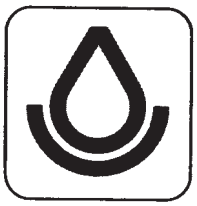
SOIL SURVEY OF

Goodhue County, Minnesota



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

This is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and agencies of the States, usually the Agricultural Experiment Stations. In some surveys, other Federal and local agencies also contribute. The Soil Conservation Service has leadership for the Federal part of the National Cooperative Soil Survey.

Major fieldwork for this soil survey was completed in the period 1940–72. 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 Goodhue County Soil and Water Conservation District.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY contains information that can be applied in managing farms 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 Goodhue 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 woodland group, community development group, and outdoor recreation group to which the soil has been assigned.

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 and woodland groups.

Foresters and others can refer to the section "Woodland, Windbreaks, and Shelterbelts," 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 for recreation areas in the section "Town and Country Planning."

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 Goodhue 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."

Contents

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SOIL SURVEY OF GOODHUE COUNTY, MINNESOTA

BY GEORGE A. POCH

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA AGRICULTURAL EXPERIMENT STATION

GOODHUE COUNTY, in the southeastern part of Minnesota (fig. 1), has a total land area of 485,120 acres. It contains 22 townships or parts of townships. The population was 34,763 in 1970. The city of Red Wing is the county seat. Other important towns and settlements are Kenyon, Bombay, Wanamingo, Pine Island, Zumbrota, Bellechester, Goodhue, Belle Creek, Sogn, Dennison, Stanton, Cannon Falls, Whiterock, Vasa, Welch, Hay Creek, Wacouta, and Frontenac.

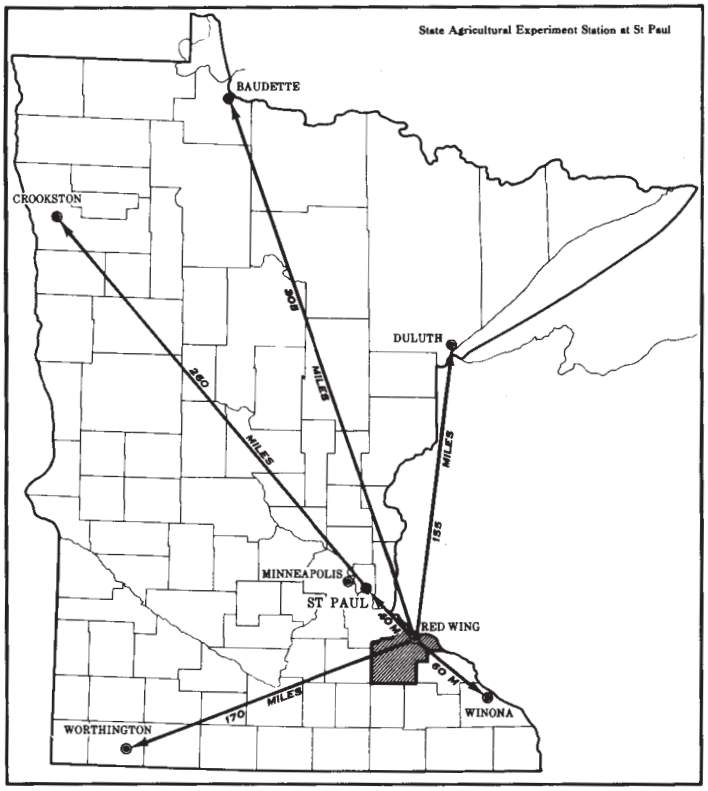

Figure 1.—Location of Goodhue County in Minnesota.

The county is mainly rural. Growing corn, oats, and soybeans and dairying, cattle feeding, and stock raising produce most of the income.

Goodhue County has light-colored to dark-colored, nearly level to very steep soils that formed in loess or glacial material. The original vegetation was tall and medium grasses of the prairie and deciduous hardwood forest.

How This Survey Was Made

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

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

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Seaton and Vasa, 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 characteristics 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, Seaton silt loam, 2 to 6 percent slopes, is one of several phases within the Seaton series.

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

The areas shown on a soil map are called mapping units. On most maps detailed enough to be useful in planning the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some kind that 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. Two such kinds of mapping units are shown on the soil map of Goodhue County: soil complexes and undifferentiated groups.

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. Brodale-Sogn flaggy loams, steep, is an example.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or of two or more. If there are two or more dominant series represented in the group, the name of the group ordinarily consists of the names of the dominant soils, joined by "and." Sogn and Copaston soils, 12 to 25 percent slopes, is an example.

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

While a soil survey is in progress, soil scientists take soil samples needed for laboratory measurements and for engineering tests. Laboratory data from the same kind of soil in other places are also assembled. Data on yields of crops under defined practices are assembled from the 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 sewage fail on a given kind of soil, and they relate this to the slow permeability of the soil or its high water table. They see that streets, road pavements, and foundations for houses are cracked on a named kind of soil, and they relate this failure to the high shrink-swell potential of the soil material. Thus, they use observation and knowledge of soil properties, together with available research data, to predict limitations or suitability of soils for present and potential uses.

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

General Soil Map

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

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

The 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 Maxfield-Klinger association, the words "moderately fine textured" refer to the texture of the surface layer.

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

The 10 soil associations in Goodhue County are described in the following pages.

Soils Formed in Loess and Glacial Till

These are mostly broad upland soils that formed in about 14 to 40 inches of loess and the underlying glacial till. They range from well drained to very poorly drained and are nearly level to sloping. They formed under deciduous hardwood forest or prairie.

Three of the soil associations of Goodhue County are in this group.

1. Maxfield-Klinger association

Nearly level, somewhat poorly drained to very poorly drained, moderately fine textured soils

This association is on an almost smooth ground moraine of glacial till. Weakly developed swalelike or hummocky drainageways finger into most areas. Areas are mostly nearly level, but a few are very gently sloping. Surface runoff is slow.

This association makes up about 2 percent of the county. About 60 percent is Maxfield soils, 25 percent is Klinger soils, and 15 percent is soils of minor extent.

Maxfield soils are on flats and in swales. They are poorly drained and very poorly drained. The surface layer is black silty clay loam about 11 inches thick. The upper 23 inches of the subsoil is olive-gray silty clay loam. The lower part of the subsoil and the underlying material are mottled yellowish-brown, firm loam.

Klinger soils are on crests. They are somewhat poorly drained. The surface layer is very dark brown silty clay loam about 10 inches thick. The upper 15 inches of the subsoil is mottled dark-brown and brown silty clay loam and silt loam. The lower 25 inches of the subsoil and the underlying material are yellowish-brown, firm loam.

Of minor extent are the Kasson, Ostrander, Racine, and Skyberg soils. They are mostly on crests.

Most of this association is used for cultivated crops, especially the parts that are drained. Growing cash crops and feed for livestock, chiefly cows, hogs, and cattle, is the major enterprise. This association is well suited to most cultivated crops grown in the county, especially corn and soybeans. The content of major plant nutrients is low to medium, and the content of organic matter is high. Available water capacity is also high. Improving internal drainage of the poorly drained and very poorly drained soils is the main management need. Wildlife habitat needs to be reestablished if the association is drained.

2. Klinger-Maxfield-Kasson association

Gently sloping and nearly level, moderately well drained to very poorly drained, moderately fine textured and medium textured soils

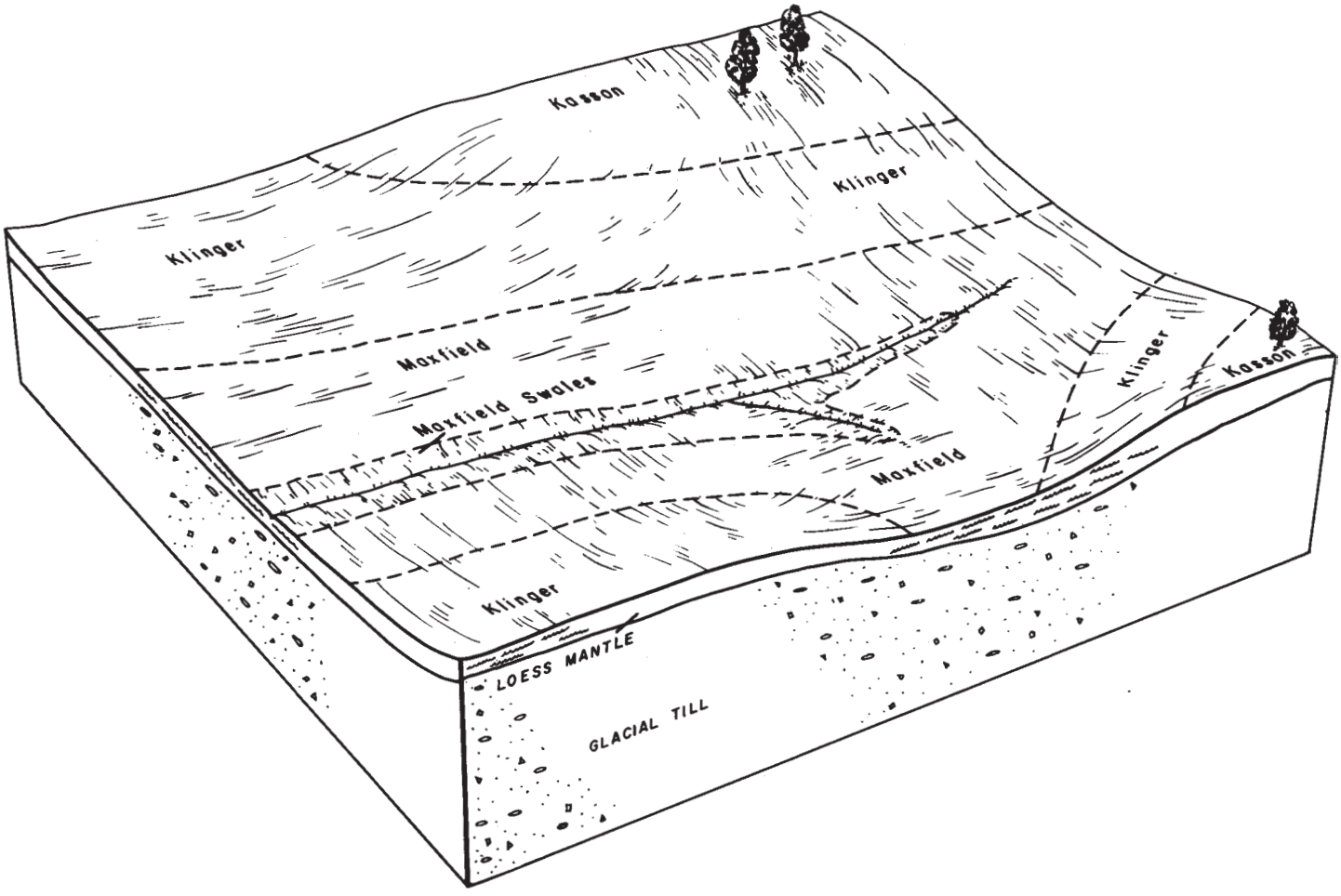

Figure 2.—**Pattern of soils and parent material in Klinger-Maxfield-Kasson association.**

This association is on gently rolling, broad uplands. Well-formed drainageways are in all areas, and the landscape slopes naturally from the crests into the drainageways. Slopes range from 1 to 4 percent and are 200 to 600 feet long. Elevations range from 5 to 15 feet. Most soils are seasonally wet for short periods, and undrained soils in drainageways have a seasonal water table. Springs flow in the lower part of some drainageways.

This association makes up about 7 percent of the county. About 30 percent is Klinger soils, 30 percent is Maxfield soils, 20 percent is Kasson soils, and 20 percent is soils of minor extent (fig. 2).

Klinger soils are on side slopes downslope from natural crests and just above wet drainageways. They are somewhat poorly drained. The surface layer is very dark brown silty clay loam about 10 inches thick. The upper 15 inches of the subsoil is mottled dark-brown and brown silty clay loam and silt loam. The lower 25 inches of the subsoil and the underlying material are firm, grayish-brown and yellowish-brown loam.

Maxfield soils are in natural drainageways and upper reaches of natural drainageways. They are poorly drained and very poorly drained. The surface layer is black silty clay loam about 11 inches thick. The upper 23 inches of the subsoil is olive-gray silty clay loam. The lower part of the subsoil and the underlying material are mottled yellowish-brown loam.

Kasson soils are on crests of uplands. They are moderately well drained. The surface layer is very dark brown silt loam about 9 inches thick. The upper 11 inches of the subsoil is dark-brown and brown, friable silty clay loam; and the lower 22 inches is mottled brown and yellowish-brown, firm heavy loam. The underlying material is mottled yellowish-brown loam.

Of minor extent are the Ostrander, Racine, and Skyberg soils. They are on crests and side slopes on uplands.

This association is well suited to cultivated crops and is used extensively for such crops as corn and soybeans and to some extent for small grain and hay. Dairying and the raising of hogs and beef cattle are the major livestock enterprises. The content of organic matter is mainly medium or high. Available water capacity is high. The hazard of wetness is slight to severe because a seasonal water table is perched at a depth of 1 foot to 3 feet or is in drainageways almost all the time. Improving internal drainage and constructing waterways that reduce surface runoff are the main management needs. Wildlife habitat needs to be reestablished if the association is drained.

3. *Racine-Ostrander-Maxfield association*

Nearly level to sloping, well drained to very poorly drained, medium textured and moderately fine textured soils

This association is on gently rolling and rolling, broad uplands. Well-formed drainageways are in all areas and are well entrenched near stream valleys. Nearly level to gently sloping soils are along the crests of uplands, and gently sloping to sloping soils are along side slopes adjacent to entrenched drainageways. Most slopes are 200 to 600 feet long from the crest to the lower part of the side slope. Most soils in natural drainageways have a seasonal water table (fig. 3).

This association makes up about 5 percent of the county. About 40 percent is Racine soils, 30 percent is Ostrander soils, 10 percent is Maxfield soils, and 20 percent is soils of minor extent.

Racine soils are on crests of broad uplands and on side slopes adjacent to drainageways. They generally are closer to major stream valleys than other major soils in this association. They are well drained. Slopes range from 1 to 35 percent. The surface layer is very dark grayish-brown silt loam about 7 inches thick, and the subsurface layer is dark-brown silt loam about 4 inches thick. The upper 12 inches of the subsoil is brown silt loam; the lower 32 inches formed in glacial till and is yellowish-brown, friable and firm loam. The underlying material is light olive-brown loam.

Ostrander soils are on crests of broad uplands and on side slopes adjacent to drainageways. They are well drained. Slopes range from 1 to 12 percent. The surface layer is very dark brown silt loam about 11 inches thick. The subsoil is dark-brown and yellowish-brown, friable loam about 30 inches thick. The underlying material is brown loam.

Maxfield soils are in drainageways. They are very poorly drained and poorly drained and are nearly level to depressional. The surface layer is black silty clay loam about 11 inches thick. The upper 23 inches of the subsoil is olive-gray silty clay loam. The lower part of the subsoil and the underlying material are mottled yellowish-brown loam.

Of minor extent are the Brodale, Copaston, Klinger, Marlean, Lindstrom, Schapville, Sogn, and Terril soils. They are on upland ridges, valley walls, and foot slopes.

This association is well suited to cultivated crops and is used extensively for such crops as corn and soybeans. To some extent, small grain and hay crops are also grown. Dairying and the raising of hogs and beef cattle are the major livestock enterprises. The hazard of erosion is moderate for most soils in this association. Surface runoff is medium. Maxfield soils generally are wet and need some drainage devices and waterways that reduce surface runoff. Wildlife habitat needs to be reestablished if drainage systems are developed.

Soils Formed in Loess

These are mostly soils that formed in 5 to about 10 feet of loess on broad uplands. Glacial till is under the loess in most areas. These soils are well drained and poorly drained and are nearly level to sloping. They formed under a deciduous hardwood forest or prairie.

Two of the soil associations of Goodhue County are in this grouping.

4. *Seaton association*

Nearly level to sloping, well-drained, medium-textured soils

This association is on gently rolling, very broad uplands. Well-formed, somewhat entrenched drainageways reach into all areas. Elevations vary from 5 to 30 feet. These soils are nearly level and gently sloping

Figure 3.—**Racine-Ostrander-Maxfield association. Dark-colored Maxfield soil is in the drainageway.**

near the summits or high divides and are more sloping along the more entrenched drainageways that lead away from the areas of this association.

This association makes up about 12 percent of the county. About 60 percent is Seaton soils and 40 percent is soils of minor extent.

