moderate to high shrink-swell potential. | Moderate: clay loam. | Moderate: moderate to high shrink-swell potential. |
| KkC2 | Severe: moderately slow permeability. | Severe: slope | Moderate: clay loam; slope. | Moderate: moderate shrink-swell potential. | Moderate: clay loam. | Moderate: moderate shrink-swell potential. |
| KkD2, KkE | Severe: moderately slow permeability; slope. | Severe: slope | Severe: slope | Severe: slope | Moderate: clay loam; slope. | Severe: slope |

See footnotes at end of table.

*properties of the soils*—Continued

| Suitability as source of— | | | Soil features affecting— | | | | |
|---|---|---|---|---|---|---|---|
| Road fill | Sand | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terraces and diversions |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Fair to poor: less than 16 inches of suitable material. | Moderate permeability. | Fair stability. | Not needed. | Moderate permeability. | Short, uneven slopes in places. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Poor: less than 16 inches of suitable material. | Moderate permeability. | Fair stability; slope. | Not needed. | Moderate permeability; slope. | Short, uneven slopes in places. |
| Fair: moderate shrink-swell potential; slope. | Unsuited: no sand. | Poor: less than 16 inches of suitable material. | Moderate permeability. | Fair stability; slope. | Not needed. | Moderate permeability; slope. | Short, uneven slopes in places; steep slope. |
| Fair to good: moderate shrink-swell potential. | Unsuited: no sand. | Good. | Moderate permeability; seasonal high water table at depth of 2 to 5 feet. | Fair to poor stability; seasonal high water table at depth of 2 to 5 feet. | Moderate permeability; seasonal high water table at depth of 2 to 5 feet. | Generally not irrigated; seasonal high water table at depth of 2 to 5 feet. | Not needed; seasonal high water table at depth of 2 to 5 feet. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Fair: less than 16 inches of suitable material. | Moderately slow permeability; seasonal high water table at depth of 2 to 5 feet. | Fair stability; seasonal high water table at depth of 2 to 5 feet. | Moderately slow permeability; seasonal high water table at depth of 2 to 5 feet. | Moderately slow permeability; seasonal high water table at depth of 2 to 5 feet. | Not needed; nearly level. |
| Poor: seasonal high water table. | Good: mixed, medium and coarse sand and fine gravel; seasonal high water table. | Poor: seasonal high water table. | Seasonal high water table. | Poor stability; seasonal high water table. | Seasonal high water table; hazard of sloughing and caving during construction; tile needed for crops. | Generally not irrigated; seasonal high water table. | Not needed; nearly level. |
| Fair: moderate to high shrink-swell potential. | Unsuited: no sand. | Fair: less than 16 inches of suitable material. | Moderately slow permeability. | Fair to poor stability. | Not needed. | Moderately slow permeability. | Moderately slow permeability. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Fair: less than 16 inches of suitable material. | Moderately slow permeability. | Fair to poor stability. | Not needed. | Moderately slow permeability. | Moderately slow permeability. |
| Fair: moderate to high shrink-swell potential; slope. | Unsuited: no sand. | Poor: slope. | Moderately slow permeability; slope. | Fair to poor stability. | Not needed. | Moderately slow permeability. | Moderately slow permeability. |

TABLE 8.—*Interpretations of engineering*

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings without basements | Sanitary landfill [1] (trench type) | Local roads and streets |
| Klinger: KIA | Severe: moderately slow permeability; seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate to severe: seasonal high water table at depth of 2 to 5 feet; high frost-action potential. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate shrink-swell potential; seasonal high water table at depth of 2 to 5 feet. |
| Lake beaches: La. Too variable for interpretations to be made. Onsite investigation needed. | | | | | | |
| Lerdal: | | | | | | |
| LbB | Severe: slow permeability; seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet; slope. | Moderate: clay loam; seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate to high shrink-swell potential; seasonal high water table at depth of 2 to 5 feet. | Moderate: clay loam; seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate to high shrink-swell potential; seasonal high high water table at depth of 2 to 5 feet. |
| LeC2 | Severe: slow permeability; seasonal high water table at depth of 2 to 5 feet. | Severe: slope; seasonal high water table at depth of 2 to 5 feet. | Moderate: clay loam; seasonal high water table at depth of 2 to 5 feet; slope. | Moderate: moderate to high shrink-swell potential; seasonal high water table at depth of 2 to 5 feet. | Moderate: clay loam; seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate to high shrink-swell potential; seasonal high water table at depth of 2 to 5 feet. |
| LeD2 | Severe: slow permeability; seasonal high water table at depth of 2 to 5 feet. | Severe: seasonal high water table at depth of 2 to 5 feet; slope. | Severe: seasonal high water table at depth of 2 to 5 feet; slope. | Severe: moderate to high shrink-swell potential; seasonal high water table at depth of 2 to 5 feet; slope. | Moderate: clay loam; seasonal high water table at depth of 2 to 5 feet; slope. | Severe: seasonal high water table at depth of 2 to 5 feet; slope. |
| Lester: | | | | | | |
| LIB | Slight | Moderate: moderate permeability; slope. | Slight | Slight | Slight | Moderate: moderate shrink-swell potential. |
| LIC, LIC2 | Moderate: moderate permeability. | Severe: moderate permeability; slope. | Moderate: slope. | Moderate: slope. | Slight | Moderate: moderate shrink-swell potential. |
| LID2, LIE | Severe: slope | Severe: slope | Severe: slope | Severe: slope | Moderate: slope. | Severe: slope |

See footnotes at end of table.

*properties of the soils*—Continued

| Suitability as source of— | | | Soil features affecting— | | | | |
|---|---|---|---|---|---|---|---|
| Road fill | Sand | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terraces and diversions |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Good | Moderately slow permeability; seasonal high water table at depth of 2 to 5 feet. | Fair stability; seasonal high water table at depth of 2 to 5 feet. | Moderately slow permeability; seasonal high water table at depth of 2 to 5 feet. | Generally not irrigated; seasonal high water table at depth of 2 to 5 feet. | Not needed; nearly level. |
| Poor: moderate to high shrink-swell potential. | Unsuited: no sand. | Fair: less than 16 inches of suitable material. | Slow permeability; seasonal high water table at depth of 2 to 5 feet. | Poor to fair stability; seasonal high water table at depth of 2 to 5 feet. | Seasonal high water table at depth of 2 to 5 feet. | Slow permeability; seasonal high water table at depth of 2 to 5 feet. | Slow permeability. |
| Poor: moderate to high shrink-swell potential. | Unsuited: no sand. | Fair: less than 16 inches of suitable material. | Slow permeability; seasonal high water table at depth of 2 to 5 feet. | Poor to fair stability; seasonal high water table at depth of 2 to 5 feet. | Seasonal high water table at depth of 2 to 5 feet. | Slow permeability; seasonal high water table at depth of 2 to 5 feet. | Slow permeability. |
| Poor: moderate to high shrink-swell potential. | Unsuited: no sand. | Poor: less than 16 inches of suitable material. | Slow permeability; slope; seasonal high water table at depth of 2 to 5 feet. | Poor to fair stability; seasonal high water table at depth of 2 to 5 feet. | Seasonal high water table at depth of 2 to 5 feet. | Slow permeability; seasonal high water table at depth of 2 to 5 feet. | Slow permeability. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Fair: less than 16 inches of suitable material. | Moderate permeability. | Fair stability | Not needed | Moderate permeability. | Short, uneven slopes in places. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Fair: less than 16 inches of suitable. material. | Moderate permeability. | Fair stability | Not needed | Moderate permeability. | Short, uneven slopes in places. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Poor: slope | Moderate permeability; slope. | Fair stability | Not needed | Moderate permeability. | Short, uneven slopes in places. |

TABLE 8.—*Interpretations of engineering*

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings without basements | Sanitary landfill [1] (trench type) | Local roads and streets |
| Le Sueur: LuA | Moderate: moderate permeability; seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate permeability; seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate shrink-swell potential; seasonal high water table at depth of 2 to 5 feet. |
| Marsh: Ma | Severe: water table at or near surface. | Severe: water table at or near surface. | Severe: water table at or near surface. | Severe: water table at or near surface. | Severe: water table at or near surface. | Severe: water table at or near surface. |
| Maxcreek: Mb, Mc | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. |
| Maxfield: Mf, Mh | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. |
| Mazaska: Mk | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. |
| Merton: MnA | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate permeability; seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate shrink-swell potential; seasonal high water table at depth of 2 to 5 feet. |
| Moland: | | | | | | |
| MoB | Slight | Moderate: moderate permeability; slope. | Slight | Slight | Slight | Moderate: moderate shrink-swell potential. |
| MoC | Moderate: slope. | Severe: slope | Moderate: slope. | Moderate: slope. | Slight | Moderate: moderate shrink-swell potential; slope. |
| MoD2 | Severe: slope | Severe: slope | Severe: slope | Severe: slope | Moderate: slope. | Severe: slope |
| Muskego: Mu | Severe: high water table. | Severe: high water table. | Severe: high water table. | Severe: high water table. | Severe: high water table. | Severe: high water table. |

See footnotes at end of table.