Seaton soils are on crests and side slopes. In a wooded area, the surface layer is very dark grayish-brown silt loam about 5 inches thick, and the subsurface layer is grayish-brown silt loam about 13 inches thick. The subsoil is yellowish-brown silt loam about 27 inches thick. The underlying material is yellowish-brown, friable silt loam.

Of minor extent are mainly the Vasa, Garwin, and Orion soils. These soils are moderately well drained and poorly drained. They are mainly in drainageways or on uplands adjacent to these drainageways. Other soils of minor extent are the Chaseburg, Colo, Joy, and Mt. Carroll soils.

Most of this association is used for cultivated crops and is well suited to corn. Legumes are also suited, but they require more lime. Field corn, sweet corn, and peas are cash crops, and most farms raise livestock. Available water capacity is very high. Surface runoff is medium. The content of organic matter is low to moderate, and that of lime is mainly low. The hazard of erosion is slight to moderate. Most of the soils of minor extent in drainageways need drainage devices to reduce wetness and contain runoff. Maintaining fertility and reducing erosion and runoff are the main management needs.

5. *Mt. Carroll-Garwin-Port Byron association*

Nearly level to gently sloping, well drained and poorly drained, medium textured and moderately fine textured soils

This association is on gently rolling, very broad uplands. Well-formed drainageways are in all areas. The soils in drainageways are nearly level and in places are depressional. Nearly level to gently sloping soils are on crests and side slopes adjacent to drainageways. Slopes range from 200 to 400 feet in length. Elevations vary from 5 to 20 feet.

This association makes up about 9 percent of the county. About 50 percent is Mt. Carroll soils, 15 percent is Garwin soils, 10 percent is Port Byron soils, and 25 percent is soils of minor extent.

Mt. Carroll soils are on crests and side slopes adjacent to natural drainageways. They are nearly level and gently sloping. The surface layer is very dark brown silt loam about 7 inches thick. The subsoil is dark-brown to yellowish-brown silt loam about 29 inches thick. The underlying material is yellowish-brown coarse silt loam.

Garwin soils are in long, narrow drainageways and on some side slopes adjacent to the upper reaches of drainageways. These soils are mainly nearly level. The surface layer is black silty clay loam about 14 inches thick. The subsoil is dark grayish-brown to grayish-brown silty clay loam and silt loam about 33 inches thick. The underlying material is grayish-brown silt loam.

Port Byron soils are on crests and side slopes adjacent to natural drainageways. The surface layer is very dark brown silt loam about 19 inches thick. The subsoil is dark-brown and brown silt loam about 21 inches thick. The underlying material is mainly yellowish-brown silt loam.

Of minor extent are mainly the Chaseburg, Colo, Joy, Orion, Seaton, and Timula soils. Seaton and Timula soils are on crests and side slopes of uplands, and the other soils are in drainageways.

Most of this association is well suited to crops, mostly field corn and soybeans. Small grain and hay are grown in areas where livestock is raised extensively. These soils are also suited to canning crops, such as sweet corn and peas. Available water capacity is very high. Surface runoff ranges from medium to slow. The content of organic matter is moderate to high. Wetness is a hazard on about 25 percent of this association that needs drainage devices. The hazard of erosion is slight to moderate. Most of this association needs management that contains runoff and reduces erosion.

Soils Formed in Alluvium, Loess, Glacial Till, and Loess and Residuum

These are mostly soils on dissected uplands and in narrow tributary valleys of streams. The soils formed in very recent alluvium, very deep loess, loess and glacial till, and loess and bedrock residuum. They are mostly well drained and are nearly level to very steep. They mainly formed under a deciduous hardwood forest.

Three of the soil associations in Goodhue County are in this group.

6. *Seaton-Racine-Marlean association*

Nearly level to very steep, well-drained, medium-textured soils

This association is on dissected uplands in the vicinity of major stream valleys. Gently sloping to sloping soils are on the upper part of upland ridges; sloping to steep soils are on sides of entrenched drainageways and ravines; and very steep soils are on walls of stream valleys.

This association makes up about 14 percent of the county. About 30 percent is Seaton soil, 30 percent is Racine soils, 10 percent is Marlean soils, and 30 percent is soils of minor extent.

Nearly level to steep Seaton soils are in areas where loess is the dominant soil material. In a wooded area, the surface layer is very dark grayish-brown silt loam about 5 inches thick, and the subsurface layer is grayish-brown silt loam about 13 inches thick. The subsoil is yellowish-brown silt loam about 27 inches thick. The underlying material is yellowish-brown, friable silt loam.

The nearly level to gently sloping Racine soils are on crests, and the sloping to steep Racine soils are on sides of entrenched drainageways. The surface layer is very dark grayish-brown silt loam about 7 inches thick, and the subsurface layer is dark-brown silt loam about 4 inches thick. The upper 2 inches of the subsoil is brown silt loam; the lower 32 inches formed in glacial till and is yellowish-brown, friable and firm loam. The underlying material is light olive-brown loam.

Marlean soils are on walls of stream valleys. Slopes range from 25 to 80 percent. The surface layer is black silt loam about 12 inches thick. It is underlain by dark yellowish-brown and dark-brown flaggy sandy loam, which is 24 to 60 inches thick over bedrock.

Of minor extent are deep soils that formed in glacial till, such as Kasson, Klinger, and Ostrander soils; soils that are shallow or moderately deep to bedrock, such as Copaston, Derinda, Dubuque, Eleva, Schapville, and Shullsburg soils; and Billett, Gotham, and Terril soils. These soils are scattered throughout the association.

Most of this association is used for crops grown to supplement livestock feed. Corn, small grain, and hay are well suited to most areas used for crops. Marlean soils and other very steep soils on valley walls are better suited to timber than to crops. Available water capacity of the soils used for crops is high to very high, and the content of organic matter is moderate or low. Periodic applications of lime generally are needed. The hazard of erosion is moderate to severe. Runoff is medium to very rapid, and a large amount of sediment is deposited in streams. The main management needs in cultivated areas are to control erosion and contain runoff.

7. *Timula-Frontenac association*

Sloping to very steep, well-drained, medium-textured soils

This association is on narrow and broad upland ridges, broken and very steep valley walls, and narrow valley floors. Deep, entrenched, well-formed drainageways or small ravines are in most areas. In the upper part of uplands, drainageways are very wide and almost bulb shaped. They are narrower and entrenched where two or more small watershed areas come together. Gently sloping and sloping soils are in most wide drainageways, and sloping to very steep soils are on sides of entrenched, narrow drainageways. These areas eventually tie into stream valleys. Elevations in the uplands vary from 20 to 60 feet, and along valley walls, they vary from 200 to 350 feet (fig. 4).

This association makes up about 16 percent of the county. About 40 percent is Timula soils, 20 percent is Frontenac soils, and 40 percent is soils of minor extent.

Timula soils are on crests and on sides of drainageways in all areas of the uplands. Areas are circular in shape. Permeability is moderate. The surface layer is very dark grayish-brown silt loam. The subsoil is yellowish-brown silt loam about 20 inches thick. The underlying material is light olive-brown silt loam.

Frontenac soils are very steep and are on walls of stream valleys and side tributaries. The surface layer is very dark brown silt loam about 12 inches thick. The subsoil is dark yellowish-brown silt loam about 18

Figure 4.—**Timula-Frontenac association. Timula soils are on ridgetops; Frontenac soils are in wooded areas.**

inches thick. The underlying material is very pale brown cobbly sandy loam.

Of minor extent are the Billett, Bold, Brodale, Chaseburg, Dubuque, Lamont, Lindstrom, Marlean, Port Byron, Seaton, Sogn, and Whalan soils. Chaseburg soils are in narrow drainageways. The other soils are in a variety of areas near Timula and Frontenac soils.

Most of this association is used for crops grown to supplement livestock feed, but Frontenac and other very steep soils are better suited to timber. Corn, small grain, and hay are well suited to most areas used for crops. Available water capacity of cultivated soils is high to very high. The content of organic matter is moderate. The hazard of erosion is slight to severe. Runoff is dominantly medium, and a fairly large amount of sediment is deposited in major streams. The main management need in cultivated areas is to control erosion and contain runoff.

8. Seaton-Frontenac-Chaseburg association

Nearly level to very steep, well-drained, medium-textured soils

This association is on broad upland ridges, broken and very steep valley walls, and narrow valley floors. Soils on broad uplands are dissected by well-entrenched, long, narrow drainageways. Slopes range from 1 to 30 percent, are single and convex, and extend from the crest of an area to the drainageway. They range from 200 to 700 feet in length. Elevations vary from 10 to 60 feet. Soils on narrower upland ridges adjacent to valley walls do not have the long drainageways. Slopes range from 1 to 30 percent on the narrow upland ridges and from 25 to 80 percent on the valley walls. Elevations vary from 10 to 60 feet in the upland; the ridgetop to the valley floor ranges from 200 to 400 feet. Soils on the valley floor are nearly level to gently sloping on the narrow flood plain and are gently sloping to steep on foot slopes at the base of the valley wall.

This association makes up about 18 percent of the county. About 45 percent is Seaton soils, 19 percent is Frontenac soils, 10 percent is Chaseburg soils, and 26 percent is soils of minor extent.

Seaton soils are on crests and side slopes of uplands and on foot slopes on valley floors. In a wooded area, the surface layer is very dark grayish-brown silt loam about 5 inches thick, and the subsurface layer is grayish-brown silt loam about 13 inches thick. The subsoil is yellowish-brown silt loam about 27 inches thick. The

underlying material is friable, yellowish-brown silt loam.

Steep and very steep Frontenac soils are on walls of stream valleys and side tributaries. The surface layer is very dark brown silt loam about 12 inches thick. The subsoil is dark yellowish-brown silt loam about 18 inches thick. The underlying material is very pale brown cobbly loam.

Chaseburg soils are in long, entrenched, narrow drainageways or on small flood plains of most upland areas. The surface layer is very dark grayish-brown silt loam about 11 inches thick. The underlying material is stratified very dark grayish-brown and dark grayish-brown silt loam.

Some of the soils of minor extent are the Brodale, Dubuque, Marlean, Mt. Carroll, Radford, and Sogn soils. They are on upland ridges and valley walls.

Most of this association is used for cultivated crops grown to supplement livestock feed, but Frontenac and other very steep soils on valley walls are better suited to timber and this is their main use. Corn, small grain, and hay are well suited to most areas of this association used for crops. Available water capacity of soils used for crops is high to very high. The content of organic matter is moderate or low. Periodic applications of lime generally are needed. The hazard of erosion is moderate to severe. Runoff is medium to very rapid, and a large amount of sediment is deposited in major streams. The main management needs in cultivated areas are to control erosion and contain runoff.

Soils Formed in Outwash or Recent Alluvium

These soils mostly occupy benches and flood plains of streams. The recent alluvium is on the flood plains, while outwash materials are on the benches. These soils range from somewhat excessively drained to very poorly drained and are nearly level to sloping.

Two of the soil associations of Goodhue County are in this grouping.

9. Estherville-Waukegan-Alluvial land association

Nearly level to sloping, somewhat excessively drained, well-drained, and poorly drained, medium-textured and coarse-textured soils

This association is on benches and flood plains of major rivers. The benches range from 20 to 50 feet above the natural level of the streams, and the flood plains range from 2 to 15 feet. Most soils on stream benches are nearly level and smooth. They slope very gently with the gradient of the stream. Soils range from sloping to very steep where they are part of foot slopes and escarpments. Flood plains are both smooth or plain and braided in appearance and are very gently undulating.

This association makes up about 11 percent of the county. About 50 percent is Estherville and other somewhat similar sandy or shallow gravelly soils, such as Gotham, Plainfield, Burkhardt, and Salida; about 27 percent is Waukegan and other similar or associated soils, such as Fairhaven, Kegonsa, and Dickinson; about 18 percent is Alluvial land and soils on flood plains; and 5 percent is soils of minor extent on small buttes of upland ridges. The three major soils make up about 25 percent of the association; the rest is similar soils with which they are associated.

Nearly level to sloping Estherville soils are on stream benches. They are somewhat excessively drained. The surface layer is about 14 inches thick and is very dark brown loam in the upper part and very dark grayish-brown sandy loam in the lower part. The upper part of the subsoil is dark-brown sandy loam, and the lower part is gravelly coarse sand. The underlying material is grayish-brown gravelly coarse sand.

Waukegan soils are on broad stream benches some distance from the stream. The surface layer is very dark brown silt loam about 13 inches thick. The subsoil is yellowish-brown silt loam about 20 inches thick. The underlying material is gravelly coarse sand.

Alluvial land is on very low flood plains of streams. It is stratified sediment consisting of sand, loam, sandy loam, and silt loam. The nature and thickness of the sediment vary.

Waukegan soils are well suited to corn and soybeans. Available water capacity is moderate. The main management need is to supply sufficient available water. Because available water capacity is low, Estherville soils are poorly suited to crops. Where available water is sufficient, small grains and hay crops are suited to some extent. Most of the Estherville soils have been converted to permanent woodland or pasture, but some areas are used as a source of sand and gravel. Alluvial land is used as pasture or woodland or is left idle. It is better suited to pasture than to other crops because flooding is frequent.

10. Marsh-McPaul-Radford association

Depressional, very poorly drained marshes; and nearly level, moderately well drained and somewhat poorly drained, medium-textured soils

This soil association is on flood plains along major rivers. The flood plains are either at the natural water level of the river or are within 5 feet. The very poorly drained marshes are generally more distant from the main channel, and the moderately well drained soils are adjacent to the main channel.

This association makes up about 6 percent of the county. About 25 percent is Marsh, 20 percent is McPaul soils, 20 percent is Radford soils, and 35 percent is soils of minor extent.

Marsh areas are small, shallow, isolated, and landlocked ponds surrounded by poorly drained soils on flood plains.

McPaul soils are on flood plains along the stream channel. The surface layer is very dark grayish-brown silt loam about 12 inches thick. The underlying layer is stratified, very dark grayish-brown and grayish-brown silt loam about 18 inches thick. Below this is black and very dark gray loam and silt loam about 30 inches thick.

Radford soils are on first bottoms of flood plains that are some distance from the stream channel, and most areas are on the narrower stream bottoms. The surface layer is very dark grayish-brown silt loam about 9 inches thick. The underlying material is very dark grayish-brown silt loam that has thin strata of grayish brown and is about 17 inches thick. Below this is black silt loam and silty clay loam about 34 inches thick.

Of minor extent are the Colo, Ankeny, Lawson, Houghton, Orion, and Zumbro soils.

Most of Marsh and adjoining areas are left idle or are used for pasture or hay. Most of the McPaul soils are pastured or are idle, but some areas are cropped. Radford soils are used for crops and are well suited to corn and soybeans.

Descriptions of the Soils

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

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second is much more detailed and is for those who need to make thorough and precise studies of soils. Color terms are for moist soil unless otherwise stated. Coarse fragments are reported as a percentage of the total volume of the soil material. 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.

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

The names, descriptions, and delineations of soils in this published soil survey do not always agree or join fully with soil maps of adjoining counties published at an earlier date. Differences are brought about by better knowledge about soils or modification and refinements in soil series concepts. In addition, in some mapping units, it is feasible to include with the regular correlated soil small areas of similar soils, where management and response is much the same, rather than to map them separately. 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.

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, community development group, and outdoor recreation group in which the mapping unit has been placed. The page for the description of some of these can be found by referring to the "Guide to Mapping Units" at the back of this survey.

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary at the end of this survey, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*5*).[1]

Alluvial Land

Alluvial land consists of alluvium deposited in old channel bottoms or along banks of rivers and streams. This alluvial material lacks uniformity of color, texture, and soil reaction. It shows little or no soil formation.

Alluvial land, frequently flooded (0 to 2 percent slopes) (Af).—This land type consists of moderately well drained to poorly drained stratified sand, loamy sand, silt, sandy loam, silt loam, and loam. These sediments, which vary in texture and in thickness, are deposited during brief, hour-long floods or during floods that last as long as 1 or 2 days. This type is on narrow first bottoms along stream channels. Areas range from 200 to 1,200 feet in width and from 5 to 100 acres in size. A water table is at a depth of 1 to 4 feet. Reaction is neutral to mildly alkaline.

Included with this land in mapping are areas of sandy riverwash. These are soil materials that have been deposited by swift-moving flood waters in very thick beds adjacent to stream channels, mainly along the Mississippi River.

Alluvial land, frequently flooded, is mainly used for pasture or is idle. It is not suited to crops because flooding generally is too frequent. Idle areas tend to revegetate heavily with willow, cottonwood, and silver maple. Capability unit VIw-2; woodland group 7; community development group 1; outdoor recreation group 1.