*properties of the soils*—Continued

| Suitability as source of— | | | Soil features affecting— | | | | |
|---|---|---|---|---|---|---|---|
| Road fill | Sand | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terraces and diversions |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Fair: clay loam. | Moderate permeability; seasonal high water table at depth of 2 to 5 feet. | Fair to good stability; seasonal high water table at depth of 2 to 5 feet. | Moderate permeability; seasonal high water table at depth of 2 to 5 feet. | Generally not irrigated; seasonal high water table at depth of 2 to 5 feet. | Not needed; nearly level. |
| Poor: water table at or near surface. | Variable: generally unsorted. | Poor: water table at or near surface. | Water table at or near surface. | Variable | Water table at or near surface; no outlets. | Water table at or near surface. | Not needed. |
| Poor: seasonal high water table. | Unsuited: no sand. | Poor: seasonal high water table. | Seasonal high water table. | Fair stability; seasonal high water table. | Seasonal high water table; moderate permeability; tile needed for crops. | Generally not irrigated; seasonal high water table. | Not needed; nearly level. |
| Poor: seasonal high water table. | Unsuited: no sand. | Poor: seasonal high water table. | Seasonal high water table. | Fair stability; seasonal high water table. | Seasonal high water table; moderately slow permeability; tile needed for crops. | Generally not irrigated; seasonal high water table. | Not needed; nearly level. |
| Poor: seasonal high water table. | Unsuited: no sand. | Poor: seasonal high water table. | Seasonal high water table. | Fair to poor stability; seasonal high water table. | Seasonal high water table; slow permeability; tile needed for crops. | Generally not irrigated; seasonal high water table. | Not needed; nearly level. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Good | Moderate permeability; seasonal high water table at depth of 2 to 5 feet. | Fair stability; seasonal high water table at depth of 2 to 5 feet. | Moderate permeability; seasonal high water table at depth of 2 to 5 feet. | Generally not irrigated; seasonal high water table at depth of 2 to 5 feet. | Not needed; nearly level. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Good | Moderate permeability. | Fair stability | Not needed | Moderate permeability. | Features generally favorable. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Fair: slope | Moderate permeability. | Fair stability | Not needed | Moderate permeability. | Features generally favorable. |
| Fair: moderate shrink-swell potential; slope. | Unsuited: no sand. | Poor: slope | Moderate permeability; slope. | Fair stability | Not needed | Moderate permeability; slope. | Slope. |
| Poor: high organic-matter content; high shrink-swell potential. | Unsuited: no sand. | Poor: high water table. | High water table. | Very poor stability; high water table. | High water table; tile required for crops. | Generally not irrigated; high water table. | Not needed; nearly level. |

Table 8.—*Interpretations of engineering*

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings without basements | Sanitary landfill [1] (trench type) | Local roads and streets |
| Nicollet: NcA | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate permeability; seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. |
| Ostrander: | | | | | | |
| OsD2, OsE2 | Severe: slope | Severe: slope | Severe: slope | Severe: slope | Moderate: slope. | Severe: slope |
| OtC2 | Moderate: slope. | Severe: slope | Moderate: slope. | Moderate: slope. | Slight | Moderate: moderate shrink-swell potential. |
| OtB, OuA | Slight | Moderate: moderate permeability. | Slight | Slight | Slight | Moderate: moderate shrink-swell potential. |
| Palms: Pa | Severe: high water table. | Severe: high water table. | Severe: high water table. | Severe: high water table. | Severe: high water table. | Severe: high water table. |
| *Port Byron: | | | | | | |
| PbA, PbB | Slight | Moderate: slope. | Slight | Moderate: ML materials. | Slight | Moderate: ML materials. |
| PbC, PoC For Bold part of PoC, see Bold series. | Moderate: slope. | Severe: slope | Moderate: slope. | Moderate: ML materials; slope. | Slight | Moderate: ML materials. |
| PbD, PoD For Bold part of PoD, see Bold series. | Severe: slope | Severe: slope | Severe: slope | Severe: slope | Moderate: slope. | Severe: slope |
| Renova: | | | | | | |
| RnB | Moderate: moderate to moderately slow permeability. | Moderate: moderate to moderately slow permeability. | Slight | Slight | Slight | Moderate: moderate shrink-swell potential. |
| RnC | Moderate: moderate to moderately slow permeability. | Severe: slope | Moderate: slope. | Moderate: slope. | Slight | Moderate: moderate shrink-swell potential. |

See footnotes at end of table.

*properties of the soils*—Continued

| Suitability as source of— | | | Soil features affecting— | | | | |
|---|---|---|---|---|---|---|---|
| Road fill | Sand | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terraces and diversions |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Good | Moderate permeability; seasonal high water table at depth of 2 to 5 feet. | Fair to good stability; seasonal high water table at depth of 2 to 5 feet. | Moderate permeability; seasonal high water table at depth of 2 to 5 feet. | Generally not irrigated; seasonal high water table at depth of 2 to 5 feet. | Not needed; nearly level. |
| Fair: moderate shrink-swell potential; slope. | Unsuited: no sand. | Poor: slope. | Moderate permeability; slope. | Fair stability. | Not needed | Moderate permeability; slope. | Slope. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Fair: slope | Moderate permeability. | Fair stability. | Not needed | Moderate permeability. | Features generally favorable. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Good | Moderate permeability. | Fair stability. | Not needed | Moderate permeability. | Features generally favorable. |
| Poor: high shrink-swell potential. | Unsuited: no sand. | Poor: high water table. | High water table. | Very poor stability; high water table. | High water table; tile required for crops. | Generally not irrigated; high water table. | Not needed; nearly level. |
| Fair: moderate shrink-swell potential; ML materials. | Unsuited: no sand. | Fair: slope | Piping hazard; moderate permeability. | Poor stability; piping hazard. | Not needed | Moderate permeability. | Moderate permeability. |
| Fair: moderate shrink-swell potential; ML materials. | Unsuited: no sand. | Good | Piping hazard; moderate permeability. | Poor stability; piping hazard. | Not needed | Moderate permeability. | Moderate permeability. |
| Fair: moderate shrink-swell potential; ML materials; slope. | Unsuited: no sand. | Poor: slope | Moderate permeability; piping hazard; slope. | Poor stability; piping hazard. | Not needed | Moderate permeability; slope. | Moderate permeability; slope. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Poor: less than 8 inches of suitable material. | Moderate to moderately slow permeability. | Fair stability | Not needed | Moderate to moderately slow permeability. | Features generally favorable. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Poor: less than 8 inches of suitable material; slope. | Moderate to moderately slow permeability; slope. | Fair stability | Not needed | Moderate to moderately slow permeability. | Slope. |

TABLE 8.—*Interpretations of engineering*

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings without basements | Sanitary landfill [1] (trench type) | Local roads and streets |
| Renova—Continued RnD2, RnE | Severe: slope | Severe: slope | Severe: slope | Severe: slope | Moderate: slope. | Severe: slope |
| Rolfe: Ro | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. |
| Rough broken land: Ru. | Severe: slope | Severe: slope | Severe: slope | Severe: slope | Severe: slope | Severe: slope |
| Salida: SaC | Moderate: slope.[2] | Severe: very rapid permeability; slope. | Severe: coarse-textured materials. | Moderate: slope. | Severe: very rapid permeability. | Moderate: slope. |
| SaD | Severe: slope [2] | Severe: very rapid permeability; slope. | Severe: coarse-textured materials; slope. | Severe: slope | Severe: very rapid permeability. | Severe: slope |
| Shields: Sh | Severe: slow permeability; seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet; high frost-action potential. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate to severe: seasonal high water table at depth of 2 to 5 feet; moderate to high shrink-swell potential; high frost-action potential. |
| Skyberg: Sk | Severe: moderately slow permeability; seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate to severe: seasonal high water table at depth of 2 to 5 feet; high frost-action potential. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate to severe: seasonal high water table at depth of 2 to 5 feet; moderate shrink-swell potential; high frost-action potential. |
| Sogn: SoE | Severe: bedrock within depth of 1 foot. | Severe: bedrock within depth of 1 foot. | Severe: bedrock within depth of 1 foot. | Severe: bedrock within depth of 1 foot. | Severe: bedrock within depth of 1 foot. | Severe: bedrock within depth of 1 foot. |

See footnotes at end of table.