Alluvial land, sloping (2 to 12 percent slopes) (An).—This land type is well drained, and most areas contain large quantities of gravel and cobblestones. In some places stratified silt loam and loam or sandy loam 1 to 3 feet thick overlie the gravel and cobblestones. In other places, especially in the fan-shaped areas, the soil is mostly sandy. It is in intermittent drainageways in side valleys of tributary streams. The drainageways are along the outer edges of foot slopes of valley walls, and they fan out adjacent to the flood plain. Areas range from 50 to 300 feet in width and are frequently flooded by fast-moving waters. Periods of flooding can be brief or continue for hours. Watershed areas above this land type generally range from 160 to 2,000 acres in size. Included in mapping are some areas that are nearly level and some areas of Chaseburg soils.

The main limitation is the severe hazard of flooding. Most areas are idle, but some are used as pasture or woodland. Capability unit VIw-3; woodland suitability group 7; community development group 1; outdoor recreation group 1.

Alvin Series

The Alvin series consists of nearly level and gently sloping, well-drained soils on river terraces. These soils

[1] Italic numbers in parentheses refer to Literature Cited, p. 127.

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

Soil	Acres	Percent	Soil	Acres	Percent
Alluvial land, frequently flooded	6,558	1.4	McPaul silt loam	5,895	1.2
Alluvial land, sloping	1,199	.2	Mt. Carroll silt loam, 0 to 2 percent slopes	1,131	.2
Alvin fine sandy loam, 0 to 3 percent slopes	1,080	.2	Mt. Carroll silt loam, 2 to 6 percent slopes	27,100	5.6
Ankeny sandy loam, 0 to 3 percent slopes	702	.1	Mt. Carroll silt loam, 6 to 12 percent slopes, eroded	9,232	1.9
Bellechester sand, 25 to 45 percent slopes	3,569	.7	Mt. Carroll silt loam, benches, 0 to 3 percent slopes	2,313	.5
Billett sandy loam, 2 to 6 percent slopes	1,370	.3	Orion silt loam, wet	2,110	.4
Billett sandy loam, 6 to 12 percent slopes	701	.1	Ostrander silt loam, 1 to 6 percent slopes	8,943	1.8
Biscay loam	748	.2	Ostrander silt loam, 6 to 12 percent slopes, eroded	331	.1
Bremer silty clay loam, wet	3,545	.7	Plainfield loamy sand, 0 to 6 percent slopes	3,608	.7
Brodale-Sogn flaggy loams, steep	1,572	.3	Plainfield loamy sand, 6 to 25 percent slopes	1,223	.3
Brodale-Sogn flaggy loams, very steep	4,726	1.0	Port Byron silt loam, 0 to 2 percent slopes	1,036	.2
Burkhardt loam, 0 to 3 percent slopes	1,806	.4	Port Byron silt loam, 2 to 6 percent slopes	4,500	.9
Canisteo silty clay loam	488	.1	Port Byron silt loam, 6 to 12 percent slopes, eroded	591	.1
Chaseburg silt loam, 0 to 3 percent slopes	9,484	2.0	Port Byron silt loam, benches, 0 to 3 percent slopes	598	.1
Colo silty clay loam	4,027	.8	Racine silt loam, 1 to 6 percent slopes	29,717	6.1
Copaston loam, 1 to 6 percent slopes	594	.1	Racine silt loam, 6 to 12 percent slopes	2,456	.5
Copaston loam, 6 to 12 percent slopes, eroded	959	.2	Racine silt loam, 6 to 12 percent slopes, eroded	10,655	2.2
Copaston loam, moderately deep, 0 to 6 percent slopes	483	.1	Racine silt loam, 12 to 18 percent slopes, eroded	6,041	1.2
Copaston loam, moderately deep, 6 to 12 percent, slopes, eroded	215	(1)	Racine soils, 18 to 35 percent slopes	1,686	.4
Dakota loam, 0 to 3 percent slopes	872	.2	Radford silt loam	5,266	1.1
Derinda silt loam, 5 to 12 percent slopes, eroded	299	.1	Salida gravelly coarse sand, 1 to 12 percent slopes	836	.2
Derinda silt loam, 12 to 25 percent slopes, eroded	593	.1	Salida gravelly coarse sand, 12 to 45 percent slopes	2,285	.5
Dickinson sandy loam, 0 to 2 percent slopes	985	.2	Schapville silty clay loam, 2 to 12 percent slopes	694	.1
Dickinson sandy loam, 2 to 6 percent slopes	2,061	.4	Schapville silty clay loam, 12 to 18 percent slopes	805	.2
Dickinson sandy loam, 6 to 12 percent slopes	983	.2	Schapville-Sogn complex, 18 to 35 percent slopes	1,229	.3
Dodgeville silt loam, 1 to 6 percent slopes	714	.1	Seaton silt loam, 0 to 2 percent slopes	2,541	.5
Dodgeville silt loam, 6 to 12 percent slopes, eroded	248	.1	Seaton silt loam, 2 to 6 percent slopes	28,953	6.0
Dubuque silt loam, 2 to 6 percent slopes, eroded	240	.1	Seaton silt loam, 6 to 12 percent slopes, eroded	40,298	8.3
Dubuque silt loam, 6 to 12 percent slopes, eroded	721	.2	Seaton silt loam, 12 to 18 percent slopes, eroded	21,263	4.4
Dubuque silt loam, 12 to 18 percent slopes, eroded	4,108	.8	Seaton silt loam, 18 to 25 percent slopes	4,353	.9
Dubuque silt loam, 18 to 35 percent slopes	9,729	2.0	Seaton silt loam, valleys, 6 to 12 percent slopes, eroded	618	.1
Eleva sandy loam, 2 to 6 percent slopes	240	.1	Seaton silt loam, valleys, 12 to 18 percent slopes, eroded	1,562	.3
Eleva sandy loam, 6 to 18 percent slopes	668	.1	Seaton silt loam, valleys, 18 to 25 percent slopes	1,634	.3
Estherville loam, 0 to 6 percent slopes	2,436	.5	Seaton complex, 6 to 12 percent slopes, eroded	1,786	.4
Estherville soils, 6 to 18 percent slopes	617	.1	Seaton complex, 12 to 25 percent slopes, eroded	753	.2
Fairhaven silt loam, 0 to 3 percent slopes	5,145	1.1	Seaton, Timula, and Bold silt loams, steep	1,836	.4
Frontenac soils, steep	2,273	.5	Shullsburg silty clay loam, 2 to 14 percent slopes	1,118	.2
Frontenac soils, very steep	15,472	3.2	Skyberg silt loam	1,687	.3
Gale silt loam, 0 to 3 percent slopes	500	.1	Sogn and Copaston soils, 12 to 25 percent slopes	2,138	.4
Garwin silty clay loam	5,536	1.1	Sparta loamy sand, 0 to 3 percent slopes	588	.1
Garwin silty clay loam, swales	936	.2	Terril sandy loam, 2 to 6 percent slopes	304	.1
Gotham fine sand, 2 to 12 percent slopes	1,633	.3	Terril sandy loam, 6 to 12 percent slopes	648	.1
Gotham fine sand, 12 to 35 percent slopes	2,136	.4	Terril sandy loam, 12 to 25 percent slopes	1,246	.3
Houghton muck	585	.1	Timula silt loam, 2 to 6 percent slopes	25,522	5.3
Houghton muck, seepy	284	.1	Timula silt loam, 6 to 12 percent slopes	8,157	1.7
Joy silt loam, 0 to 3 percent slopes	6,704	1.4	Timula-Bold silt loams, 12 to 25 percent slopes	8,226	1.7
Kasson silt loam, 1 to 3 percent slopes	7,538	1.6	Vasa silt loam, 0 to 3 percent slopes	4,255	.9
Kegonsa silt loam, 0 to 3 percent slopes	1,078	.2	Waukegan silt loam, 0 to 3 percent slopes	4,195	.9
Kegonsa and Fairhaven silt loams, 6 to 18 percent slopes	654	.1	Whalan silt loam, 1 to 6 percent slopes	469	.1
Klinger silty clay loam, 1 to 3 percent slopes	19,152	4.0	Whalan silt loam, 6 to 12 percent slopes, eroded	335	.1
Lawson silt loam	2,385	.5	Whalan silt loam, moderately shallow, 1 to 6 percent slopes	364	.1
Lilah sandy loam, 0 to 6 percent slopes	777	.2	Whalan silt loam, moderately shallow, 6 to 12 percent slopes, eroded	573	.1
Lilah sandy loam, 6 to 35 percent slopes	1,019	.2	Whalan silt loam, moderately shallow, 12 to 18 percent slopes, eroded	1,725	.4
Lindstrom silt loam, 2 to 6 percent slopes	524	.1	Whalan silt loam, moderately shallow, 18 to 35 percent slopes	1,808	.4
Lindstrom silt loam, 6 to 12 percent slopes	1,066	.2	Zumbro loamy sand	926	.2
Lindstrom silt loam, 12 to 25 percent slopes	1,077	.2			
Marlean soils, steep	2,175	.4			
Marlean soils, very steep	4,670	1.0			
Marsh	4,065	.8			
Maxfield silty clay loam	21,453	4.4	Total	485,120	100.0
Maxfield silty clay loam, swales	6,781	1.4			

[1] Less than 0.05 percent.

formed in glacial outwash. The native vegetation was deciduous hardwood forest.

In a representative profile the surface layer is dark grayish-brown fine sandy loam about 7 inches thick, and the subsurface layer is dark grayish-brown fine sandy loam about 6 inches thick. The subsoil is dark-brown and yellowish-brown, friable and very friable fine sandy loam about 47 inches thick. The underlying material is grayish-brown gravelly coarse sand.

Permeability is moderate, and available water capacity is moderate and high. The content of organic matter is moderately low. The content of available phosphorus is medium, and that of available potassium is low.

Most areas are used for crops or pasture. The main limitations are hazards of erosion and droughtiness.

Representative profile of Alvin fine sandy loam, 0 to 3 percent slopes, 325 feet east and 1,450 feet north of the southwest corner of sec. 32, T. 112 N., R. 12 W., approximately 50 feet north of road:

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) fine sandy loam, light brownish gray (10YR 6/2) dry; weak, fine, granular structure; very friable; medium acid; abrupt, wavy boundary.

A2—7 to 13 inches, dark grayish-brown (10YR 4/2) fine sandy loam; weak, medium, subangular blocky structure; very friable; medium acid; clear, wavy boundary.

B1—13 to 20 inches, dark-brown (10YR 4/3) fine sandy loam; dark grayish-brown (10YR 4/2) coatings on faces of peds; weak, fine and medium, subangular blocky structure; friable; many, fine and very fine, tubular pores; medium acid; clear, wavy boundary.

B21t—20 to 32 inches, yellowish-brown (10YR 5/4) fine sandy loam; dark-brown (7.5YR 4/4) coatings on faces of peds; weak, medium, subangular blocky structure; friable; common thin clay films; many, very fine and fine, tubular pores; medium acid; clear, wavy boundary.

B22t—32 to 37 inches, yellowish-brown (10YR 5/4) fine sandy loam; dark-brown (7.5YR 4/4) coatings on faces of peds; weak, medium and coarse, subangular blocky structure; very friable; many continuous clay films; medium acid; gradual, wavy boundary.

B3—37 to 60 inches, yellowish-brown (10YR 5/4) fine sandy loam, some very thin strata of very fine sandy loam; very friable; moderate, medium, prismatic structure; medium acid; abrupt, wavy boundary.

IIC—60 to 65 inches, grayish-brown (10YR 5/2) gravelly coarse sand; loose; single grained; mildly alkaline.

The thickness of the solum, or the depth to underlying sand and gravel, ranges from 38 to 70 inches. The lower part of the solum is as much as 10 percent gravel in places. The A horizon generally is fine sandy loam or very fine sandy loam, but it ranges to sandy loam in a few places. The B horizon ranges from 25 to 50 inches in thickness and from dark brown to yellowish brown in color. It is mostly fine sandy loam, very fine sandy loam, or loam, but the lower part of the horizon is silt loam in some places. The IIIC horizon ranges from gravelly sand or sand to stratified sand and loam.

Alvin soils are near Burkhardt and Lilah soils and are similar to Billett soils. They have few or no pebbles in the A and B horizons, whereas Burkhardt and Lilah soils contain large quantities. They have a thicker B horizon than Billett soils.

Alvin fine sandy loam, 0 to 3 percent slopes (AvA).—This soil is on broad benches along major streams in the county. Long, narrow areas are on convex rises or knolls. They range from 2 to 20 acres in size. Included in mapping are some soils that are less than 38 inches deep over sand and gravel.

The main limitation is a moderate hazard of droughtiness. Gently sloping areas have a slight hazard of erosion. Runoff is slow or medium. Most of it is absorbed because the infiltration rate is moderate, or it is drained to adjacent soils where the infiltration rate is moderately high or high. Natural fertility is low to medium. Controlling erosion, increasing soil fertility, and irrigating where feasible are the chief management needs.

Most areas of this soil are used for crops, and some areas are pasture or woodland. Small areas north of Lake City are used for housing developments. Where the soil is used as a septic tank absorption field and the water table is below a depth of 20 feet, pollution of ground water is a hazard because the underlying material is rapidly permeable. Capability unit IIs–1; woodland group 3; community development group 3; outdoor recreation group 10.

Ankeny Series

The Ankeny series consists of nearly level to slightly undulating, well-drained soils on flood plains. These soils formed in alluvium. The native vegetation was mixed prairie and some deciduous forest.

In a representative profile the surface layer is about 36 inches thick. The upper 27 inches is very dark brown sandy loam, and the lower 9 inches is very dark grayish-brown loam. The subsoil is dark-brown, loose loamy sand about 24 inches thick. The underlying material is grayish-brown coarse sand. A water table is at a depth of 60 to 80 inches.

Permeability is moderately rapid, and available water capacity is moderate. The content of organic matter is high. The content of available phosphorous is medium, and that of potassium is low.

Most areas are used for crops or pasture and are better suited to these than to most other uses. The main limitations are moderate available water capacity and the hazard of flooding.

Representative profile of Ankeny sandy loam, 0 to 3 percent slopes, in a cultivated field about 70 feet north and 215 feet west of the southeast corner of sec. 36, T. 112 N., R. 18 W.

Ap—0 to 12 inches, very dark brown (10YR 2/2) sandy loam; weak, very fine, granular structure; very friable; about 2 percent coarse fragments; neutral; abrupt, wavy boundary.

A12—12 to 27 inches, very dark brown (10YR 2/2) sandy loam; weak, fine, subangular blocky structure; very friable; many, very fine and fine, tubular pores; about 3 percent coarse fragments; neutral; clear, wavy boundary.

A3—27 to 36 inches, very dark grayish-brown (10YR 3/2) loam; weak, fine, subangular blocky structure; friable; many, very fine and fine, tubular pores; about 7 percent coarse fragments; slightly acid; clear, wavy boundary.

B2—36 to 60 inches, dark-brown (10YR 4/3) loamy sand; weak, coarse, subangular blocky structure; loose; about 7 percent coarse fragments; slightly acid; clear, wavy boundary.

IIC—60 to 70 inches, grayish-brown (10YR 5/2) coarse sand; single grained; loose; about 10 percent coarse fragments; mildly alkaline.

The solum ranges from 36 to 70 inches in thickness. In a few places, the solum is as much as 10 percent gravel, but

most places have none. Depth to free carbonates ranges from 50 to 70 inches. The A horizon ranges from 25 to 40 inches in thickness. It is typically sandy loam, fine sandy loam, or loam but ranges to silt loam. The B2 horizon ranges from 10 to 40 inches in thickness and from loamy sand to sandy loam or fine sandy loam in texture. A thin, yellowish-brown loamy sand or sand B3 horizon, as much as 5 inches thick, is in some places. The C horizon is loamy sand, coarse sand, sand, or silt loam.

Ankeny soils are near Lawson and Zumbro soils. They contain less sand in the solum than Zumbro soils and more sand than Lawson soils.

Ankeny sandy loam, 0 to 3 percent slopes (AxA).—This soil is in a pattern of slightly convex rises and swales and is on high bottoms along streams. Areas range from 2 to 100 acres in size. This soil is flooded by the less frequent, major floods. Included in mapping are some areas of poorly drained soils along the outer edge of flood plains.

The main limitation is the hazard of flooding. Natural runoff is slow and medium. Most of it is absorbed by infiltration, or it collects, briefly ponds, and then seeps away into the small, natural swales. The hazard of drought is moderate because available water capacity is moderate. Some soil blowing is possible where broad areas are left exposed. Controlling erosion and maintaining fertility are the main management needs. Very little can be done to minimize the hazard of flooding.

This soil is used for crops and some pasture. It is suited to most row crops grown in the country. Capability unit IIs–1; woodland group 8; community development group 1; outdoor recreation group 2.