*properties of the soil*—Continued

| Suitability as source of— | | | Soil features affecting— | | | | |
|---|---|---|---|---|---|---|---|
| Road fill | Sand | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terraces and diversions |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Poor: less than 8 inches of suitable material; slope. | Moderate to moderately slow permeability; slope. | Fair stability. | Not needed. | Moderate to moderately slow permeability. | Slope. |
| Poor: seasonal high water table. | Unsuited: no sand. | Poor: seasonal high water table. | Seasonal high water table. | Poor: seasonal high water table. | Seasonal high water table; slow permeability; tile needed for crops. | Generally not irrigated; seasonal high water table. | Not needed; nearly level. |
| Poor: slope. | Poor: slope. | Poor: slope. | Steep and very steep slopes. | Variable materials. | Not needed. | Not cropped; too steep. | Slope. |
| Good: stony in places. | Good: sand and gravel. | Poor: sandy; less than 8 inches of suitable material. | Very rapid permeability. | Fair stability. | Not needed. | Very low available water capacity. | Not needed; short, uneven slopes. |
| Good: stony in places; slope. | Good: sand and gravel. | Poor: sandy; less than 8 inches of suitable material. | Very rapid permeability. | Fair stability. | Not needed. | Very low available water capacity; slope. | Not needed; short, uneven slopes. |
| Fair: moderate to high shrink-swell potential. | Unsuited: no sand. | Poor: less than 8 inches of suitable material. | Slow permeability; seasonal high water table at depth of 2 to 5 feet. | Fair to poor stability; seasonal high water table at depth of 2 to 5 feet. | Seasonal high water table at depth of 2 to 5 feet; slow permeability. | Generally not irrigated; slow permeability; seasonal high water table at depth of 2 to 5 feet. | Not needed; nearly level. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Fair: less than 16 inches of suitable material. | Moderately slow permeability; seasonal high water table at depth of 2 to 5 feet. | Fair to good stability; seasonal high water table at depth of 2 to 5 feet. | Seasonal high water table at depth of 2 to 5 feet; moderately slow permeability. | Generally not irrigated; moderately slow permeability. | Not needed; nearly level. |
| Poor: bedrock within depth of 1 foot. | Unsuited: no sand. | Poor: bedrock within depth of 1 foot. | Bedrock within depth of 1 foot. | Bedrock within depth of 1 foot. | Not needed. | Bedrock within depth of 1 foot. | Bedrock within depth of 1 foot. |

TABLE 8.—*Interpretations of engineering*

| Soil series and map symbols | Degree and kind of limitation for— | | | | | |
|---|---|---|---|---|---|---|
| | Septic tank absorption fields | Sewage lagoons | Shallow excavations | Dwellings without basements | Sanitary landfill [1] (trench type) | Local roads and streets |
| Storden (mapped only in complexes with Clarion and Estherville soils): Storden part of CnC2, CsC. | Moderate: slope. | Severe: slope | Moderate: slope. | Moderate: slope. | Slight | Moderate: slope; moderate shrink-swell potential. |
| Storden part of CsD, CsE. | Severe: slope | Severe: slope | Severe: slope | Severe: slope | Moderate: slope. | Severe: slope |
| Terrill: TeB | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet; moderate permeability. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate shrink-swell potential; seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate shrink-swell potential; seasonal high water table at depth of 2 to 5 feet. |
| TeC | Moderate: seasonal high water table at depth of 2 to 5 feet. | Severe: slope; seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate shrink-swell potential; seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate shrink-swell potential; seasonal high water table at depth of 2 to 5 feet. |
| Vlasaty: VlA | Severe: moderately slow permeability; seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate shrink-swell potential; seasonal high water table at depth of 2 to 5 feet. | Moderate: seasonal high water table at depth of 2 to 5 feet. | Moderate: moderate shrink-swell potential; seasonal high water table at depth of 2 to 5 feet. |
| Waukegan: WaA, WaB. | Slight [2] | Severe: rapid permeability in underlying material. | Severe: coarse-textured underlying material. | Slight | Severe: rapid permeability in underlying material. | Slight |
| Webster: We | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. | Severe: seasonal high water table. |
| Zumbro: Zu | Severe: subject to flooding. | Severe: subject to flooding. | Severe: subject to flooding. | Severe: subject to flooding. | Severe: subject to flooding. | Severe: subject to flooding. |

[1] Onsite studies of the underlying strata, water tables, and hazards of aquifer pollution and drainage into ground water need to be made for landfills deeper than 5 or 6 feet.

[2] Possible hazard of pollution.

*properties of the soils*—Continued

| Suitability as source of— | | | Soil features affecting— | | | | |
|---|---|---|---|---|---|---|---|
| Road fill | Sand | Topsoil | Pond reservoir areas | Dikes, levees, and other embankments | Drainage for crops and pasture | Irrigation | Terrances and diversions |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Fair: less than 16 inches of suitable material; slope. | Moderate permeability. | Fair to good stability. | Not needed | Moderate permeability. | Short, uneven slopes. |
| Fair: moderate shrink-swell potential; slope. | Unsuited: no sand. | Poor: slope | Moderate permeability; slope. | Fair to good stability. | Not needed | Moderate permeability. | Short, uneven, steep slopes. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Good | Moderate permeability; seasonal high water table at depth of 2 to 5 feet. | Fair stability; seasonal high water table at depth of 2 to 5 feet. | Seasonal high water table at depth of 2 to 5 feet; moderate permeability. | Generally not irrigated; seasonal high water table at depth of 2 to 5 feet. | Not needed; nearly level; seasonal high water table at depth of 2 to 5 feet. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Good | Moderate permeability; seasonal high water table at depth of 2 to 5 feet. | Fair stability; seasonal high water table at depth of 2 to 5 feet. | Seasonal high water table at depth of 2 to 5 feet; moderate permeability. | Generally not irrigated; seasonal high water table at depth of 2 to 5 feet. | Not needed; nearly level; seasonal high water table at depth of 2 to 5 feet. |
| Fair: moderate shrink-swell potential. | Unsuited: no sand. | Fair: less than 16 inches of suitable material. | Moderately slow permeability; seasonal high water table at depth of 2 to 5 feet. | Fair stability; seasonal high water table at depth of 2 to 5 feet. | Seasonal high water table at depth of 2 to 5 feet; moderately slow permeability. | Generally not irrigated; moderately slow permeability; seasonal high water table at depth of 2 to 5 feet. | Not needed; nearly level. |
| Good | Good | Good | Rapid permeability in underlying material. | Fair to poor stability; piping hazard. | Not needed | Moderate to rapid permeability. | Sand and gravel at depth of 24 to 36 inches; short slopes. |
| Poor: seasonal high water table. | Unsuited: no sand. | Poor: seasonal high water table. | Seasonal high water table. | Fair to good stability. | Seasonal high water table; moderate permeability; tile needed for crops. | Generally not irrigated; seasonal high water table. | Not needed; nearly level. |
| Good | Good to poor: poorly graded sand. | Fair: less than 16 inches of suitable material. | Rapid permeability; subject to flooding. | Fair stability; subject to flooding. | Subject to flooding. | Rapid permeability; subject to flooding. | Rapid permeability; subject to flooding. |

This information, however, does not eliminate need for further investigations 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 to soil scientists that is not known to all engineers. The Glossary defines many of these terms commonly used in soil science.

### *Engineering soil classification systems*

The two systems most commonly used in classifying samples of soils for engineering are the Unified system used by the SCS engineers, Department of Defense, and others, and the AASHO system adopted by the American Association of State Highway Officials.

In the Unified system (*13*) soils are classified according to particle size distribution, plasticity, liquid limit, and organic-matter content. Soils are grouped in 15 classes. There are four classes of coarse-grained soils, identified as GW, GP, SW, and SP; four classes of fine-grained soils, identified as ML, CL, MH, and CH; four combinations of coarse- and fine-grained soils, identified as GC, GM, SC, and SM; and three organic soils, identified as OL, OH, and PT. Soils on the borderline between two classes are designated by symbols for both classes; for example, ML–CL.

The AASHO system (*1*) is used to classify soils according to those properties that affect use in highway construction and maintenance. In this system, a soil is placed in 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 of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A–7, are clay soils that have low strength when wet and that 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 AASHO classification for the estimated classification, without group index numbers, is given in table 7 for all soils mapped in the survey area.

### *Soil properties significant in engineering*

Several estimated soil properties significant in engineering are given in table 7. These estimates are made for typical soil profiles, by layers sufficiently different to have different significance 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 countries. Following are explanations of some of the columns in table 7.

Depth to bedrock is distance from the surface of the soil to the upper surface of the rock layer.

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 7 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 contains 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.

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 the semisolid to plastic state; and the liquid limit, from a plastic to a liquid state. 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 7.

Permeability is that quality of a soil that enables it 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 7 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 as it dries out or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in 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.

### *Engineering interpretations of soils*

The estimated interpretations in table 8 are based on the engineering properties of soils shown in table 7, on test data for soils in this survey area and others nearby or adjoining, and on the experience of engineers and soil scientists with the soils of Rice County. In table 8, ratings are used to summarize limitation or suitability of the soils for all listed purposes other than for drainage of cropland and pasture, irrigation, ponds and reservoirs, embankments, and terraces and diversions. For these

particular uses, table 8 lists those soil features not to be overlooked in planning, installation, and maintenance.

Soil limitations are indicated by the ratings slight, moderate, and severe. *Slight* means soil properties generally are favorable for the rated use, or in other words, limitations are minor and easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* means soil properties are so unfavorable and so difficult to correct or overcome as to require major soil reclamation, special designs, or intensive maintenance.

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 the columns in table 8.

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 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 is a soil property that affects difficulty of layout and construction and also the risk of soil erosion, lateral seepage, and downslope flow or 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. The assumption is made that the embankment is compacted to medium density and the pond is protected from flooding. Properties are considered that affect the pond floor and the embankment. Those that affect the pond floor are permeability, organic matter, and slope, and if the floor needs to be leveled, depth to bedrock becomes 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 amounts of stones, if any, that influence 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, open ditches, and cemeteries. Desirable soil properties are good workability, moderate resistance to sloughing, gentle slopes, absence of rock outcrops or big stones, and freedom from flooding or a high water table.