Bellechester Series

The Bellechester series consists of very steep, excessively drained soils on concave foot slopes below valley walls in mature, dissected terrain. These soils formed in sandy colluvium and sandstone residuum. The native vegetation was tall prairie grasses and, in some areas, redcedar and bur oak.

In a representative profile the surface layer is very dark brown and very dark gray sand about 16 inches thick. The upper 7 inches of the subsoil is very dark gray and dark-brown, loose sand; the lower 19 inches is mainly yellowish-brown, loose sand. The underlying material is white, soft sandstone. A stone line of limestone or sandstone flags is at a depth of 28 inches.

Permeability is rapid, and available water capacity is low. The content of organic matter is moderately low. The content of available phosphorus and potassium is low.

Most areas are in pasture or forest. Most potential uses are limited by droughtiness. The main limitations are hazards of drought and erosion.

Representative profile of Bellechester sand, 25 to 45 percent slopes, 790 feet east and 330 feet south of the northwest corner of sec. 11, T. 112 N., R. 13 W.

A1—0 to 7 inches, very dark brown (10YR 2/2) sand, dark gray (10YR 4/1) dry; single grained; loose; many roots; mildly alkaline; gradual, wavy boundary.

A3—7 to 16 inches, very dark gray (10YR 3/1) sand, dark grayish brown (10YR 4/2) dry; single grained; loose; many roots; mildly alkaline; clear, irregular boundary.

B1—16 to 23 inches, very dark gray (10YR 3/1) and dark-brown (10YR 4/3) sand, dark grayish brown (10YR 4/2) rubbed; single grained; loose; common roots; about 5 percent coarse fragments, mainly hard limestone channers; mildly alkaline; clear, irregular boundary.

B2—23 to 28 inches, yellowish-brown (10YR 5/6) and dark grayish-brown (10YR 4/2) sand, dark yellowish brown (10YR 4/4) rubbed; single grained; loose; about 10 percent coarse fragments, mainly sandstone and limestone flags; moderately alkaline; slightly effervescent; clear, wavy boundary.

B3—28 to 42 inches, yellowish-brown (10YR 5/8) sand; single grained; loose; stone line in upper part, and lower part about 10 percent coarse fragments, mainly sandstone and limestone flags; mildly alkaline; slightly effervescent; clear, wavy boundary.

C—42 to 60 inches, white (10YR 8/1), soft sandstone.

The solum ranges from 30 to 50 inches in thickness. In places free carbonates are at a depth of 20 to 40 inches. Depth to sandstone bedrock ranges from 40 to 70 inches. The solum ranges from 0 to 20 percent coarse fragments, which are commonly concentrated in a stone line in one or two horizons.

The A horizon ranges from 12 to 24 inches in thickness and from sand to loamy fine sand in texture. The B1 horizon ranges from 6 to 12 inches in thickness. The B horizon is typically sand, but it ranges to loamy sand or loamy fine sand in the upper part in some places. Except for some cemented layers, it is mainly single grained or has weak structure. It ranges from neutral to moderately alkaline. In some places a C horizon of loose, single grained sand or fine sand as much as 18 inches thick is immediately above the bedrock.

Bellechester soils are near Brodale, Marlean, Sogn, and Terril soils. They contain more sand than any of those soils.

Bellechester sand, 25 to 45 percent slopes (BaF).—This soil is on foot slopes and the lower part of valley walls. Slopes are smooth to concave and are 100 to 400 feet long. This soil is typically downslope from areas of Brodale and Sogn soils.

Included with this soil in mapping are areas of Brodale and Sogn soils on the steeper valley walls and some Terril soils adjacent to lower foot slopes. Also included are some similar soils that have bedrock at a depth of only 30 inches.

Runoff is medium, and much of it is absorbed because the rate of infiltration is high. This soil is susceptible to gullying in areas that receive very rapid runoff from the very steep soils on valley walls. The main management needed is the containment of excess runoff.

This soil is poorly suited to pasture, because it is very droughty. It is better suited to trees, especially pine. Capability unit VIIs–1; woodland group 6; community development group 7; outdoor recreation group 12.

Billett Series

The Billett series consists of gently sloping to sloping, well-drained soils on side slopes and crests of narrow uplands along valleys. These soils formed in sandy outwash and windblown sediment. The native vegetation was deciduous hardwood forest.

In a representative profile the surface layer is very dark grayish-brown sandy loam about 7 inches thick. The upper 13 inches of the subsoil is yellowish-brown, very friable sandy loam; the lower 14 inches is yellowish-brown, very friable loamy sand. The underlying material is yellowish-brown sand.

Permeability is moderately rapid, and available

water capacity is low and moderate. The content of organic matter is low. The content of available phosphorus and potassium is low.

Most areas are used for crops, pasture, or woodland. The main limitations are hazards of drought and erosion.

Representative profile of Billett sandy loam, 2 to 6 percent slopes, 165 feet north and 495 feet west of the southeast corner of NE¼SE¼ of sec. 11, T. 112 N., R. 17 W.

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) sandy loam, grayish brown (10YR 5/2) dry; weak, very fine, subangular blocky structure; very friable; neutral; abrupt, wavy boundary.

B21t—7 to 12 inches, yellowish-brown (10YR 5/4) sandy loam; weak, fine, subangular blocky structure; very friable; slightly acid; abrupt, wavy boundary.

B22t—12 to 20 inches, yellowish-brown (10YR 5/4) sandy loam; weak, fine, subangular blocky structure; very friable; few clay films; slightly acid; abrupt, wavy boundary.

B23t—20 to 27 inches, yellowish-brown (10YR 5/6) loamy sand; weak, fine, subangular blocky structure; very friable; common, thin clay bridgings between sand grains; neutral; abrupt, wavy boundary.

B3—27 to 34 inches, yellowish-brown (10YR 5/6) loamy sand; weak, medium, subangular blocky structure; very friable; common masses of loam till; about 8 percent coarse fragments; neutral; clear, wavy boundary.

C—34 to 60 inches, yellowish-brown (10YR 5/4) sand; single grained; loose; about 10 percent coarse fragments; few, very thin sandy loam bands; neutral.

The solum ranges from 30 to 40 inches in thickness. Some places have an A2 horizon, as much as 8 inches thick, that ranges from dark grayish brown to grayish brown. The B2 horizon ranges from 15 to 25 inches in thickness. It is brown or yellowish brown. It is sandy loam or loam in the upper part and is loamy sand in the lower part. It ranges from neutral to strongly acid. The C horizon is fine sand or sand. Bedrock is at a depth of 5 to 10 feet in most places; however, firm loam till is at this depth in some places.

Billett soils are near Racine and Whalan soils and are similar to Alvin soils. They have less clay and more sand in their solum than those soils. Also, they have a coarser textured C horizon than Racine soils. They are not shallow over bedrock, and Whalan soils are. They have more medium-textured and coarser textured sand in the solum, have a thinner B horizon, and have a darker colored A horizon than Alvin soils.

Billett sandy loam, 2 to 6 percent slopes (BbB).—This soil is on low-lying convex knolls on upland ridges adjacent to the major river valleys in the county. The knolls are oval shaped and their sides range from 100 to 300 feet in length. Areas range from 2 to 25 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are some areas of severely eroded soils and some Gotham soils. Also included are areas of soils that have loamy till in the lower part of the underlying material.

Because available water capacity is low and moderate, the main limitation is droughtiness. This soil is subject to some soil blowing and water erosion in areas that lack sufficient vegetation. Surface runoff is slow or medium. Most of it is absorbed because the infiltration rate is moderately high and permeability is moderately rapid. The main management needs are scheduling fieldwork and selecting early maturing crops that best utilize available water in the soil and the frequent seasonal rain. Fertility also needs to be maintained. Some irrigation can be used where feasible.

Most of this soil is used for crops, pasture, or woodland. It is well suited to small grain, corn, and red clover. It is also suited to some shallow-rooted garden crops. Where the soil is used as a septic tank absorption field and the water table is below a depth of 20 feet, pollution of ground water is a hazard because the underlying material is rapidly permeable. Capability unit IIIe–4; woodland group 3; community development group 3; outdoor recreation group 10.

Billett sandy loam, 6 to 12 percent slopes (BbC).—This soil is on crests and sides of convex knolls on upland ridges. Slopes range from 100 to 300 feet in length. Areas range from 2 to 15 acres in size. Included in mapping are some areas of Gotham soils.

The main limitation is the severe or moderate hazard of erosion. Surface runoff is medium. This soil is highly erodible, especially in deep cuts and where it is subject to surface runoff. It is subject to soil blowing in areas that lack sufficient vegetation. The hazard of drought is moderate because available water capacity is low to moderate. The main management needs are controlling erosion and runoff, scheduling fieldwork, and selecting early maturing crops that best utilize available water in the soil and more frequent seasonal rain.

This soil is used for crops, pasture, or woodland. It is suited to small grain, corn, and red clover. It is also suited to shallow-rooted garden crops that are well suited to sandy soils. Where the soil is used as a septic tank absorption field and the water table is below a depth of 20 feet, pollution of ground water is a hazard because the underlying material is rapidly permeable. Capability unit IVe–4; woodland group 3; community development group 3; outdoor recreation group 13.

Biscay Series

The Biscay series consists of nearly level to depressional, poorly drained soils on benches along major rivers. These soils formed in loamy over sandy or gravelly outwash material. The native vegetation was tall prairie grasses and sedges.

In a representative profile the surface layer is black loam about 12 inches thick. The subsoil is dark-gray and gray, slightly sticky clay loam about 18 inches thick. The underlying material is grayish-brown coarse sand and grayish-brown and yellowish-brown gravelly coarse sand.

Permeability is moderate. Available water capacity is moderate in drained areas. The content of organic matter is high. The content of available phosphorus and potassium is low. These soils have a seasonal water table at a depth of 1 to 3 feet.

Most areas are used for crops or pasture. Adequately drained areas are well suited to corn and soybeans. The main limitation is the hazard of wetness.

Representative profile of Biscay loam, at junction of a township road and U.S. Highway 52, 65 feet north and 400 feet west of the southeast corner of SE¼ sec. 23, T. 110 N., R. 16 W.

A11—0 to 8 inches, black (N 2/0) highly organic loam; weak, fine, subangular blocky structure; friable; many fine roots; mildly alkaline; abrupt, wavy boundary.

A12—8 to 12 inches, black (N 2/0) loam; weak, fine, granular structure; friable; mildly alkaline; clear, wavy boundary.
B21g—12 to 17 inches, dark-gray (5Y 4/1) clay loam; weak, medium, subangular blocky structure; slightly sticky; few black (10YR 2/1) tongues; mildly alkaline; gradual, irregular boundary.
B22g—17 to 26 inches, gray (5Y 5/1) clay loam; many, medium, distinct, olive (5Y 5/4) mottles and few, fine, prominent, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; slightly sticky; about 10 percent gravel; mildly alkaline; clear, wavy boundary.
B23g—26 to 30 inches, gray (5Y 5/1) clay loam; many, medium, distinct, olive (5Y 5/4) mottles and common, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, medium, subangular blocky structure; slightly sticky; about 12 percent gravel; mildly alkaline; abrupt, wavy boundary.
IIC1—30 to 45 inches, grayish-brown (2.5Y 5/2) coarse sand; many large, distinct, yellowish-brown (10YR 5/6) mottles; single grained; loose; mildly alkaline; clear, wavy boundary.
IIC2—45 to 60 inches, mottled about 60 percent grayish-brown (2.5Y 5/2) and 40 percent yellowish-brown (10YR 5/6) gravelly coarse sand; single grained; loose; mildly alkaline; slightly effervescent.

Thickness of the solum, or the depth to the IIC horizon, ranges from 26 to 48 inches. Depth to free carbonates generally ranges from 26 to 48 inches, but in some places, very small amounts of free carbonates are in the upper part of the A horizon. Reaction of the solum ranges from neutral to mildly alkaline. The A horizon is heavy loam, clay loam, or silty clay loam. A thin, very dark gray A3 horizon occurs in some places. The B horizon ranges from dark gray to grayish brown or olive gray. It typically is loam or clay loam, but in some places it is silty clay loam. The IIC horizon is coarse sand, gravelly coarse sand, or stratified sand and gravel.

Biscay soils are near Dickinson, Fairhaven, and Kegonsa soils. They are poorly drained, and those soils are well drained.

Biscay loam (0 to 2 percent slopes) (Bc).—This soil is in low-lying areas on broad benches along small streams and major rivers. Areas range from 2 to 30 acres in size.

Included with this soil in mapping are some areas of soils that are shallower over sand and contain more sand. These areas are on the benches along the Cannon River. Also included are some areas of soils that are silty.

The main limitation is the moderate to severe hazard of wetness. Ponding is a concern in areas where the water table is very high. Surface runoff is slow and is occasionally ponded. Much of it is absorbed because infiltration is moderate and permeability is moderate in the upper part of this soil and is rapid in the underlying material. A seasonal water table is at a depth of 20 to 40 inches. The main management need is artificial drainage. Many areas have been drained. Because available water capacity is moderate, this soil can be overdrained or the water table can be lowered too far and the soil becomes droughty.

Most of the acreage is used for crops. Adequately drained areas are well suited to corn and soybeans. Capability unit IIw–1; woodland group 9; community development group 2; outdoor recreation group 3.

Bold Series

The Bold series consists of moderately steep to very steep, well-drained soils that formed in loess. These soils are on the more dissected uplands. The native vegetation was deciduous hardwoods. These soils are mapped only with Timula soils.

In a representative profile the surface layer is dark grayish-brown silt loam about 6 inches thick. The underlying material is dark-brown and olive, very friable silt loam that is many feet thick.

Permeability is moderate, and available water capacity is very high. The content of organic matter is low. The content of available phosphorus and potassium is low.

Most areas are used for crops, pasture, or woodland. The main limitation is the hazard of erosion. These soils are well suited to alfalfa-brome hay, and they are also well suited to pasture or woodland.

Representative profile of Bold silt loam in an area of Timula-Bold silt loams, 12 to 25 percent slopes, in a cultivated field 330 feet north and 680 feet west of the southeast corner of NE¼ sec. 32, T. 112 N., R. 16 W.

Ap—0 to 6 inches, dark grayish-brown (10YR 4/2) silt loam; weak, fine, granular structure; very friable; moderately alkaline; slightly effervescent; abrupt, wavy boundary.
C1—6 to 11 inches, dark-brown (10YR 4/3) silt loam; massive; very friable; moderately alkaline; strongly effervescent; gradual, wavy boundary.
C2—11 to 70 inches, olive (5Y 5/4) silt loam; massive; very friable; moderately alkaline; strongly effervescent.

The A horizon ranges from dark grayish brown to dark brown. The C horizon ranges from dark brown or brown to olive brown or olive.

Bold soils are mapped only with Timula soils. They have free lime in all parts of the profile, whereas Timula soils do not have free lime in the A and B horizons.

Bremer Series

The Bremer series consists of level to slightly depressional, very poorly drained soils on flood plains. These soils formed in alluvium. The native vegetation was tall prairie grasses and sedges.

In a representative profile the surface layer is black silty clay loam about 15 inches thick. The upper 20 inches of the subsoil is very dark gray and dark-gray, firm silty clay loam, and the lower 6 inches is gray, firm silty clay. The underlying material is gray silt loam.

Permeability is moderately slow, and available water capacity is very high. The content of organic matter is high. The content of available phosphorus is medium, and that of potassium is low. A water table is at a depth of 1 foot to 4 feet.

Most areas are in pasture. Some drained areas are used for crops. The main limitations are hazards of flooding and wetness.

Representative profile of Bremer silty clay loam, wet, in a cultivated field 330 feet east and 165 feet north of the southwest corner of NW¼NW¼ sec. 18, T. 111 N., R. 17 W.

A11—0 to 8 inches, black (10YR 2/1) silty clay loam; weak to moderate, fine, granular structure; friable; neutral; abrupt, wavy boundary.
A12—8 to 15 inches, black (N 2/0) silty clay loam; moderate, very fine, granular structure; friable; slightly acid; abrupt, wavy boundary.
B21tg—15 to 27 inches, very dark gray (10YR 3/1) silty clay loam, black coatings on faces of peds; moderate to strong, very fine, granular and sub-

angular blocky structure; firm; many, very fine and fine, tubular pores; continuous thin clay films on faces of peds; slightly acid; abrupt, wavy boundary.

B22tg—27 to 35 inches, dark-gray (10YR 4/1) silty clay loam, very dark gray coatings on faces of peds; strong, very fine, angular blocky structure; firm; many, very fine and fine, tubular pores; thin continuous clay films and common fine sand grains on faces of peds; slightly acid; clear, wavy boundary.