Dwellings, as rated in table 8, are not 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 are those that relate to capacity to support load and resist settlement under load, and those that relate 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 excavation are wetness, slope, depth to bedrock, and content of stones and rocks.

Sanitary landfill is a method of disposing of refuse in dug trenches. 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 8 apply only to a depth of about 6 feet, and therefore limitation ratings of slight or moderate may not be valid if trenches are to be much deeper than that. For some soils, reliable predictions can be made to a depth of 10 or 15 feet, but regardless of that, every site should be investigated before it is selected.

Local roads and streets, as rated in table 8, 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 AASHO and Unified classifications of the soil material, and also the shrink-swell potential, indicate 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 (1) the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage and (2) the relative ease of excavating the material at borrow areas.

Sand is used in great quantities in many kinds of construction. The ratings in table 8 provide guidance about where to look for probable sources. A soil rated as a *good* or *fair* source of sand 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, and 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 for preparing a seedbed; natural fertility of the material, or its response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and its content of stone fragments are characteristics that affect suitability, but also considered in the ratings is damage that will result in the area from which topsoil is taken.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractures or permeable bedrock or other permeable material.

Dikes, levees, and other embankments require soil material resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compactibility. Presence of stones or organic material in a soil are among factors that are unfavorable.

Drainage for crops 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; accumulations 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 need for drainage, or 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; presence of 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.

# *Formation and Classification of the Soils*

This section discusses the factors of soil formation, the processes of soil formation, and the classification of the soils. The classification of soils by higher categories is shown in table 9.

## Factors of Soil Formation

Soil is produced by 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 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, determine 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 development 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 Rice County area is covered mainly by glacial drift of the Bemis and Mankato phases of the late Wisconsin glaciation, but older glacial drift of perhaps Illinois age is in the eastern part of the county in an area called the Iowan Erosion Surface (*14*). These glacial phases occurred more than 13,000 years ago. The drift is mostly glacial till and is composed of material derived through reworking of older glacial deposits and bedrock (flow till).

Moderately fine textured and fine textured glacial till, high in content of shale, covers some parts of the county. This material formed a mantle 3 to 10 feet thick on the medium-textured glacial drift. Kilkenny, Lerdal, Shields, and Mazaska soils formed in this material.

Glacial outwash deposits formed from the meltwater of the glacier. These deposits are mainly in the form of outwash plains and valley trains. Soils on these areas commonly have a sandy and gravelly substratum and a sandy to silty upper layer. Biscay, Estherville, Fairhaven, Kato, Waukegan, and Salida soils are dominant in these areas.

The eastern edge of the Cary drift is covered by a thin mantle of loess. Maxcreek, Moland, and Merton soils formed in this material. The glacial drift is calcareous and loamy. Clarion, Lester, Hayden, and Webster soils formed in this material where it lacks a mantle of loess.

### *Climate*

Rice County has a cool, sub-humid, continental type of climate that has wide variations in temperature from summer to winter. During winter, soil-forming processes are largely dormant. Generally, the soils are frozen to a depth of 2 to 3 feet for 4 or 5 months of the year. The depth to which frost penetrates depends mostly on the quantity of snowfall late in fall or early in winter.

The climate is essentially uniform for the county (*3*, *6*); however, differences in vegetation, soil materials, and relief can cause variations on the microclimate. Soils in the prairie regions are exposed to greater variations in temperature than those in the forest region. Fine-textured soils, such as the Shields and Mazaska, warm up more slowly than moderately coarse textured soils, such as the Estherville and Dickman, because they contain more moisture. Dark-colored soils, such as the Clarion and Nicollet, absorb more heat from the sunlight than the lighter colored Hayden soils. Soils on south- and west-facing slopes receive more sunlight than soils on north- and east-facing slopes; therefore, they tend to be drier and warmer. The interaction of all these factors affects the development of soils. For additional information about the climate of Rice County, see "Climate" in the section "General Nature of the County."

### *Plants and animals*

Two types of vegetation, forest and prairie, have strongly influenced soil formation in Rice County (fig. 13). This county is located along the northern margin of an extensive zone of ecological tension between prairie and forest regions. Throughout the centuries this margin advanced and retreated as shifts in the climate pattern affected temperature, relative humidity, wind velocity, and precipitation patterns. In addition, prairie fires may have been a modifying factor in the formation of soils along the edges of the prairie. The activities of animals,

TABLE 9.—*Classification of soil series by higher categories*

| Series | Family | Subgroup | Order |
|---|---|---|---|
| Biscay | Fine-loamy over sandy or sandy-skeletal, mixed, mesic. | Typic Haplaquolls | Mollisols. |
| Biscay, seepy variant | Fine-loamy over sandy or sandy-skeletal, mixed, mesic, sloping. | Typic Haplaquolls | Mollisols. |
| Bold | Coarse-silty, mixed (calcareous), mesic | Typic Udorthents | Entisols. |
| Boone | Mesic, uncoated | Typic Quarzisamments | Entisols. |
| Canisteo | Fine-loamy, mixed (calcareous), mesic | Typic Haplaquolls | Mollisols. |
| Caron | Coprogenous, euic, mesic | Limnic Medihemists | Histosols. |
| Clarion | Fine-loamy, mixed, mesic | Typic Hapludolls | Mollisols. |
| Colo | Fine-silty, mixed, mesic | Cumulic Haplaquolls | Mollisols. |
| Copaston | Loamy, mixed, mesic | Lithic Hapludolls | Mollisols. |
| Cordova | Fine-loamy, mixed, mesic | Typic Argiaquolls | Mollisols. |
| Dickman | Sandy, mixed, mesic | Typic Hapludolls | Mollisols. |
| Dodgeville [1] | Fine-silty over clayey, mixed, mesic | Typic Argiudolls | Mollisols. |
| Dundas | Fine-loamy, mixed, mesic | Udollic Ochraqualfs | Alfisols. |
| Erin | Fine, montmorillonitic, mesic | Glossoboric Hapludalfs | Alfisols. |
| Estherville | Coarse-loamy over sandy or sandy-skeletal, mixed, mesic. | Typic Hapludolls | Mollisols. |
| Etter | Coarse-loamy, mixed, mesic | Typic Hapludolls | Mollisols. |
| Fairhaven | Fine-loamy over sandy or sandy-skeletal, mixed, mesic. | Typic Hapludolls | Mollisols. |
| Fairhaven, loamy subsoil variant. | Fine-loamy, mixed, mesic | Typic Hapludolls | Mollisols. |
| Faxon | Fine-loamy, mixed, mesic | Typic Haplaquolls | Mollisols. |
| Garwin [1] | Fine-silty, mixed, mesic | Typic Haplaquolls | Mollisols. |
| Glencoe | Fine-loamy, mixed, mesic | Cumulic Haplaquolls | Mollisols. |
| Hayden | Fine-loamy, mixed, mesic | Typic Hapludalfs | Alfisols. |
| Judson | Fine-silty, mixed, mesic | Cumulic Hapludolls | Mollisols. |
| Kasson | Fine-loamy, mixed, mesic | Aquollic Hapludalfs | Alfisols. |
| Kato | Fine-silty over sandy or sandy-skeletal, mixed, mesic | Typic Haplaquolls | Mollisols. |
| Kilkenny | Fine, montmorillonitic, mesic | Mollic Hapludalfs | Alfisols. |
| Klinger [1] | Fine-silty, mixed, mesic | Aquic Argiudolls | Mollisols. |
| Lerdal | Fine, montmorillonitic, mesic | Udollic Ochraqualfs | Alfisols. |
| Lester | Fine-loamy, mixed, mesic | Mollic Hapludalfs | Alfisols. |
| Le Sueur | Fine-loamy, mixed, mesic | Aquic Argiudolls | Mollisols. |
| Maxcreek | Fine-silty, mixed, mesic | Typic Haplaquolls | Mollisols. |
| Maxfield | Fine-silty, mixed, mesic | Typic Haplaquolls | Mollisols. |
| Mazaska | Fine, montmorillonitic, mesic | Typic Argiaquolls | Mollisols. |
| Merton | Fine-loamy, mixed, mesic | Aquic Hapludolls | Mollisols. |
| Moland | Fine-loamy, mixed, mesic | Typic Hapludolls | Mollisols. |
| Muskego | Coprogenous, euic, mesic | Limnic Medisaprists | Histosols. |
| Nicollet | Fine-loamy, mixed, mesic | Aquic Hapludolls | Mollisols. |
| Ostrander [1] | Fine-loamy, mixed, mesic | Typic Hapludolls | Mollisols. |
| Palms | Loamy, mixed, euic, mesic | Terric Medisaprists | Histosols. |
| Port Byron | Fine-silty, mixed, mesic | Typic Hapludolls | Mollisols. |
| Renova | Fine-loamy, mixed, mesic | Typic Hapludalfs | Alfisols. |
| Rolfe | Fine, montmorillonitic, mesic | Typic Argialbolls | Mollisols. |
| Salida | Sandy-skeletal, mixed, mesic | Entic Hapludolls | Mollisols. |
| Shields | Fine, montmorillonitic, mesic | Mollic Ochraqualfs | Alfisols. |
| Skyberg | Fine-loamy, mixed, mesic | Udollic Ochraqualfs | Alfisols. |
| Sogn | Loamy, mixed, mesic | Lithic Haplustolls | Mollisols. |
| Storden | Fine-loamy, mixed (calcareous), mesic | Typic Udorthents | Entisols. |
| Terril | Fine-loamy, mixed, mesic | Cumulic Hapludolls | Mollisols. |
| Vlasaty | Fine-loamy, mixed, mesic | Glossaquic Hapludalfs | Alfisols. |
| Waukegan | Fine-silty over sandy or sandy-skeletal, mixed, mesic | Typic Hapludolls | Mollisols. |
| Webster | Fine-loamy, mixed, mesic | Typic Haplaquolls | Mollisols. |
| Zumbro | Sandy, mixed, mesic | Entic Hapludolls | Mollisols. |

[1] In this county, the following soils are taxadjuncts to the series for which they are named: Dodgeville soils lack the horizon formed in clayey residuum immediately above bedrock that is defined for the series. Garwin soils have a solum that contains less clay than is defined for the series. Klinger soils have a B horizon that contains less translocated clay and in the upper part of which are colors that have a higher chroma than is defined for the series. Ostrander series lack the IIB2 horizon that has a dominant texture of sandy clay loam that is defined for the series.

except for earthworms, probably had little effect on soil formation.

### *Relief*

The relief of Rice County is mainly the product of the melting continental glacier that deposited glacial drift of such thickness that the underlying rock strata have little effect on the configuration of the relief. The relief of the county ranges from nearly level on the lake plains and ground moraines to rolling in the complex pattern of end moraines. Large lakes were formed and numerous small depressions were left in the scattered depressional areas. The main drainage channels developed during the retreat of the glacier and occur as broad valleys within the landscape. Secondary drainage was very immature and needed extensive artificial development.

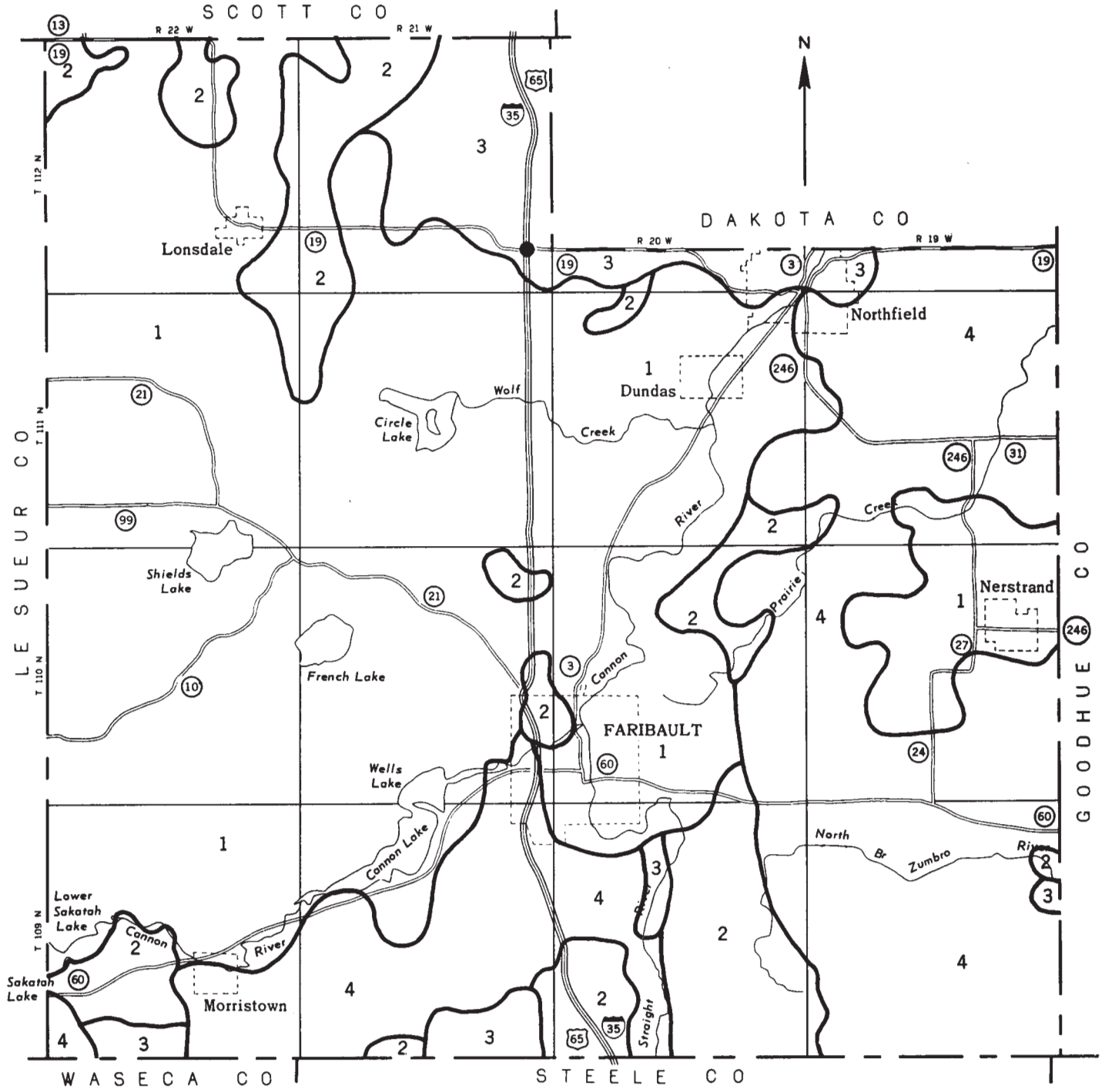


*Figure 13.*—**Original vegetation in Rice County. The vegetation was (1) forests that consisted of oak, elm, basswood, ash, maple, aspen, birch, hickory, butternut, and black walnut; (2) small dense stands of aspen and scattered oak trees; (3) oak groves and openings covered with grass; and (4) prairie that was dominantly tall grasses.**

The morainic topography is of two distinct types. One is a complex of short, uneven slopes that have many, small, indistinct drainage patterns. The other type of topography is a series of flat-topped, smooth-sided drumlins.

### *Time*

Geologically, soils of the county are young. They were first exposed to soil-forming processes 13,000 years ago or more. However, presuming most of the material was reworked drift of proceeding glaciers, the weathering of minerals was somewhat advanced at the time of deposition, as evidenced by the dominance of montmorillonite clays (*2*). Soils may have a well-developed profile, a weakly developed profile, or one that is between these two, depending on the intensity of the weathering factors and the resistence of the soil material to weathering.

The Lester and similar soils have been exposed to greater intensities of influence of the five factors of soil formation than have many other soils, and they have moderately distinct layers or horizons. The Webster soils have lower horizons that are less pronounced than those of the Clarion soils because they occupy relief where a fluctuating water table modifies the normal effect of time. Storden soils have a very shallow profile because of a combination of high content of carbonates and steep slopes. Recent alluvial deposits adjacent to the major drainageways have no profile development.

## Processes of Soil Formation

Soils are natural bodies that formed on the land surface. In only a few places are individual bodies of soils set apart from their neighbors by sharp boundaries. Changes in the combined influence of soil-forming factors are generally manifest in a gradual shifting of properties as one soil body grades into another.

Soil genesis (7) can be viewed as consisting of two steps, (a) the accumulation of parent materials and (b) the development of distinctive properties in the profile. The development of soil properties is due to the interaction of processes of additions, removals, transfers, and transformations of organic matter, silicate clays, silica, soluble salts, iron, aluminum oxides, and carbonates. The terms podzolization, calcification, gleization, and laterization stress the dominant processes in the development of soil properties.

In Rice County the five factors of soil formation interact in such a way that four processes are dominant—podzolization, calcification, gleization, and solonization.

Podzolization is the dominant soil-forming process in areas that have high humidity and forest vegetation.

Podzolization is expressed in the formation of the Hayden, Lester, and Le Sueur soils. The partial removal of organic matter and of iron and aluminum oxides, with the resultant concentration of quartz, results in a graying in surface color and a reduction of thickness in the A1 horizon. In the Hayden soils the removal has advanced to where the quartz and other light-colored minerals have become concentrated to develop a clearly expressed A2 horizon. In the Lester soils the A2 horizon is not clearly expressed. The silicate clays and organic matter removed from the surface layer accumulate in the B horizon as films along channels or on the faces of the structural aggregates. This clay-organic accumulation, together with some weathering of silicate minerals in places, develops a distinct increase in the clay content of the subsoil.

The increase in carbonates or pH in the lower part of the B horizon induces a precipitation of the organic materials. This results in prominent organic coatings on the surface of the structural aggregates just above the calcareous till. In Rice County the intensity of the podzolization process is aided by variations in the amount of carbonates in the parent materials. This is expressed in the stronger horizonation and thicker solum of the Kilkenny soils. Except for areas adjacent to drainageways and lakes, long-term variations in the climatic regime have restricted the normal influence of timber on the soils of Rice County.

Calcification is a process normally restricted to regions of the temperate zone where rainfall is 25 inches or less and where the dominant vegetation is grass or brush. In this process carbonates are transferred in the profile but not entirely removed. Because of the low rainfall, not enough water percolates through the profile to remove entirely the calcium carbonate that existed in the parent material.