B23tg—35 to 41 inches, gray (10YR 5/1) silty clay, dark-gray (10YR 4/1) coatings on faces of peds; common, fine, prominent, dark yellowish-brown (10YR 4/4) mottles; strong, fine and medium, angular blocky structure; firm; slightly acid; abrupt, wavy boundary.

Cg—41 to 60 inches, gray (5Y 5/1) silt loam; many, coarse, prominent, yellowish-brown (10YR 5/8) mottles; massive; friable; neutral.

The solum ranges from 40 to 60 inches in thickness. The A horizon ranges from 15 to 20 inches in thickness and from black to very dark gray in color. It is silty clay loam or silt loam. Clay films in the B horizon are continuous or discontinuous. The C horizon is mostly silt loam or silty clay loam, but in some places, it has strata of coarser textured material.

Bremer soils are near Lawson soils and are similar to Colo soils. They have a thinner A horizon than Colo soils and are wetter and contain more clay than Lawson soils.

Bremer silty clay loam, wet (0 to 2 percent slopes) (Bm).—This soil is at the outer edge of flood plains and in adjoining areas at higher elevations along broad streams or rivers. Areas range from 5 to 200 acres in size. Included in mapping are areas of shallow Marsh, Alluvial land, and Orion soils.

Surface runoff is slow, and water is ponded for variable periods. The main limitations are hazards of flooding and wetness. These limitations are severe to moderate and mainly limit this soil to use for permanent pasture or hay. Some areas along the Little Cannon River are extensively cropped. The main management need is internal drainage and some control of flooding where possible.

Adequately drained areas of this soil are well suited to corn and soybeans. Capability unit IIIw–3; woodland group 9; community development group 1; outdoor recreation group 3.

Brodale Series

The Brodale series consists of steep and very steep, excessively drained soils on south-facing and west-facing convex sides of valley walls in mature, dissected terrain. These soils formed in colluvium and residuum from limestone bedrock. The native vegetation was mid and tall prairie grasses.

In a representative profile the surface layer is very dark brown flaggy loam about 6 inches thick. The subsoil is yellowish-brown, friable flaggy very fine sandy loam about 4 inches thick. The underlying material is yellowish-brown, friable flaggy very fine sandy loam. Limestone bedrock is at a depth of about 50 inches.

Permeability is moderate, and available water capacity is low. The content of organic matter is high. The content of available phosphorus and potassium is low.

Most areas are in pasture or are idle. The main limitations are hazards of erosion and drought.

Representative profile of Brodale flaggy loam in an area of Brodale-Sogn flaggy loams, very steep, 1,160 feet east and 132 feet south of the northwest corner of sec. 22, T. 112 N., R. 14 W.

A1—0 to 6 inches, very dark brown (10YR 2/2) flaggy loam; weak, fine, granular structure; friable; common roots; many very fine to medium pores; about 45 percent rock fragments, mainly flagstones, and about 15 percent stones and a few channers; moderately alkaline; strongly effervescent; abrupt, wavy boundary.

B2—6 to 10 inches, yellowish-brown (10YR 5/4) flaggy very fine sandy loam; massive; friable; about 40 percent rock fragments, mainly flagstones, and about 15 percent stones and a few channers; many coatings of lime ranging from 2 to 5 millimeters in thickness on undersides of coarse fragments; common roots; moderately alkaline; strongly effervescent; clear, wavy boundary.

C—10 to 50 inches, yellowish-brown (10YR 5/6) flaggy very fine sandy loam; massive; friable; about 50 percent coarse fragments, mainly flagstones, and about 20 percent stones and a few channers; moderately alkaline; strongly effervescent; abrupt, smooth boundary.

R—50 inches +, limestone bedrock.

The solum ranges from 8 to 20 inches in thickness. Depth to bedrock ranges from 50 to 80 inches or more. Free carbonates are throughout the profile, and reaction ranges from mildly alkaline to moderately alkaline. The solum typically ranges from 40 to 70 percent flagstones or fragments. In some places, the coarse fragments are mainly pebbles, cobblestones, or stones. The fine earth is sandy loam, fine sandy loam, very fine sandy loam, loam, or silt loam. In places loamy sand or loamy coarse sand is in some horizons.

The A1 horizon ranges from black to very dark grayish brown and has weak or moderate granular structure. The B horizon ranges from dark brown to yellowish brown. It is massive or has weak, subangular blocky structure. The C horizon is brown or yellowish brown.

Brodale soils are near Bellechester and Sogn soils. They have more coarse fragments and less sand than Bellechester soils. They are deeper over bedrock than Sogn soils.

Brodale-Sogn flaggy loams, steep (25 to 40 percent slopes) (BoE).—These soils are on sides of entrenched valleys that are upstream from major rivers. They are on the upper part of convex, south-facing and west-facing sides. Brodale soils make up about 50 percent of this unit and Sogn soils about 40 percent. The Brodale soil is below the Sogn soil (fig. 5). Elevations range from 75 to 200 feet. Included in mapping are some areas of Alluvial land, sloping, and some outcrops of bedrock. The bedrock is of the Shakopee, Plattsville, and Galena Formations.

Runoff is very rapid, and it sometimes causes gullying in adjoining, lower lying soils. The main management needs are reducing the rate of runoff and limiting excessive traffic and grazing. Reducing the rate of runoff also helps recharge ground water reservoirs in the underlying rock strata.

Because slopes are steep and available water capacity is low, these soils are suited to native grassland. Capability unit VIIs–2; woodland group 6; community development group 7; outdoor recreation group 12.

Brodale-Sogn flaggy loams, very steep (35 to 80 percent slopes) (BoF).—These soils are on the sides of deeply entrenched valleys along major rivers. They are on the upper parts of convex south-facing and west-facing sides. Brodale soils make up about 50 percent of this unit and Sogn soils about 30 percent. The Brodalé soil is on the lower part of the valley sides,

Figure 5.—Typical landscape of Brodale-Sogn flaggy loams, steep, shows warm-season vegetation and bedrock outcroppings.

and the Sogn soil is on the upper part. Elevations range from 200 to 400 feet.

Included with these soils in mapping are some areas of Alluvial land, sloping, on lower foot slopes and some outcrops of bedrock on valley walls. The bedrock mainly is of the Oneota, Shakopee, Platteville, and Galena Formations.

Runoff is very rapid and is of very high velocity in drainageways. Some of the runoff causes gullies in adjoining soils along lower slopes. The main management need is reducing the rate of runoff by excluding grazing and excessive traffic. Reducing the rate of runoff also helps recharge ground water reservoirs in the underlying rock strata.

Because slopes are steep and available water capacity is low, these soils are suited to native grassland. Capability unit VIIIs–1; woodland group 6; community development group 7; outdoor recreation group 12.

Burkhardt Series

The Burkhardt series consists of nearly level, somewhat excessively drained soils on smooth or plane river benches. These soils formed in glacial outwash. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is very dark brown loam about 10 inches thick. The subsoil is dark-brown, friable loam about 6 inches thick. The underlying material is dark-brown and grayish-brown stratified sand and gravel (fig. 6).

Permeability is moderately rapid, and available water capacity is low. The content of organic matter is moderate. The content of available phosphorus and potassium is low.

Most areas are used for crops, woodland, or pasture. Some are used as sites for housing or as a source of gravel. The main limitation is the hazard of drought.

Representative profile of Burkhardt loam, 0 to 3 percent slopes, 70 feet south of road, 1,980 feet east of west edge of section, along west edge of gravel pits in the NE¼SW¼ sec. 24, T. 112 N., R. 13 W.

Ap—0 to 10 inches, very dark brown (10YR 2/2) loam, black (10YR 2/1) coatings on faces of peds; moderate, very fine, granular structure; very friable; about 15 percent gravel; neutral; clear, wavy boundary.

B2—10 to 16 inches, dark-brown (7.5YR 3/2) loam; moderate, medium, granular structure; friable; about 15 percent gravel; neutral; clear, wavy boundary.

IIC1—16 to 35 inches, dark-brown (7.5YR 3/2) stratified sand and gravel; single grained; loose; neutral; clear, wavy boundary.

IIC2—35 to 70 inches, grayish-brown (10YR 5/2) stratified coarse sand and fine gravel; single grained; mildly alkaline.

The solum ranges from 12 to 24 inches in thickness. Depth to carbonates ranges from 55 to 80 inches. The A horizon is very dark brown or very dark grayish brown loam or sandy loam. It ranges from 0 to 20 percent gravel. The B2

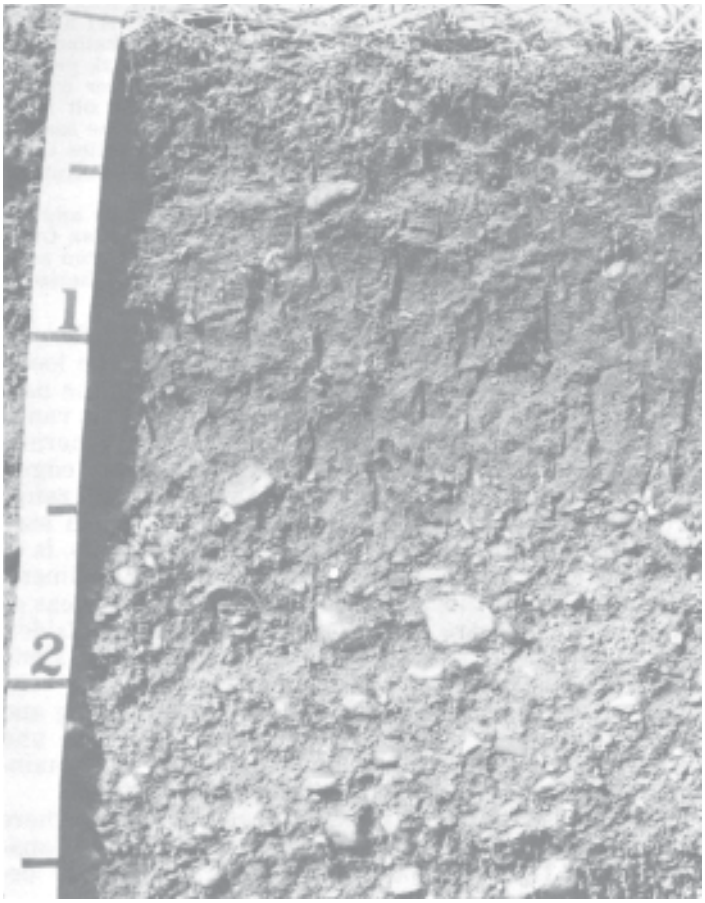

Figure 6.—**Profile of Burkhardt loam. Scale is in feet.**

horizon ranges from dark brown to brown loam or sandy loam. It ranges from 5 to 20 percent gravel. The IIC horizon is stratified sand and gravel or gravelly coarse sand. The IIC1 horizon ranges from dark brown to brown.

Burkhardt soils are near Alvin and Lilah soils and are similar to Estherville soils. They do not have the appreciable amount of translocated clay in the B horizon that Alvin and Lilah soils do. They are deeper over free carbonates than Estherville soils.

Burkhardt loam, 0 to 3 percent slopes (BrA).—This soil is on broad benches along major streams. In some areas it occupies the entire width of these benches. In others it adjoins areas of Dakota and Lilah soils and Salida soils on escarpments. Areas range from 2 to 70 acres in size. Included in mapping are areas of Lilah soils and some areas of gently sloping Burkhardt soils.

The main limitation is the low available water capacity and the moderate hazard of drought. The hazard of soil blowing is moderate. Runoff is slow. Most of it is absorbed because the infiltration rate is moderately high and permeability is moderately rapid. Natural fertility is low. The main management needs are controlling erosion, maintaining fertility, and irrigating where feasible.

This soil is used for crops and some pasture or woodland. Some areas that are being developed for housing north of Lake City are used as sources of sand and gravel. Where the soil is used as a septic tank absorption field, pollution of ground water is a hazard because the underlying material is rapidly permeable. Capability unit IIIs–1; woodland group 4; community development group 3; outdoor recreation group 11.

Canisteo Series

The Canisteo series consists of nearly level, poorly drained soils on broad uplands adjacent to smaller drainageways. These soils formed in loess and glacial till. The native vegetation was wet prairie grasses and sedges.

In a representative profile the surface layer is very dark gray silty clay loam about 10 inches thick. The subsoil is dark-gray to light olive-gray, slightly sticky silty clay loam and silt loam about 19 inches thick. The underlying material is grayish-brown and yellowish-brown sandy loam and loam.

Permeability is moderate, and available water capacity is high. The content of organic matter is high. The content of available phosphorus and potassium is low. A seasonal water table is at a depth of 2 to 4 feet.

Most areas are used for crops or pasture, for which the soils are better suited than for most other uses. The main limitation is the hazard of wetness.

Representative profile of Canisteo silty clay loam, 285 feet east and 1,260 feet north of the southwest corner of sec. 26, T. 109 N., R. 18 W.

Ap—0 to 10 inches, very dark gray (10YR 3/1) silty clay loam; weak, very fine, granular structure; friable; about 2 percent coarse fragments; mildly alkaline; slightly effervescent; abrupt, wavy boundary.

B1g—10 to 14 inches, dark-gray (5Y 4/1) silty clay loam, common black (10YR 2/1) tubular fillings; weak, coarse, subangular blocky structure parting to moderate, very fine, subangular blocky; slightly sticky; about 2 percent coarse fragments; mildly alkaline; slightly effervescent; clear, wavy boundary.

B21g—14 to 18 inches, olive-gray (5Y 5/2) silty clay loam; weak, coarse, subangular blocky structure parting to moderate, very fine, subangular blocky; slightly sticky; few very fine, fine, and medium, tubular pores; few, fine, dark-colored soft masses; mildly alkaline; slightly effervescent; clear, wavy boundary.

B22g—18 to 23 inches, light olive-gray (5Y 6/2) silt loam; few, fine, prominent, yellowish-brown (10YR 5/6) mottles; weak, very fine, subangular blocky structure; slightly sticky; mildly alkaline; slightly effervescent; clear, wavy boundary.

B23g—23 to 29 inches, light olive-gray (5Y 6/2) silt loam; common, fine, prominent, yellowish-brown (10YR 5/6) mottles; weak, fine, subangular blocky structure; slightly sticky; few, medium, soft masses of segregated lime; mildly alkaline; slightly effervescent; abrupt, wavy boundary.

IIC1—29 to 50 inches, grayish-brown (10YR 5/2) sandy loam; many, coarse, faint, brown (10YR 5/3) mottles; weak, coarse, subangular blocky structure; very friable; about 15 percent coarse fragments; mildly alkaline; slightly effervescent; abrupt, wavy boundary.

IIC2—50 to 60 inches, yellowish-brown (10YR 5/4) loam; many, coarse, distinct, gray (5Y 5/1) mottles; massive; firm; about 4 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum and silty mantle range from 25 to 30 inches in thickness. Depth to firm till ranges from 30 to 50 inches. The A horizon ranges from 10 to 15 inches in thickness. It is black or very dark gray silt loam or silty clay loam. The IIC1 horizon ranges from 2 to 25 inches in thickness. It is loam or sandy loam and is 5 to 25 percent coarse fragments. The IIC2 horizon is 2 to 8 percent coarse fragments.

Canisteo soils are near Maxfield and Klinger soils. They have a high content of lime throughout the solum, whereas Maxfield and Klinger soils do not contain lime.

Canisteo silty clay loam (0 to 2 percent slopes) (Ca).—This soil is on the rims of slightly elevated mounds around shallow depressions in drainageways of the broad, glaciated uplands. The surface layer of this soil appears lighter and grayer than that of adjoining Maxfield soils. Areas range from 2 to 20 acres in size.

The main limitations are the hazard of wetness and the reduced fertility caused by mild alkalinity. The main management needs are internal drainage and maintenance of fertility. Surface runoff is slow.

This soil is used for pasture or crops. If drainage is improved and fertility is maintained, it is well suited to corn and soybeans. Capability unit IIw–1; woodland group 9; community development group 2; outdoor recreation group 3.

Chaseburg Series

The Chaseburg series consists of nearly level to gently sloping, well-drained soils in narrow, smooth, entrenched drainageways on loess-covered uplands. The soils formed in recent alluvium. The native vegetation was bluegrasses.

In a representative profile the surface layer is very dark grayish-brown silt loam about 11 inches thick. The underlying material is stratified, very dark grayish-brown, grayish-brown, very dark gray, and black, friable silt loam.

Permeability is moderate, and available water capacity is very high. The content of organic matter is moderate. The content of available phosphorus and potassium is medium.

Most areas are used for pasture and crops, for which the soils are better suited than for most other uses. The main limitation is the hazard of flooding.

Representative profile of Chaseburg silt loam, 0 to 3 percent slopes, 50 feet west and 100 feet north of the southeast corner of SW¼ sec. 28, T. 111 N., R. 15 W.

A1—0 to 11 inches, very dark grayish-brown (10YR 3/2) silt loam; common, thin strata of dark grayish brown (10YR 4/2); weak, very thin, platy structure; very friable; neutral; abrupt, wavy boundary.

C1—11 to 24 inches, very dark grayish-brown (10YR 3/2) silt loam; common, thin strata of grayish brown (10YR 5/2); moderate, medium, platy structure; friable; few, fine, tubular pores; neutral; clear, wavy boundary.

C2—24 to 41 inches, very dark grayish-brown (10YR 3/2) silt loam; common, thin strata of grayish brown (10YR 5/2); moderate, thick, platy structure parting to moderate, fine, subangular blocky; friable; common, very fine and fine, tubular pores; neutral; gradual, wavy boundary.

C3—41 to 54 inches, very dark grayish-brown (10YR 3/2) silt loam; common, thin strata of grayish brown (10YR 5/2); coatings of very dark gray (10YR 3/1) on faces of peds; moderate, thick, platy structure parting to moderate, medium, subangular blocky; friable; neutral; abrupt, wavy boundary.

C4—54 to 66 inches, very dark gray (10YR 3/1) silt loam; common to many strata of grayish brown (10YR 5/2); many, fine, faint, dark-brown (10YR 4/3) mottles; weak to moderate, medium, platy structure parting to moderate, medium, subangular blocky; friable; neutral; abrupt, wavy boundary.

A1b—66 to 74 inches, black (10YR 2/1) silt loam that is high in content of sand; moderate, medium, granular structure; friable; neutral.

The A1 horizon is mainly very dark grayish brown or dark grayish brown, but lighter colored strata are in this horizon. It is mainly silt loam, but is stratified with loamy fine sand or fine sandy loam in most places. The A1 horizon is 4 to 14 inches thick and is neutral to mildly alkaline. The C horizon is mainly very dark grayish brown, dark grayish brown, or dark gray, but is stratified with lighter colored material in places. The C horizon is dominantly silt loam, but is stratified with fine sandy loam or loamy fine sand in some places. An Ab horizon, or buried soil, underlies the C horizon at a depth of 40 to 70 inches or more. It is stratified sandy to gravelly sediment.

Chaseburg soils are near Orion and Seaton soils and are similar to McPaul soils. They are better drained than Orion soils. Their profile is not so defined as that of Seaton soils. They do not have free carbonates in the A and C horizons, whereas McPaul soils do.

Chaseburg silt loam, 0 to 3 percent slopes (ChA).—This soil is in long, narrow drainageways in the loess-covered uplands and in the flood plains along the narrow upper reaches of major river valleys. Areas range from 50 to 300 feet in width; the width is generally defined by more sloping soils along the outer edges. Drainageways or watershed areas above this soil range from 40 acres to as much as 10 square miles in size. Flooding is frequent, follows most heavy showers, is of brief duration, and leaves varying amounts of sediment.

Included with this soil in mapping are some areas of Orion soils that are near some of the seepy hillsides. Also included are areas of Alluvial land, sloping, along the lower reaches of major drainageways.

The main limitations are the hazards of flooding and erosion in areas that have unstable channels and active gullies. The main management need is to maintain and improve these areas for waterway use.

This soil is suited to some pasture and crops where runoff waters can be contained in waterways. Capability unit IIw–3; woodland group 7; community development group 1; outdoor recreation group 1.

Colo Series

The Colo series consists of nearly level, poorly drained soils on flood plains along most narrow stream drainageways. These soils formed in alluvium. The native vegetation was water-tolerant grasses.

In a representative profile the surface layer is black and very dark gray silty clay loam about 42 inches thick. The subsoil is dark-gray, firm silty clay loam about 7 inches thick. The underlying material is olive-gray silty clay loam.

Permeability is moderately slow, and available water capacity is very high. The content of organic matter is high. The content of available phosphorus is medium, and that of potassium is low. A water table is at a depth of 1 foot to 3 feet.

Most areas are used for crops or pasture. These soils are better suited to such uses than to most others. The main limitations are hazards of flooding and wetness.

Representative profile of Colo silty clay loam, 395 feet south and 330 feet west of the northeast corner of SE¼SE¼ sec. 5, T. 109 N., R. 18 W.

A11—0 to 9 inches, black (10YR 2/1) silty clay loam; moderate, very fine and fine, granular structure; friable; neutral; abrupt, wavy boundary.

A12—9 to 20 inches, black (10YR 2/1) silty clay loam; moderate, fine, subangular blocky structure parting to moderate, fine, granular; friable; many, very fine and fine, tubular pores; neutral; clear, wavy boundary.

A13—20 to 30 inches, black (N 2/0) silty clay loam high in content of organic matter; weak, very fine, granular structure; very friable; many very fine, fine, and medium pores; neutral; clear, wavy boundary.
A14—30 to 35 inches, black (10YR 2/1) silty clay loam; moderate, fine, granular structure; friable; neutral; gradual, wavy boundary.
A3—35 to 42 inches, very dark gray (10YR 3/1) silty clay loam; moderate, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.
B2g—42 to 49 inches, dark-gray (5Y 4/1) silty clay loam; continuous, very dark gray (10YR 3/1) coatings on faces of peds and few, fine, faint, yellowish-brown (10YR 5/4) mottles; weak, fine, prismatic structure parting to moderate, fine, subangular blocky; firm; neutral; gradual, wavy boundary.
Cg—49 to 60 inches, olive-gray (5Y 5/2) silty clay loam; common, medium, distinct, olive (5Y 4/4) mottles; very dark gray (10YR 3/1) coatings on faces of some peds; weak, medium, subangular blocky structure; slightly sticky; mildly alkaline.

The solum ranges from 36 to 54 inches in thickness. Depth to carbonates ranges from 40 to 70 inches. The A horizon ranges from 25 to 50 inches in thickness. It is silty clay loam or heavy silt loam. Content of organic matter in the A horizon typically is high but ranges to very high. The B2g horizon typically is silt loam or silty clay loam, but ranges to clay loam. The C horizon typically is silty clay loam or silt loam, but contains coarser textured layers in some places.

Colo soils are near Maxfield soils and Orion soils and are similar to Bremer soils. They have a thicker A horizon than Maxfield soils. They contain more clay and less silt than Orion soils. They do not contain translocated clay in the B horizon, but Bremer soils have appreciable amounts in the B horizon.

Colo silty clay loam (0 to 2 percent slopes) (Co).—This smooth to somewhat hummocky soil is on narrow flood plains, mostly in the upper reaches of upland drainageways. Drainageways range from 50 to 300 feet in width. This soil is near more sloping soils and Maxfield and Garwin soils in depressions and upland drainageways. Flooding is frequent and of short duration. It occurs after most heavy showers and during spring snowmelt. Areas of this soil that are on broad flood plains along major rivers are less frequently flooded. Small creeks or springs commonly begin in areas of this soil. Included in mapping are some areas of Maxfield and Garwin soils in the upper reaches and some areas of Orion soils, which are near soils that formed in thick loess.

The main limitations are the hazards of flooding and wetness. The main management needs are installing drainage where feasible and containing floods.

This soil is used for crops and pasture. Most areas are well suited to pasture. Areas on broad flood plains where flooding is less frequent and the water table is below a depth of 30 inches are well suited to corn and soybeans. Capability unit IIIw–3; woodland group 9; community development group 1; outdoor recreation group 1.

Copaston Series

The Copaston series consists of nearly level to steep, well-drained soils on crests and sides of narrow upland ridges along major stream valleys. These soils formed in loamy sediment underlain by bedrock. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is very dark grayish-brown loam about 6 inches thick. The subsoil is dark yellowish-brown and dark-brown, friable loam about 10 inches thick. The underlying material is hard limestone bedrock.

Permeability is moderate, and available water capacity is low. The content of organic matter is moderate. The content of available phosphorus and potassium is low.

Most areas are used for pasture, forest, or crops. The soils are better suited to forest or pasture than to crops. The main limitations are hazards of drought and erosion.

Representative profile of Copaston loam, 1 to 6 percent slopes, in a pasture 530 feet west and 300 feet south of the northeast corner of NW¼ sec. 33, T. 112 N., R. 18 W.

A1—0 to 6 inches, very dark grayish-brown (10YR 3/2) loam; weak, very fine, granular structure; friable; about 2 percent coarse fragments; many roots; medium acid; abrupt, wavy boundary.
B21—6 to 12 inches, dark yellowish-brown (10YR 4/4) loam; dark-brown (10YR 4/3) coatings on faces of peds; weak, medium, subangular blocky structure; friable; about 2 percent coarse fragments; many roots; common, very dark gray (10YR 3/1), tubular fillings; slightly acid; clear, wavy boundary.
B22—12 to 16 inches, dark-brown (10YR 4/3) and dark yellowish-brown (10YR 4/4) loam; weak, medium, prismatic structure; friable; about 2 percent coarse fragments; neutral; abrupt, wavy boundary.
IIR—16 inches, limestone bedrock.

Thickness of the solum, or the depth to bedrock, ranges from 12 to 20 inches. The solum typically ranges from 0 to 15 percent coarse fragments. The A horizon is very dark grayish-brown, very dark brown, or dark-brown loam, sandy loam, or silt loam. The B horizon is loam, fine sandy loam, or sandy loam.

The Copaston moderately deep soils are 20 to 40 inches deep over bedrock, which is deeper than is defined as the range for the series. Available water capacity is moderate. Therefore, these soils are better suited to cultivated crops than the shallower Copaston soils.

Copaston soils are near Sogn soils. They do not have free carbonates, whereas Sogn soils have free carbonates throughout.

Copaston loam, 1 to 6 percent slopes (CvB).—This soil is on crests of narrow upland ridges that are adjacent to stream valleys. Areas range from 2 to 20 acres in size. This soil has the profile described as representative of the series. Included in mapping are some areas of moderately deep Copaston soils.

Because available water capacity is low, the main limitation is the severe hazard of drought. The hazard of erosion is moderate. Surface runoff is medium. The main management need is to control erosion and runoff by soil conserving practices or permanent vegetation.

This soil is used for pasture, woodland, and crops. It is well suited to pasture or woodland. It is suited to small grain and is poorly suited to row crops. Where septic tank absorption fields are planned, the pollution of ground water in the underlying bedrock is a hazard. Capability unit IIIe–3; woodland group 3; community development group 4; outdoor recreation group 7.

Copaston loam, 6 to 12 percent slopes, eroded (CvC2).—This soil is on sides of narrow upland ridges that are adjacent to stream valleys. Areas range from 2 to 15 acres in size. Included in mapping are some areas of Sogn soils. Also included are some soils that are similar to Copaston soils but contain more pebbles and cobblestones.

The hazards of further erosion and drought are severe. Surface runoff is medium. The main management needs are to control erosion and runoff by permanent vegetation or soil conserving practices.

This soil is used for pasture, woodland, and crops. It is well suited to pasture or woodland. Very close control of grazing is required because runoff and erosion are excessive. This soil is poorly suited to crops. Where septic tank absorption fields are planned, the pollution of ground water in the underlying bedrock is a hazard. Capability unit IVe–3; woodland suitability group 3; community development group 4; outdoor recreation group 8.

Copaston loam, moderately deep, 0 to 6 percent slopes (CwB).—This soil is on parts of stream benches that are underlain by bedrock and on some crests of narrow upland ridges. Areas range from 2 to 60 acres in size. This soil has a profile similar to the one described as representative of the series, but it is underlain by bedrock at a depth of 20 to 40 inches. Included in mapping are areas of soils that are more than 40 inches deep over bedrock.

Because available water capacity is moderate, the main limitation is the moderate hazard of drought. Surface runoff is medium. Some areas of this soil on stream benches are subject to soil blowing. The main management need is to schedule fieldwork to best utilize seasonal rainfall and the available water in the soil.

Most of the acreage is used for crops or pasture, and the soil is suited to this use. Where septic tank absorption fields are planned, pollution is a possible hazard. Capability unit IIe–2; woodland group 3; community development group 4; outdoor recreation group 7.

Copaston loam, moderately deep, 6 to 12 percent slopes, eroded (CwC2).—This soil is on sides of narrow upland ridges and stream benches. Slopes range from 50 to 200 feet in length. Areas range from 2 to 15 acres in size. This soil has a profile similar to the one described as representative of the series, but it is underlain by bedrock at a depth of 20 to 40 inches. Also, part of the surface layer has been lost through erosion and the subsoil is partly mixed into the surface layer. Included in mapping are some areas of Copaston soils that are less than 20 inches deep over bedrock.

The main limitations are moderate hazards of further erosion and drought. Surface runoff is medium. Erosion is most severe in areas that lack plant cover, especially during seedbed preparation and early plant growth. The main management needs are to control erosion and contain runoff. Minimum tillage that leaves crop residue on the surface is effective. Fertility needs to be maintained.

Most of the acreage is used for crops or pasture. Corn, small grain, and alfalfa-brome hay are suitable crops. Where septic tank absorption fields are planned, pollution is a possible hazard because the underlying limestone is fractured. Capability unit IIIe–2; woodland group 3; community development group 4; outdoor recreation group 8.

Dakota Series

The Dakota series consists of nearly level, well-drained soils on broad, smooth benches along streams. These soils formed in loamy and gravelly outwash. The native vegetation was tall prairie grasses and mixed hardwood forest.

In a representative profile the surface layer is very dark brown and very dark grayish-brown loam about 11 inches thick. The subsoil is about 34 inches thick. The upper 24 inches is dark-brown and yellowish-brown, friable loam and sandy loam; the lower 10 inches is stratified, yellowish-brown sand and dark yellowish-brown sandy loam. The underlying material is brown gravelly coarse sand.

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

Most areas are used for crops or pasture, and some are mined for gravel. The main limitation is the hazard of drought.

Representative profile of Dakota loam, 0 to 3 percent slopes, in the southwest corner of NW¼SE¼ sec. 23, T. 110 N., R. 16 W.

A1—0 to 8 inches, very dark brown (10YR 2/2) loam; moderate, very fine, granular structure; friable; medium acid; abrupt, wavy boundary.

A3—8 to 11 inches, very dark grayish-brown (10YR 3/2) loam; very dark brown (10YR 2/2) coatings on faces of peds; weak, very thin, platy structure; friable; few bleached silt particles on faces of peds; medium acid; clear, wavy boundary.

B21t—11 to 18 inches, dark-brown (10YR 4/3) loam; very dark grayish-brown (10YR 3/2) coatings on faces of peds; moderate, fine, subangular blocky structure; friable; many, medium, tubular fillings of very dark brown (10YR 2/2); many, very fine and fine, tubular pores; very few bleached sand grains on faces of peds; few clay films on faces of peds; medium acid; clear, wavy boundary.

B22t—18 to 27 inches, yellowish-brown (10YR 5/4) loam, dark-brown (10YR 4/3) coatings on faces of peds; moderate, medium, subangular blocky structure; friable; common, very fine and fine, tubular pores; about 1 percent gravel; very few bleached sand grains on faces of peds; few clay films on faces of peds; medium acid; abrupt, wavy boundary.

B23t—27 to 35 inches, yellowish-brown (10YR 5/4) sandy loam; weak, medium, subangular blocky structure; friable; few thin clay bridgings between sand grains; about 10 percent gravel; strongly acid; abrupt, wavy boundary.

IIB3t—35 to 45 inches, yellowish-brown (10YR 5/4) sand; thick, dark yellowish-brown (10YR 4/4) sandy loam bands; single grained; very friable; about 10 percent gravel; continuous clay bridgings between sand grains in bands; medium acid; abrupt, wavy boundary.

IIC—45 to 60 inches, brown (10YR 5/3) gravelly coarse sand; single grained; loose; about 25 percent gravel; moderately alkaline; slightly effervescent.

The solum ranges from 36 to 50 inches in thickness. It ranges from 1 to 10 percent gravel. The A horizon ranges from 10 to 15 inches in thickness. The A1 or Ap horizon ranges from 10 to 15 inches in thickness. The A1 or Ap horizon is very dark brown or very dark grayish brown. It typically is loam, but ranges to sandy loam. The A3 horizon, which is very dark grayish brown and is as much as 2 to 5 inches thick, occurs only in some places. The upper part of the B2t horizon is yellowish-brown, dark-brown, or dark yellowish-brown loam, clay loam, or sandy clay loam. The lower part is sandy clay loam or sandy loam. The IIB3t horizon ranges from 3 to 15 inches in thickness. It typically has few to many loamy sand or sandy loam bands. The IIC horizon is sand, coarse sand, or gravelly coarse sand. The content of gravel in the IIC horizon ranges from a trace to as much as 30 percent.