In the calcification process, calcium and magnesium carbonates accumulate at some point in the profile that approximates the depth to which surface water most frequently percolates. A secondary result of the process is the somewhat granular condition of the soil material. The granulation results from the action of the carbonates on the clay colloids in the soil material. Also, because the colloids are thus influenced, there is little downward movement of colloids in the profile. The calcification process therefore involves accumulation of carbonates in the soil and the absorption of calcium and magnesium ions by clay colloids.

Vegetation contributes in the formation of soils influenced by calcification. Grasses and other plants that require relatively large amounts of bases, particularly calcium, bring these bases to the surface through their roots. When the plants decay, the calcium is restored to the surface soil. In this way the loss through leaching is partly offset. Soils formed through the process of calcification therefore seldom have a strongly acid surface layer.

The large accumulation of decayed grasses on the surface of the soil and in the surface layer to a depth of 8 to 16 inches results in the accumulation of organic matter, nitrogen, phosphorus, and sulphur.

In Rice County the Clarion, Nicollet, Moland, and Merton soils were influenced by the process of calcification. However, they formed under a higher rainfall than is characteristic for lime-accumulation soils. Because of the higher rainfall average, downward percolation of water in soils under good grass cover may be such that there is no zone in which calcium carbonate has accumulated. Yet these soils possess a high degree of base saturation.

Gleization is a process that forms a light olive-gray or gray-colored horizon immediately below the dark-colored surface. In Rice County this occurs in areas where a seasonal high water table occurs at or slightly below the surface. The gleization process is evident in the Webster, Maxcreek, and associated wet soils of Rice County.

Some soils in Rice County developed in relief where fluctuation of the water table caused percolation to be offset by evaporation. This caused free carbonates to be diffused throughout the profile. This condition is a result of solonization. Canisteo clay loam and Canisteo clay loam, depressional, are examples of soils having this condition.

Small, shallow depressions exhibit prominent A2 horizon development and a pronounced textural development in the B horizon. This condition is generally associated with a site location where a low water table allowed the removal of organic matter and silicate clays from the A1 horizon, the concentration of silica in the A2 horizon, and the accumulation of silicate clays and organic matter in the B horizon. Because of limited acreage, these depressions have been included with areas of Glencoe, Rolfe, and Webster soils.

Some soils developed in sites where abundant water encourages luxuriant growth of reeds sedges, and mosses. The organic matter from these plants decays slowly under these very poorly drained conditions. The plant remains

accumulate faster than they decay, and so a body of organic matter known as peat accumulates. If drainage is improved, the peat decays and is oxidized, thus forming muck.

## Classification of the Soils

Classification consists of an orderly grouping of soils according to a system designed to make it easier to remember soil characteristics and interrelationships. Classification is useful in organizing and applying the results of experience and research. Soils are placed in narrow classes for discussion in detailed soil surveys and for application of knowledge within farms and fields. The many thousands of narrow classes are then grouped into progressively fewer and broader classes in successively higher categories so that information can be applied to large geographic areas.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*4*) and revised later (*10*). The system currently used by the National Cooperative Soil Survey was developed in the early sixties (*12*) and was adopted in 1965 (*8*). It is under continual study.

The current system of classification has six categories. Beginning with the most inclusive, these categories are the order, the suborder, the great group, the subgroup, the family, and the series. The criteria for classification are soil properties that are observable or measurable, but the properties are selected so that soils of similar genesis are grouped together. The placement of some soil series in the current system of classification, particularly in families, may change as more precise information becomes available.

Table 9 shows the classification of each soil series of Rice County by family, subgroup, and order, according to the current system. Most of the classes 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, the Entisols and Histosols, occur in many different climates. Each order is named with 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 water logging, or soil differences that resulted from the climate or vegetation. The names of suborders have two syllables. The last syllable indicates the order. An example is Aquoll (Aqu, meaning water or wet, and oll, from Mollisol).

GREAT GROUP.—Soil suborders are separated 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 has 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 and are made by adding a prefix to the name of the suborder. An example is Haplaquoll (Hapl, meaning simple horizons, aqu for wetness of water, and oll, from Mollisols).

SUBGROUP.—Great groups are divided into subgroups, 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 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 separated 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 consistence, and thickness of horizons. 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 to differentiate families. See table 9. An example is the fine-silty, mixed, mesic family of Typic Haplaquolls.

## *General Nature of the County*[5]

Rice County was first settled in 1826 by Alexander Faribault, a French fur trader who established a trading post near Cannon Lake.

The city of Northfield was founded in 1855 by John W. North. In 1856, the townsites of Cannon City and Morristown were plotted. Other early townsites were Wheatland, Warsaw, Walcott, Shieldsville, Dundas, and Millerburg. Rice County was organized in 1855, and Faribault was selected as the county seat.

According to the 1970 census, Rice County had a population of 41,582. Of this total, 14,752 persons lived in rural areas and 6,968 persons lived on farms. An influx of people from the nearby Minneapolis-St. Paul metropolitan area is increasing the rural population.

The county has 14 townships, and the total area of the county is 316,800 acres. There are 1,572 farms in the county, and the total area in farmland is about 265,046 acres. Many of the farms are operated by the owners.

In early times, the farm products were mostly wheat, oats, and some barley, but most farms were diversified. Raising livestock has been an important farm enterprise in the county. Dairy farming is the leading enterprise, raising hogs is next in importance; and recently beef production has increased. In 1970, there were 57,600 cattle and calves in the county, 49,800 hogs and pigs, and 2,000 sheep and lambs.

Cash-grain farming has increased in recent years. The farms in the southern and eastern parts of the county are the largest and are farmed on a full-time basis. In 1970, there were 71,100 acres of corn grown in the county, 39,200 acres of soybeans, 21,000 acres of oats, 1,600 acres of wheat, and 31,700 acres of alfalfa.

[5] ALDIS JOHNSON, district conservationist, Soil Conservation Service, helped prepare this section.

Many people from the Minneapolis-St. Paul metropolitan area are moving into the northern part of the county, where homes are being built on small tracts that are farmed as a part-time operation.

Four railroads serve the cities of Northfield and Faribault and the villages of Webster, Lonsdale, Nerstrand, Dundas, and Morristown. There also is a busline and an airport in the county. Seven interstate truck lines serve the county.

There are approximately 500 miles of county roads, 418 miles of township roads, and 137 miles of state highways in the county. Twenty-five miles of Interstate Highway 35W dissect the county from north to south.

Among the industries in the Faribault area are nursery and seed firms, a woolen mill, a canning factory, a refrigeration equipment firm, an industrial equipment firm, a turkey processing plant, and several large dairies. Northfield has 10 major industries, including a foundry and a factory that manufactures balloons for the nation's space-exploration research program. Numerous fertilizer blending plants are located in the county. These were among the first plants of this type to be built in the state.

The county has a wide variety of agricultural businesses that provide supplies and services to farmers. The many modern retail stores have made Faribault and Northfield the trade centers for an area that takes in much of the surrounding counties.

## Physiography, Relief, and Drainage

The generally level upland relief of Rice County is broken by the valleys of the Cannon River and its tributaries and by the headwater valleys of the Zumbro River. The highest area is the undissected highlands or uplands in southern Richland Township in the southeastern corner of the county, which has an elevation of about 1,200 feet. The lowest area is in Wheatland Township, the northwesternmost township; most of this area drains to the Minnesota River. The elevation in this area is about 1,000 feet, and morainal ridges rise 50 to 100 feet above the surrounding landscape. In the eastern part of the county, the morainal ridges form an interrupted belt of irregular hills extending north and south a short distance east of Faribault. This moraine marks the eastern border of the Late Wisconsin (Mankato) ice sheet. Beyond this border are a few flat-topped mesas of sandstone capped by thin beds of limestone. The western third of the county is covered by another moraine that is much broader and extends westward into Le Sueur County.

The old, gray drift of the eastern part of the county, between Northfield and Nerstrand, is a pebbly loam till covered by a thin mantle of windblown silt or loess in the district between Northfield and Nerstrand. Farther west the old till is covered by a young, gray drift that generally contains more sand and gravel and releases water more readily. The thickness of the drift ranges from 50 feet along the valleys to more than 400 feet in the northwestern part of the county. In the area of the young, gray drift, water occurs in considerable quantities, and the supply in most places is sufficient for domestic and farm purposes. Small industries in the western part of the county obtain an ample water supply from the drift (*9*).

Conspicuous terraces, as much as 2 miles in width, occur along the Cannon River. The terrace gravels include the deposits made by glacial streams flowing from the ice sheet lying to the west, through the Cannon River valley, to the Mississippi River. In the upper courses of the river, the terraces occupy the full width of the valley. In the central and northern parts of the county, the river has cut far below the terraces, and the terraces are from 1 to more than 2 miles in width at Faribault and other places. There are two distinct series of terraces, a lower series, about 45 feet above the river upon which Faribault is situated, and an upper series at a considerably higher elevation. The height of the terraces above the river varies from place to place, becoming greater downstream toward the north. The gravel of the terrace deposits readily absorbs the water and readily releases it to the valleys, and for this reason the supply of water generally is small near the drainageways.