The Dakota soils are near Fairhaven and Biscay soils and are similar to Dickinson soils. They have some translocated clay in the B horizon, and Fairhaven soils do not. They do not have a seasonal high water table that is characteristic of Biscay soils, and they have a brighter colored B horizon than those soils. They contain less sand and more clay in A and B horizons than Dickinson soils.

Dakota loam, 0 to 3 percent slopes (DaA).—This soil is on broad benches of major streams. Areas range from 2 to 50 acres in size. These areas are the parts of benches generally closest to escarpments that adjoin a flood plain or a lower lying bench.

Because available water capacity is moderate, the main limitation is the moderate hazard of drought. Natural fertility is low to medium. Surface runoff is medium. The main management needs are to schedule fieldwork and to select early maturing crops that best utilize the available water in the soil and the more frequent early-season rains. Some irrigation can be used where considered feasible.

This soil is used mostly for crops or pasture. It is well suited to corn and small grain. Some areas are woodland. Some are a source of sand and gravel. Where the soil is used as a septic tank absorption field and the water table is below a depth of 20 feet, pollution of ground water is a hazard because the underlying material is rapidly permeable. Capability unit IIs–1; woodland group 3; community development group 3; outdoor recreation group 10.

Derinda Series

The Derinda series consists of sloping to steep, moderately well drained soils on convex crests and sides of narrow upland ridges. These soils formed in loess and shale residuum. The native vegetation was deciduous forest.

In a representative profile the surface layer is very dark grayish-brown silt loam about 7 inches thick. The subsoil is 20 inches thick. The upper 17 inches is dark yellowish-brown, friable silt loam and silty clay loam; the lower 3 inches is olive, firm clay. The underlying material is olive, soft shale.

Permeability is slow, and available water capacity is moderate. The content of organic matter is moderate. The content of available phosphorus is medium, and that of potassium is low.

Most areas are used for crops, pasture, or woodland. The main limitation is the hazard of erosion.

Representative profile of Derinda silt loam, 5 to 12 percent slopes, eroded, 400 feet east and 265 feet north of the center of sec. 10, T. 111 N., R. 16 W.

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam; weak to moderate, fine, granular structure; friable; medium acid; abrupt, smooth boundary.

B21t—7 to 10 inches, dark yellowish-brown (10YR 4/4) silt loam; dark-brown (10YR 4/3) coatings on faces of peds; common tubular fillings of very dark grayish brown (10YR 3/2); weak, fine, subangular blocky structure; friable; moderate, very fine and fine, tubular pores; common, thin clay films on faces of peds; medium acid; abrupt, wavy boundary.

B22t—10 to 19 inches, dark yellowish-brown (10YR 4/4) silt loam; dark-brown (10YR 4/3) coatings on faces of peds; moderate, fine, subangular blocky structure; friable; moderate, very fine and fine, tubular pores; common thin clay films on faces of peds; medium acid; clear, wavy boundary.

B23t—19 to 24 inches, dark yellowish-brown (10YR 4/4) silty clay loam; dark-brown (10YR 4/3) coatings on faces of peds; moderate, medium, subangular blocky structure; friable; common, very fine and fine, tubular pores; common moderately thick clay films on faces of peds; medium acid; abrupt, wavy boundary.

IIB3t—24 to 27 inches, olive (5Y 5/6) clay; dark grayish-brown (2.5Y 4/2) coatings on faces of peds; strong, medium, angular blocky structure; firm; thick thread-like accumulations of clay; medium acid; abrupt, wavy boundary.

IIC—27 to 45 inches, olive (5Y 4/3) shale; few, soft, clayey masses; massive and common cleavage; firm; medium acid.

The loess ranges from 15 to 30 inches in thickness. The solum ranges from 20 to 40 inches in thickness. The A horizon is very dark grayish brown or dark grayish brown. The B2t horizon is dark yellowish brown or dark brown. It is silt loam or silty clay loam in the upper part and silty clay loam in the lower part. The IIB3t horizon is silty clay or clay. The IIC horizon ranges from olive to greenish gray. It is dominantly hard shale, but in some places part of it has been weathered to clayey masses.

Derinda soils in Goodhue County have a darker colored A horizon and less clay in the upper part of the B horizon than is defined in the range for the series. However, this difference does not alter use or behavior.

Derinda soils are near Seaton soils and are similar to Dubuque and Schapville soils. They formed in a thin mantle of loess underlain by clayey residuum derived from shale, whereas Seaton soils formed entirely in loess and Dubuque soils formed in a thin mantle of loess underlain by limestone bedrock. Derinda soils formed in a thicker loess mantle than Schapville soils.

Derinda silt loam, 5 to 12 percent slopes, eroded (DeC2).—This soil is on crests and upper sides of narrow upland ridges that are a part of major stream valleys. Areas range from 2 to 15 acres in size. Slopes range from 100 to 300 feet in length. This soil has the profile described as representative of the series. Included in mapping are some areas of soils that have a slightly thicker combined surface layer and subsoil.

The main limitation is the moderate hazard of further erosion, which is most critical during spring planting and very early crop growth. Surface runoff is medium. Because available water capacity is moderate, the hazard of drought also is moderate. Fertility is medium to low. Tilth is difficult to maintain because this soil tends to slake and crust. The main management need is to control further erosion.

Most of this soil is used for crops or pasture. Some areas are woodland. If protected from further erosion, this soil is suited to most crops grown in the county. Capability unit IIIe–2; woodland group 3; community development group 5; outdoor recreation group 8.

Derinda silt loam, 12 to 25 percent slopes, eroded (DeD2).—This soil is on the upper sides of narrow upland ridges. Areas range from 2 to 15 acres in size. Slopes range from 75 to 300 feet in length. Included in mapping are a few small areas of Dubuque soils.

The main limitation is the severe hazard of further erosion in areas that are used for cultivated crops or are intensively pastured. Surface runoff is medium to rapid. Drought is a hazard because available water capacity is moderate. Natural fertility is medium to low. The main management needs are to control erosion and grazing and to maintain fertility.

Almost all the acreage is used for pasture, crops, or woodlands. The soil is best suited to woodland or pasture. In some areas it is suited to small grain and alfalfa-brome hay. Capability unit IVe–2; woodland

group 3; community development group 5; outdoor recreation group 9.

Dickinson Series

The Dickinson series consists of nearly level to moderately steep, well-drained soils on benches along rivers and streams. These soils formed in glacial outwash. The native vegetation was grasses.

In a representative profile the surface layer is very dark brown and very dark grayish-brown sandy loam and fine sandy loam about 18 inches thick. The subsoil is dark-brown, brown, and yellowish-brown, very friable and loose fine sandy loam and loamy sand about 17 inches thick. The underlying material is brown sand.

Permeability is moderately rapid, and available water capacity is moderate. The content of organic matter is moderate. The content of available phosphorus and potassium is medium.

Most areas are used for crops or pasture. The main limitations are hazards of drought and some erosion.

Representative profile of Dickinson sandy loam, 0 to 2 percent slopes, 200 feet north and 600 feet west of southeast corner of N½ of correction area along west edge of sec. 6, T. 112 N., R. 17 W.

Ap—0 to 9 inches, very dark brown (10YR 2/2) sandy loam; weak, fine, granular structure; friable; medium acid; clear, wavy boundary.

A1—9 to 14 inches, very dark brown (10YR 2/2) fine sandy loam; few fillings of very dark grayish brown (10YR 3/2); weak, fine, granular structure; very friable; common, very fine and fine, continuous, tubular pores in peds; medium acid; clear, wavy boundary.

A3—14 to 18 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; very dark brown (10YR 2/2) tubular fillings and coatings on faces of peds; weak, medium, subangular blocky structure; very friable; common, fine, continuous, tubular pores in peds; medium acid; clear, wavy boundary.

B21—18 to 25 inches, dark brown (10YR 4/3) fine sandy loam; weak, medium, subangular blocky structure; very friable; common, fine and medium, continuous, tubular pores in peds; meidum acid; clear, wavy boundary.

B22—25 to 32 inches, brown (10YR 5/3) fine sandy loam; dark-brown (10YR 4/3) coatings on faces of peds; moderate, medium, subangular blocky structure; very friable; common, fine and medium, continuous, tubular pores in peds; medium acid; clear, wavy boundary.

B3—32 to 35 inches, yellowish-brown (10YR 5/4) loamy sand; weak, coarse, subangular blocky structure; loose; slightly coherent; medium acid; abrupt, wavy boundary.

C—35 to 60 inches, brown (10YR 5/3) sand; single grained; loose; medium acid.

The solum ranges from 30 to 45 inches in thickness. The depth to free lime ranges from 50 to 80 inches. The A horizon ranges from 10 to 20 inches in thickness. It is sandy loam, fine sandy loam, or loam. The B2 horizon ranges from dark brown to yellowish brown. It is fine sandy loam, sandy loam, or loam. The B3 horizon is fine sand, sand, loamy sand, or loamy fine sand. The horizon is fine sand, sand, or coarse sand.

Dickinson soils are similar to Dakota and Sparta soils and are near Terril soils. They have less clay in the B horizon than Dakota soils. They have more silt and clay and less sand in the solum than Sparta soils. They have a thinner A horizon and a coarser textured C horizon than Terril soils.

Dickinson sandy loam, 0 to 2 percent slopes (DkA).—This soil is on benches along some of the streams in the county. Areas of this soil make up part or all of the benches. They range from 2 to 100 acres in size. This soil has the profile described as representative of the series. Included in mapping are some areas of soils that contain more sand and are thinner.

This soil tends to be droughty, and this tendency is the main limitation. Available water capacity is only moderate. Natural fertility is low to medium. This soil is subject to soil blowing in areas not sufficiently protected by vegetation. Surface runoff is slow, and most of it is absorbed because infiltration is moderately high and permeability is moderately rapid. The main management needs are to schedule fieldwork for maximum use of the available water in the soil, to maintain fertility, and to control soil blowing.

Most of the acreage is used for crops or pasture and is suited to this use. It is also well suited to such irrigated crops as corn and soybeans. Some areas are being developed for housing. Where septic tank absorption fields are planned, pollution of ground water is a hazard because the underlying material is rapidly permeable. Capability unit IIIs–1; woodland group 3; community development group 3; outdoor recreation group 10.

Dickinson sandy loam, 2 to 6 percent slopes (DkB).—This soil is on knolls on uplands and on some of the stream benches in the county. Areas range from 8 to 20 acres in size. This soil has a profile similar to that described as representative of the series, but it is thinner. Included in mapping are some areas of eroded and sandy soils.

Because available water capacity is moderate, the main limitation is the tendency to droughtiness. Surface runoff is medium, and most of it is absorbed because the rate of infiltration is moderately high and permeability is moderately rapid. Areas not sufficiently protected by vegetation are subject to some soil blowing and water erosion. The main management needs are to schedule fieldwork and to select early maturing crops to best utilize available water in the soil and the early season rains. Other needs are to maintain fertility and to reduce loss through erosion. Some irrigation can be used where considered feasible.

Most of the acreage is used for crops or pasture. The soil is well suited to small grain and corn. Where septic tank absorption fields are planned, pollution of ground water is a hazard because the underlying material is rapidly permeable. Capability unit IIIe–4; woodland group 3; community development group 3; outdoor recreation group 10.

Dickinson sandy loam, 6 to 12 percent slopes (DkC).—This soil is on concave slopes near the base of walls of river valleys and along the sides of some knolls on stream benches. It has a profile similar to that described as representative of the series, but the surface layer is thicker in some areas where material has washed from soils upslope and is thinner in areas where slopes are convex. Included in mapping are some areas of Sparta soils on bench escarpments and other areas where slopes are more than 12 percent.

The main limitation is the severe or moderate hazard of erosion. This soil is highly erodible because it lacks stability in deep cuts and in some areas it is subject to concentrated flow of runoff. Runoff is medium and collects on this soil from soils upslope. Soil blowing is a

hazard in areas that lack sufficient vegetation. This soil tends to be droughty because available water capacity is only moderate. The main management need is to control erosion and runoff.

This soil is used for crops, pasture, or woodland. It is suited to some crops but is better suited to woodland or pasture. Where the soil is used for septic tank absorption fields, pollution of the ground water is a hazard because the underlying material is rapidly permeable. Capability unit IVe–4; woodland group 3; community development group 3; outdoor recreation group 13.

Dodgeville Series

The Dodgeville series consists of nearly level to sloping, well-drained soils on sides and crests of narrow upland ridges. These soils formed in loess and limestone bedrock residuum underlain by limestone bedrock. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is very dark brown and very dark grayish-brown silt loam about 15 inches thick. The upper 9 inches of the subsoil is yellowish-brown, friable silt loam; the lower 5 inches is light olive-brown, firm clay. The underlying material is limestone and interbedded shale.

Permeability is moderate, and available water capacity is moderate. The content of organic matter is high. The content of available phosphorus is medium, and that of potassium is low.

Most areas are used for crops. The main limitations are hazards of erosion and drought.

Representative profile of Dodgeville silt loam, 1 to 6 percent slopes, 480 feet south and 560 feet west of the center of sec. 2, T. 111 N., R. 18 W.

Ap—0 to 9 inches, very dark brown (10YR 2/2) silt loam; weak, very fine, granular structure; friable; slightly acid; abrupt, wavy boundary.

A3—9 to 15 inches, very dark grayish-brown (10YR 3/2) silt loam; common mixings of very dark brown (10YR 2/2); weak, very fine, subangular blocky structure; friable; slightly acid; abrupt, wavy boundary.

B2—15 to 24 inches, yellowish-brown (10YR 5/4) silt loam; few mixings of very dark brown (10YR 2/2), dark-brown (10YR 4/3) coatings on faces of peds; moderate, fine, subangular blocky structure; friable; few, very fine, tubular pores; slightly acid; clear, wavy boundary.

IIB3—24 to 29 inches, light olive-brown (2.5Y 5/4) clay; weak, coarse, prismatic structure; firm; about 8 percent limestone fragments; mildly alkaline; slightly effervescent in parts; clear, wavy boundary.

R—29 inches, hard limestone and some interbedded shale.

The solum ranges from 20 to 40 inches in thickness. Depth to limestone ranges from 20 to 40 inches. The silty sediment ranges from 17 to 30 inches in thickness. The A horizon ranges from 10 to 20 inches in thickness. The B2 horizon is silt loam or silty clay loam. The IIB3 horizon ranges from 3 to 10 inches in thickness. It is clay or silty clay and is 1 to 10 percent coarse fragments.

Dodgeville soils in Goodhue County have a thinner IIB horizon than is defined as the range for the series and do not have an increase in clay content in the B horizon. These differences do not appreciably alter the use or behavior of the soils.

Dodgeville soils are near Schapville and Shullsburg soils, and they are similar to Dubuque soils. They have a thicker solum and contain more silt and less clay than Schapville soils. They are underlain by limestone, whereas Shullsburg soils are underlain by shale. They do not have an A2 horizon, which is typical of Dubuque soils.

Dodgeville silt loam, 1 to 6 percent slopes (DoB).—This soil is on crests of narrow upland ridges. Areas range from 2 to 30 acres in size. This soil has the profile described as representative of the series. Included in mapping are some areas of Copaston and Shullsburg soils.

The main limitations are the moderate hazard of erosion and a tendency to be droughty. This soil is most susceptible to erosion in areas that lack vegetation. The hazard of drought is moderate, because available water capacity is moderate. Surface runoff is medium. The main management needs are to control runoff and erosion and to maintain fertility.

This soil is used for crops or pasture. It is well suited to corn, small grain, and hay. Because the soil tends to dry out early when cropped, limiting plant population and planting crops that mature early are practices that best utilize the available water in the soil and the more frequent seasonal rains. Where the soil is used for septic tank absorption fields, pollution of ground water is a hazard because the underlying limestone bedrock is cavernous and fractured. Capability unit IIe–2; woodland group 3; community development group 4; outdoor recreation group 7.

Dodgeville silt loam, 6 to 12 percent slopes, eroded (DoC2).—This soil is on sides of narrow upland ridges and drainageways of some broad uplands. Areas range from 2 to 15 acres in size. This soil has a profile similar to that described as representative of the series, but part of the original surface layer has been lost through erosion. Included in mapping are some areas of Schapville or Shullsburg soils.

The main limitation is the severe hazard of further erosion. This soil is most susceptible to erosion in areas that lack sufficient vegetation. It tends to be droughty, because available water capacity is only moderate. Surface runoff is medium. The main management needs are to control erosion and runoff and to maintain fertility. Contour stripcropping, contouring, and minimum tillage are effective.