Outwash sands and gravels and lake sediments occur in the valley of the Straight River in Walcott Township, where a temporary glacial lake formed at the margin of the ice sheet.

## Water Supply

Water supplies in Rice County are directly related to the thickness of the mantle of glacial drift and to the kind of rock formations that underlie the soils.

Solid rock formations are exposed along the valley walls of the Cannon and Straight Rivers and along and near Prairie Creek (*9*). In the northeastern part of the county, limestone-capped buttes have exposed rock formations near their crests. The subsurface of the sedimentary rocks indicates that they have been subjected to diastrophic forces of sufficient magnitude to produce some warping and arching of the strata. A structural high centers near northwestern corner of the county, where the top of the Jordan sandstone is nearly 200 feet higher than it is at Faribault. This structure extends westward into Le Sueur County. In the central and eastern parts of the county, the rocks dip gently to the south, and the difference in elevation from Northfield to the southern county line (fig. 14) is about 100 feet.

No Precambrian granites are known to have been entered by drilling in Rice County, but at Faribault Precambrian sedimentary rocks that rest on granites have been penetrated to a depth of more than 550 feet. The red Fond du Lac beds are similar to those found in the deep wells at Rochester and Mankato. The Hinckley Sandstone is typically developed and occurs at a depth of about 900 feet in the central part of the county. However, ample supplies of water should be obtained from the Dresbach Sandstone above it.

The Dresbach Formation is about 250 feet thick. Its upper sandstone member, the Galesville, and its lower member, the Mt. Simon, are both excellent water-producing horizons and afford valuable supplementary supplies to the St. Peter and Jordan Sandstones wherever they are reached by deep wells.

The Franconia greensands, silts, and shales are about 200 feet thick. They are of little importance as a source of water.

The St. Lawrence Formation is calcareous sandstone that has interbedded, buff, calcareous shales. It is not as highly dolomitic in this area as it is in adjoining counties. The formation is about 75 feet thick.

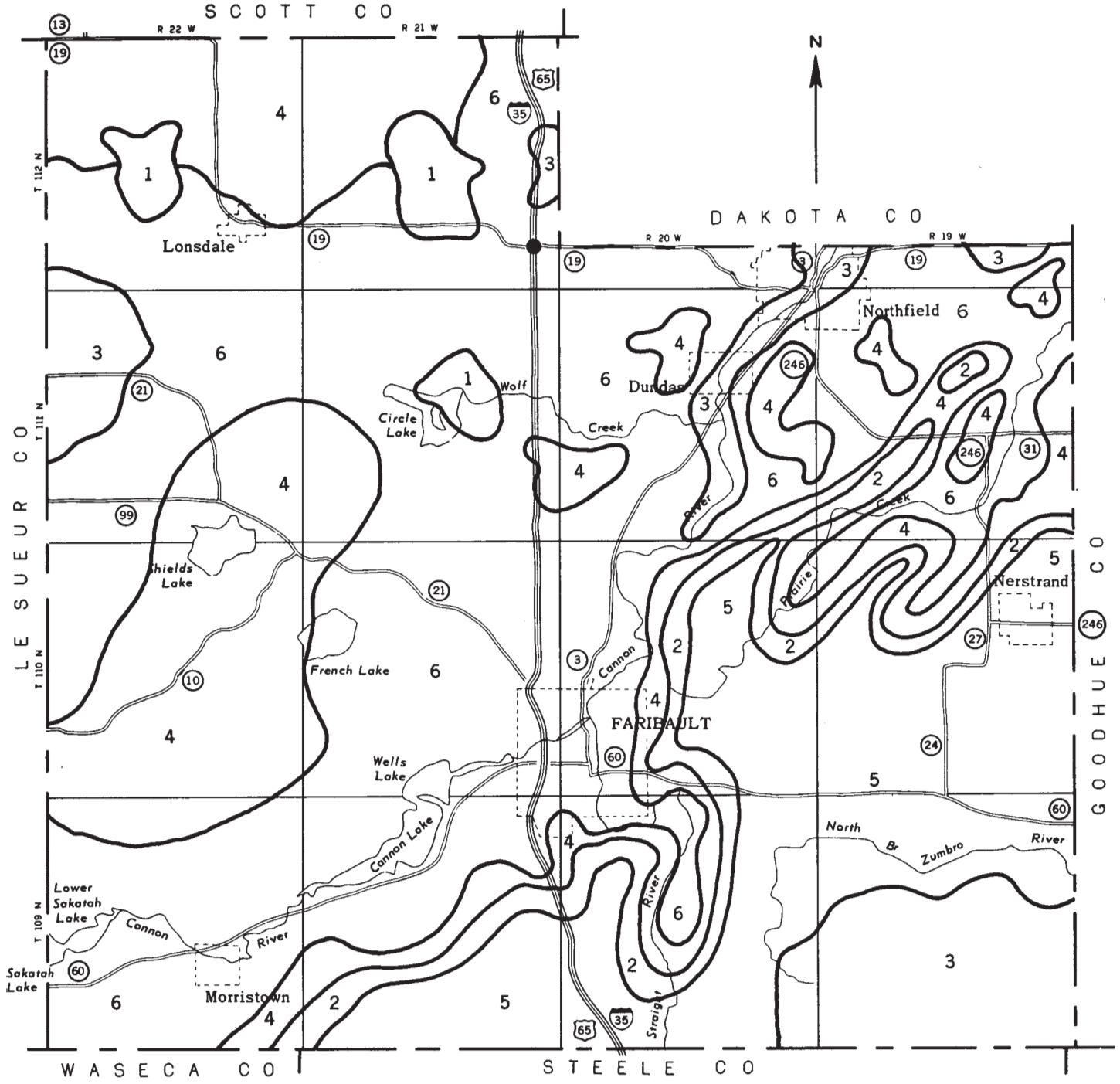


*Figure 14.*—**Underlying rock formations in Rice County are (1) Cretaceous Shale, (2) Decorah Shale, (3) Maquoketa Shale, (4) Platteville Limestone, (5) Galena Limestone, and (6) St. Peter's Sandstone.**

The Jordan Sandstone is open and porous wherever it has been penetrated in this county. The formation is about 90 feet thick. It is saturated with water under sufficient pressure to enter wells freely and to flow to the surface under considerable head in the valleys of the Cannon and Straight Rivers. The Jordan is the most dependable water-producing formation in the county and should be penetrated where large supplies are required.

The Oneota-Shakopee Group, at the base of the Ordovician Formations, has a total thickness of nearly 300 feet. The Oneota Dolomite is about 200 feet thick and is separated from the overlying Shakopee Dolomite by 5 to 10 feet of sandstone. This sandstone stratum is the equivalent of the Root Valley Sandstone that attains a thickness of 35 to 40 feet in the counties to the south and the east. In Rice County this sandstone contains

water under pressure and affords a valuable supplementary supply where the St. Peter Sandstone is not capped or where its supplies have been lessened by heavy pumping.

The Shakopee Dolomite is the oldest formation exposed in the county. About 35 feet are exposed in the Cannon River Valley directly north of Northfield. The formation has a thickness of about 125 feet. From the standpoint of water supplies, its chief value is in serving as a base that tends to confine the water in the overlying St. Peter Sandstone.

The St. Peter Sandstone, which varies in thickness from 160 feet to an eroded remnant of only a few feet, is exposed along the Cannon River from a point above Faribault and less below the uplands both east and west of this stream. To the east, and especially to the southeast, it generally underlies the Platteville Limestone and affords a good supply of water under some pressure.

Northwest of the Cannon River, the Galena, Decorah, and Platteville Formations generally are missing and the St. Peter lies immediately below the drift. In such places the water is not under much pressure and does not enter the wells as freely as where the formation is capped by impervious rocks. In most places, however, a sufficient water supply for domestic and farm uses can be obtained.

The Galena and Platteville Formations are present in this county to an aggregate thickness of about 130 feet. The Galena Limestone lies immediately beneath the drift on the uplands near the southeastern corner of the county, and outcrops of the Platteville Limestone are along the Cannon River. From well-drilling records, the Platteville Formation also appears to lie beneath the drift on uplands throughout an extensive area in the northwestern part of the county. The Galena and Platteville Limestones furnish only a small supply of water.

The recent alluvial deposits are thin and of minor importance as a source of water.

## Climate [6]

The location of Rice County near the center of the great land area of the North American continent is the chief factor that determines its climate. The land, heating under a summer sun that shines for long hours at a high altitude, causes summers to be warm. Southerly winds that bring warm, moist air from the Gulf of Mexico make summer the season of greatest precipitation. Winters are in sharp contrast. Solar heating is less effective because the days are short, the sun is low on the horizon, and the land cools rapidly. Prevailing northerly winds cause additional cooling, and as the air masses are relatively dry, winter is the season of least precipitation. Because the county has no sharply marked differences in topography, the climate is quite uniform. Table 10 gives facts about the temperature and precipitation in the county, based on records kept at Faribault, Minn.

The average temperature for December, January, and February is 17.3° F. One of the coldest winters was that of 1935–36, when the average temperature during the 3-month period was 7.4°. Almost all winters have an average 5 days when the temperature is −20° or lower. The lowest temperature recorded at Faribault was −37° on January 30, 1951.

The average temperature for June, July, and August is 70.2°. The daily maximum during these months ranges from the mid-seventies to the mid-eighties, and daily minimum ranges from mid-fifties to mid-sixties. Temperatures of 100° or higher occur about once in every 6 years and are 90° or greater about 18 times a year. The highest temperature recorded at Faribault was 108° on May 31, 1934, and on July 11 and 12, 1936.

[6] By Earl L. Kuehnast, climatologist for Minnesota, National Weather Service, U.S. Department of Commerce.

TABLE 10.—*Temperature and precipitation*

[All data from Faribault]

| Month | Temperature | | | | Precipitation | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Average daily maximum | Average daily minimum | Average monthly maximum | Average monthly minimum | Average total | One year in 10 will have [1]— | | Days with snow cover of 1 inch or more | Average depth of snow on days with snow cover |
| | | | | | | Less than— | More than— | | |
| | °F. | °F. | °F. | °F. | Inches | Inches | Inches | Number | Inches |
| January | 23.8 | 4.4 | 41.0 | −21.1 | 0.74 | 0.13 | 1.32 | 23 | 9 |
| February | 28.5 | 8.3 | 45.1 | −17.0 | .80 | .09 | 1.72 | 21 | 11 |
| March | 39.2 | 20.0 | 59.8 | 3.7 | 1.86 | .43 | 2.56 | 17 | 7 |
| April | 57.7 | 35.2 | 79.0 | 20.4 | 2.54 | .95 | 3.84 | 2 | 1 |
| May | 70.1 | 46.7 | 87.6 | 29.5 | 3.84 | 1.26 | 5.98 | 0 | ---------- |
| June | 79.3 | 57.0 | 92.7 | 41.5 | 4.73 | 1.63 | 7.12 | 0 | ---------- |
| July | 84.0 | 60.9 | 94.2 | 48.7 | 4.44 | .94 | 6.65 | 0 | ---------- |
| August | 82.3 | 59.2 | 93.3 | 45.1 | 4.19 | 1.46 | 7.16 | 0 | ---------- |
| September | 72.6 | 49.5 | 85.2 | 32.2 | 3.31 | .83 | 6.25 | 0 | ---------- |
| October | 62.6 | 39.7 | 79.6 | 22.3 | 2.04 | .63 | 3.79 | 0 | ---------- |
| November | 42.4 | 25.0 | 63.6 | 3.6 | 1.11 | .19 | 2.52 | 7 | 3 |
| December | 28.4 | 11.5 | 47.7 | −13.3 | .99 | .18 | 1.67 | 17 | 7 |
| Year | 56.0 | 34.8 | [2] 96.2 | [3] −24.0 | 30.59 | 20.96 | 34.37 | 87 | ---------- |

[1] Based on data in period 1896–1970.
[2] Average annual highest temperature.
[3] Average annual lowest temperature.

TABLE 11.—*Probabilities of low temperatures in spring and fall*

[All data from Faribault]

| Probability | Dates for given probability and temperature[1] | | | | |
|---|---|---|---|---|---|
| | 16° F. or lower | 20° F. or lower | 24° F. or lower | 28° F. or lower | 30° F. or lower |
| Spring: | | | | | |
| 1 year in 10 later than | April 7 | April 16 | May 5 | May 14 | May 20 |
| 2 years in 10 later than | April 2 | April 11 | April 28 | May 8 | May 15 |
| 5 years in 10 later than | March 22 | April 1 | April 17 | April 27 | May 6 |
| Fall: | | | | | |
| 1 year in 10 earlier than | October 28 | October 20 | October 8 | September 30 | September 22 |
| 2 years in 10 earlier than | November 3 | October 26 | October 14 | October 6 | September 27 |
| 5 years in 10 earlier than | November 14 | November 6 | October 25 | October 17 | October 5 |

[1] Published in the University of Minnesota Agricultural Experiment Station Technical Bulletin 243, March 1963.

The freeze-free period is long enough so that the staple crops of the county reach maturity without much danger from frost. The probability of certain temperatures occurring in the spring and fall is shown in table 11 (*3*). For example, in 5 years out of 10, or 50 percent of the time, a temperature of 32° or lower can be expected to occur after May 6. The probability of a temperature of 32° before October 5th is 50 percent.

About 75 percent of the annual precipitation, or almost 23.1 inches, falls during the period from April through September. Precipitation of 0.01 inch or more can be expected on about 109 days per year. Six of these days will have 1 inch or more. Rainfall intensities of about 1.5 inches an hour can be expected once in every 2 years. Annual precipitation has ranged from a low of 10.81 inches in 1910 to a high of 39.16 inches in 1965. The highest precipitation at Faribault in any month was 12.02 inches in June 1965.

The first measurable snowfall occurs in October in 1 year out of 10, and the last occurs in April in 2 years out of 10. Annual snowfall averages 38.5 inches, and the extremes range from 4.9 inches in 1967–68 to 68.5 inches in 1951–52.

Drought occurs if the supply of water for crops, either as rainfall or soil moisture, becomes inadequate. Each day of inadequate moisture in the root zone is defined as a day of drought. Severe drought occurred four times in southeastern Minnesota in the period 1931–70. The years of severe drought were 1931, 1934, 1940, and 1959.

An average of about 40 thunderstorms occur each year. Some of these storms are accompanied by hail and damaging winds. Eight tornadoes were reported during the period 1916–71.

Long-term records of humidity, cloudiness, and winds are not available for Rice County, but data from First Order National Weather Service Airport Stations (*5*) at Minneapolis-St. Paul and at Rochester, Minnesota, are representative of the county. The prevailing wind is northwesterly in winter and southeasterly in summer. The average windspeed is 11 miles per hour in winter and 10 miles per hour in summer. Noontime humidity averages 59 percent in summer and 67 percent in winter. On the average, there are 102 clear days, 100 partly cloudy days, and 163 cloudy days in a year.

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# Glossary

**Aggregate, soil.** Many fine particles held in a single mass or cluster. Natural soil aggregates such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

**Alluvium.** Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

**Available water capacity** (also termed 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 capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

**Calcareous soil.** A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

**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.

**Concretions.** Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found 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 and brittle; 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 conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

*Excessively drained* soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

*Somewhat excessively drained* soils are also very permeable and are free from mottling throughout their profile.

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

*Moderately well drained* soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

*Somewhat poorly drained* soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

*Poorly drained* soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

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

**Erosion.** The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

**First bottom.** The normal flood plain of a stream, subject to frequent or occasional flooding.

**Gleization.** The reduction, translocation, and segregation of soil compounds, notably of iron, usually in the lower horizons, as a result of water-logging with poor aeration and drainage; expressed in the soil by mottled colors dominated by gray. The soil-forming processes leading to the development of a gley soil.

**Gravelly soil material.** From 15 to 50 percent of material, by volume, consists of rounded or angular rock fragments that are not prominently flattened and are up to 3 inches in diameter.

**Horizon, soil.** A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

*O horizon.*—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

*A horizon.*—The mineral horizon at the surface or just below an *O* horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

*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 some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

*C horizon.*—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

*R layer.*—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

**Leaching.** The removal of soluble materials from soils or other material by percolating water.

**Mineral soil.** Soil composed mainly of inorganic (mineral) material and low in content of organic material. Its bulk density is greater than that of organic soil.

**Montmorillonite.** A fine, platy, alumino-silicate clay mineral that expands and contracts with the absorption and loss of water. It has a high cation-exchange capacity and is plastic and sticky when moist.

**Mottling, soil.** Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of 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 these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

**Muck.** An organic soil consisting of fairly well decomposed organic material that is relatively high in mineral content, finely divided, and dark in color.

**Munsell notation.** A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a 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.

**Parent material.** Disintegrated and partly weathered rock from which soil has formed.

**Ped.** An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

**Permeability.** The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

**Podzolization.** The process by which a soil is depleted of bases, becomes more acid, and develops a leached surface layer.

**Profile, soil.** A vertical section of the soil through all its horizons and extending 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 precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

| | *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 |
| | | Moderately alkaline | 7.9 to 8.4 |
| Strongly acid | 5.1 to 5.5 | Strongly alkaline | 8.5 to 9.0 |
| Medium acid | 5.6 to 6.0 | Very strongly alkaline | 9.1 and higher |
| Slightly acid | 6.1 to 6.5 | | |

**Relief.** The elevations or inequalities of a land surface, considered collectively.

**Sand.** Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

**Silt.** Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

**Soil.** A natural, three-dimensional body on the earth's surface that supports plants and that 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 parent material, in which the processes of soil formation are active. The solum in mature soil includes 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 characteristic of the soil are largely confined to the solum.

**Structure, soil.** The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. 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 grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

**Subsoil.** Technically, the B horizon; roughly, the part of the solum below plow depth.

**Substratum.** Technically, the part of the soil below the solum.

**Surface soil.** The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

**Terrace.** An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

**Texture, soil.** The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proprotion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, 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."

**Tilth, soil.** The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

**Topsoil.** A presumed fertile soil or soil material, or one that responds to fertilization, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

**Variant, soil.** A soil having properties sufficiently different from those of other known soils to suggest establishing a new soil series, but a soil of such limited known area that creation of a new series is not believed to be justified.

**Water table.** The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

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