This soil is used for crops or pasture. Using it as pasture or woodland helps control erosion. Small grain, corn, and hay can be grown under good management. Where the soil is used as septic tank filter fields, pollution of ground water is a hazard because the underlying limestone bedrock is cavernous and fractured. Capability unit IIIe–2; woodland group 3; community development group 4; outdoor recreation group 8.

Dubuque Series

The Dubuque series consists of gently sloping to very steep, well-drained soils on the sides and crests of narrow upland ridges along major streams. These soils formed in loess and in residuum derived from limestone bedrock. The native vegetation was deciduous hardwood.

In a representative profile the surface layer is very dark grayish-brown silt loam about 6 inches thick, and the subsurface layer is dark-brown silt loam about 8 inches thick. The upper 14 inches of the subsoil is yellowish-brown, friable silt loam; the lower 4 inches formed in residuum and is strong-brown sandy clay. The underlying material is partly weathered limestone.

Permeability and available water capacity are mod-

erate. The content of organic matter is moderate. The content of available phosphorus and potassium is low.

Most areas are used for crops, pasture, or woodland. The main limitations are hazards of erosion and drought.

Representative profile of Dubuque silt loam, 18 to 35 percent slopes, in a wooded area 500 feet west and 250 feet south of the northeast corner of NW¼ sec. 34, T. 112 N., R. 15 W.

A1—0 to 6 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, very fine, granular structure; friable; medium acid; abrupt, wavy boundary.

A2—6 to 14 inches, dark-brown (10YR 4/3) silt loam; dark grayish-brown (10YR 4/2) coatings; weak, very thin, platy structure; very friable; medium acid; clear, irregular boundary.

B1—14 to 21 inches, yellowish-brown (10YR 5/4) silt loam; weak, fine, subangular blocky structure; friable; thin, continuous, grayish-brown (10YR 5/2) coatings of silt and very fine sand on faces of peds; strongly acid; clear, wavy boundary.

B21t—21 to 28 inches, yellowish-brown (10YR 5/4) silt loam; moderate, fine, subangular blocky structure; friable; common, thin coatings of silt and very fine sand on faces of peds; few thin clay films on faces of peds and in pores; common, very fine and fine, continuous, open, tubular pores in peds; strongly acid; abrupt, wavy boundary.

IIB22t—28 to 32 inches, strong-brown (7.5YR 5/6) sandy clay; moderate, coarse, subangular blocky structure; firm; common, thin silty coatings on faces of peds; few thin clay films on faces of peds; about 3 percent coarse fragments; medium acid; clear, wavy boundary.

IIR—32 inches, hard, partly fractured limestone.

Thickness of the solum, or depth to bedrock, ranges from 20 to 40 inches. The upper part of the solum does not have coarse fragments, while the lower part ranges from 2 to 15 percent coarse fragments. The A1 horizon is silt loam and typically is very dark grayish brown but ranges to dark grayish brown. It ranges from 4 to 8 inches in thickness in wooded areas, and its thickness in cultivated areas is controlled by the depth of plowing. The A2 horizon ranges from very dark grayish brown to brown and typically is 2 to 10 inches thick, but it is missing in some cultivated areas. The B2 horizon is brown or yellowish-brown silt loam or light silty clay loam. Clay films in the B2 horizon are thin and few to common. The IIB horizon ranges from 2 to 12 inches in thickness and from strong brown or brown to yellowish brown. It ranges from sandy clay to clay. The R horizon is generally partly weathered in the upper 2 feet and is hard and jointed below this depth.

Dubuque soils are near Seaton and Mt. Carroll soils and are similar to Dodgeville soils. They formed in a thinner mantle of loess than Seaton and Mt. Carroll soils. They have an A2 horizon and Dodgeville soils do not.

Dubuque silt loam, 2 to 6 percent slopes, eroded (DuB2).—This soil is on crests of narrow upland ridges. Areas range from 2 to 30 acres in size. This soil has a profile similar to that described as representative of the series, but it is eroded, lacks a subsurface layer, and has a thinner subsoil that is partly mixed into the surface layer. Included in mapping are areas of soils that are very shallow over limestone bedrock.

The limitations are moderate hazards of further erosion and of drought. This soil is most susceptible to erosion in areas that lack sufficient vegetation. The hazard of drought is moderate because available water capacity is moderate. Surface runoff is medium. The main management needs are to control runoff and erosion and to maintain fertility.

This soil is used for crops, pasture, or woodland. It is better suited to pasture or woodland than to crops. It is suited to small grain and red clover hay. Some corn can be grown, but production is relatively low. Where the soil is used for septic tank absorption fields, pollution of ground water is a hazard because the underlying limestone bedrock is fractured and cavernous. Capability unit IIe–2; woodland group 3; community development group 4; outdoor recreation group 7.

Dubuque silt loam, 6 to 12 percent slopes, eroded (DuC2).—This soil is on sides of narrow upland ridges and of drainageways on some broad uplands. Areas range from 2 to 30 acres in size. This soil has a profile similar to that described as representative of the series, but in most cultivated areas it is eroded. The thickness of the surface layer is controlled by the depth of plowing, the subsurface layer is generally lacking, and the subsoil is thinner and partly mixed into the surface layer. Included in mapping are areas of soils that are severely eroded or that have limestone bedrock at a very shallow depth.

The main limitation is the severe hazard of further erosion, and this soil is most susceptible to erosion in areas that lack sufficient vegetation. The hazard of drought is moderate because available water capacity is moderate. Surface runoff is medium. The main management needs are to control erosion and runoff and to maintain fertility.

This soil is used for crops, pasture, or woodland. It is better suited to pasture or woodland than to crops because of erosion and drought. Some areas are being developed for housing. Where septic tank absorption fields are planned, pollution of ground water is a hazard because the underlying limestone is fractured. Capability unit IIIe–2; woodland group 3; community development group 4; outdoor recreation group 8.

Dubuque silt loam, 12 to 18 percent slopes, eroded (DuD2).—This soil is on sides of narrow upland ridges and entrenched drainageways in some of the broad uplands. Areas range from 2 to 30 acres in size. This soil has a profile similar to that described as representative of the series, but in most cultivated areas it is eroded, lacks a subsurface layer, and has a thinner subsoil that is partly mixed into the surface layer. Included in mapping are areas of soils that are severely eroded or that are very shallow over limestone bedrock.

The main limitation is the severe hazard of further erosion, and this soil is most susceptible to erosion in areas that are not protected by vegetation. The hazard of drought is moderate because available water capacity is moderate. Surface runoff is medium to rapid. The main management needs include control of erosion and runoff and maintenance of fertility.

This soil is used for crops, pasture, or woodland. It is well suited to woodland and to pasture if grazing is controlled. It is poorly suited to crops because erosion and drought are hazards. Where septic tank absorption fields are planned, pollution of ground water is a hazard because the underlying limestone is fractured. Capability unit IVe–2; woodland group 3; community development group 4; outdoor recreation group 8.

Dubuque silt loam, 18 to 35 percent slopes (DuF).—This soil is on sides of narrow upland ridges and deep ravines on broad uplands. Areas mostly range from 2 to 30 acres in size. This soil has the profile described as representative of the series. In cultivated areas, this soil is eroded, and the subsurface layer and parts of the

subsoil are generally lacking. Included in mapping are areas of severely eroded Dubuque soils and areas of Frontenac or Marlean soils on some of the lower slopes.

The main limitation is the very severe hazard of erosion. This soil is most susceptible to erosion in areas that lack vegetation or management. The hazard of drought is moderate because available water capacity is moderate. Surface runoff is rapid. The main management needs include control of erosion and runoff and maintenance of fertility.

This soil is used mostly for pasture or woodland. It is well suited to woodland. It is not suited to crops because it is steep and erosion and drought are hazards. Capability unit VIIe–2; woodland group 5; community development group 7; outdoor recreation group 9.

Eleva Series

The Eleva series consists of gently sloping to moderately steep, somewhat excessively drained soils on knolls of bedrock benches that are a part of or adjoin loamy, sandy, or gravelly outwash benches along major streams. These soils formed in loamy outwash underlain by sandstone. The native vegetation was deciduous forest.

In a representative profile the surface layer is dark grayish-brown sandy loam about 7 inches thick, and the subsurface layer is dark-brown sandy loam about 2 inches thick. The upper 14 inches of the subsoil is brown, friable sandy loam; the lower 14 inches is yellowish-brown and very pale brown sandy loam and sand. The underlying material is white, soft sandstone.

Permeability is moderately rapid, and available water capacity is low. The content of organic matter is low. The content of available phosphorus and potassium is low.

Most areas are used for crops, pasture, or woodland. The main limitations are hazards of drought and erosion.

Representative profile of Eleva sandy loam, 2 to 6 percent slopes, in a cultivated field about 100 feet north and 100 feet west of the southeast corner of SW¼SW¼ sec. 12, T. 112 N., R. 17 W.

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) sandy loam, light brownish gray (10YR 6/2) dry; weak, very fine, granular structure; very friable; about 2 percent coarse fragments; medium acid; abrupt, smooth boundary.

A2—7 to 9 inches, dark-brown (10YR 4/3) sandy loam; weak fine, subangular blocky structure; very friable; about 2 percent coarse fragments; medium acid; abrupt, wavy boundary.

B21t—9 to 23 inches, brown (10YR 5/3) sandy loam; dark-brown (7.5YR 4/4) coatings on faces of peds; moderate, fine, subangular blocky structure; friable; many clay bridgings between sand grains and common thin clay films on faces of peds; about 2 percent coarse fragments; medium acid; abrupt, wavy boundary.

B22—23 to 27 inches, yellowish-brown (10YR 5/4) sandy loam; weak, coarse, subangular blocky structure; very friable; about 2 percent coarse fragments; medium acid; abrupt, wavy boundary.

IIB3—27 to 37 inches, very pale brown (10YR 7/3) sand; single grained; loose; few, thin, dark yellowish-brown (10YR 4/4) sandy loam bands; strongly acid; clear, wavy boundary.

IIIC—37 to 40 inches, white (10YR 8/1) soft sandstone.

Thickness of the solum, or depth to sandstone, ranges from 20 to 40 inches. The solum ranges from slightly acid to strongly acid. It typically ranges from 1 to 10 percent coarse fragments. Some places have an A1 horizon that ranges from 4 to 6 inches in thickness. It is sandy loam, fine sandy loam, or light loam. The A2 horizon ranges from 1 to 5 inches in thickness. The B horizon ranges from dark brown to yellowish brown or brown. It is sandy loam, fine sandy loam, or light loam. Common to many clay bridgings are between the sand grains in the B2 horizon. Underlying sandstone is soft to weakly cemented.

Eleva soils are near Gotham soils and are similar to Billett and Gale soils. They contain more clay and less sand in the B horizon than Gotham soils. They do not have the deep, loose, sandy C horizon that Billett soils have. They contain less clay and more sand in the B horizon than Gale soils.

Eleva sandy loam, 2 to 6 percent slopes (EeB).—This soil is on knolls on stream benches underlain by bedrock and on knolls on some broad uplands. Areas range from 2 to 20 acres in size. This soil has the profile described as representative for the series. Included in mapping are some areas of sandstone outcrops near the crests of knolls. Also included are areas of soils that have sandstone at a depth of 40 to 60 inches.

Because available water capacity is low, the main limitation is the moderate hazard of drought. Surface runoff is slow or medium, and most of it is absorbed because the rate of infiltration is moderately high and permeability is moderately rapid. The soil is subject to soil blowing and water erosion in areas that lack sufficient vegetation. The main management needs are to schedule fieldwork and to select early maturing crops so that the available water in the soil is best utilized. Maintenance of fertility and control of erosion are also needed. Some irrigation can be used where it is considered feasible.

This soil is used for crops, woodland, or pasture. It is well suited to small grain and red clover hay. Where septic tank absorption fields are planned, pollution of ground water is a hazard because the underlying sandstone is permeable. Capability unit IIIe–4; woodland group 3; community development group 4; outdoor recreation group 7.

Eleva sandy loam, 6 to 18 percent slopes (EeD).—This soil is on sides of knolls on stream benches underlain by bedrock and on knolls on some broad uplands. Areas range from 2 to 20 acres in size. This soil has a profile similar to that described as representative of the series, but it is thinner. Included in mapping are areas of sandstone outcrops or areas of soils that are thin and gravelly or contain more sand.

The main limitation is the severe or moderate hazard of erosion. This soil is highly erodible because it lacks stability in deep cuts and where surface runoff flows. Surface runoff is medium. This soil is subject to soil blowing in areas that are not sufficiently protected by vegetation. The hazard of drought is moderate or severe because available water capacity is low. The main management need is to control erosion and runoff.

This soil is used for crops, pasture, or woodland. It is well suited to woodland or other permanent vegetation. Where the soil is used as a septic tank absorption field, pollution of ground water is a hazard because the underlying sandstone is permeable. Capability unit IVe–4; woodland group 3; community development group 4; outdoor recreation group 8.

Estherville Series

The Estherville series consists of nearly level to moderately steep, somewhat excessively drained soils on broad stream benches. These soils formed in loamy and gravelly glacial outwash. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is about 14 inches thick; it is very dark brown loam in the upper part and very dark grayish brown sandy loam in the lower part. The upper 8 inches of the subsoil is dark yellowish-brown, friable sandy loam; the lower 5 inches is dark-brown gravelly coarse sand. The underlying material is grayish-brown gravelly coarse sand.

Permeability is rapid, and available water capacity is low. The content of organic matter is moderate. The content of available phosphorus and potassium is low.

Most areas are used for crops or pasture, and some areas are used for residential developments. The main limitation is the hazard of drought.

Representative profile of Estherville loam, 0 to 6 percent slopes, about 350 feet north and 750 feet east of the southwest corner of NW¼ sec. 18, T. 112 N., R. 17 W.

A1—0 to 8 inches, very dark brown (10YR 2/2) loam; weak, very fine, granular structure; very friable; about 6 percent gravel; medium acid; abrupt, wavy boundary.

A3—8 to 14 inches, very dark grayish-brown (10YR 3/2) sandy loam, common mixings of very dark brown (10YR 2/2); weak, very fine, subangular blocky structure; very friable; many very fine, fine, and medium, tubular pores; about 15 percent gravel; medium acid; clear, wavy boundary.

B2—14 to 22 inches, dark yellowish-brown (10YR 3/4) sandy loam, dark-brown (7.5YR 3/2) coatings on faces of peds; weak, medium, subangular blocky structure; friable; many very fine, fine, and medium, tubular pores; about 15 percent gravel; medium acid; abrupt, wavy boundary.

IIB3—22 to 27 inches, dark-brown (7.5YR 3/2) gravelly coarse sand; single grained; loose; medium acid; clear, wavy boundary.

IIC1—27 to 45 inches, grayish-brown (10YR 5/2) gravelly coarse sand; single grained; loose; moderately alkaline; slightly effervescent; abrupt, wavy boundary.

IIC2—45 to 80 inches, grayish-brown (10YR 5/2) gravel stratified with gravelly coarse sand; about 20 percent cobblestones; moderately alkaline; strongly effervescent.

The solum ranges from 20 to 30 inches in thickness. The depth to sand and gravel ranges from 15 to 30 inches. The A1 and B2 horizons range from 1 to 15 percent gravel. The A horizon ranges from 10 to 15 inches in thickness. It is loam or sandy loam. It ranges from medium acid to neutral. The B2 horizon ranges from dark brown to dark yellowish brown. It is sandy loam or loam. The IIC horizon is gravelly sand, gravelly coarse sand, or stratified sand and gravel.

Estherville soils are near Dickinson and Salida soils and are similar to Burkhardt soils. They contain more gravel than Dickinson soils. They have a thicker solum than Salida soils. They contain free carbonates at a shallower depth than Burkhardt soils.

Estherville loam, 0 to 6 percent slopes (EsA).—This soil is on broad benches along major streams. Areas range from 2 to 100 acres in size and make up most of the benches. This soil has the profile described as representative of the series. Included in mapping are numerous small areas of Salida soils that appear as very convex rises.

The main limitations are low available water capacity and the moderate hazard of soil blowing. Surface runoff is slow, and most of it is absorbed because the rate of infiltration is moderately high and permeability is moderately rapid. Natural fertility is low. The main management needs include control of erosion and maintenance of fertility. Irrigation can be used where considered feasible.

This soil is used for crops and some pasture or woodland. Some areas are being developed for housing and are used as a source of sand and gravel. Where the soil is used as a septic tank absorption field and the water table is below a depth of 20 feet, pollution of ground water is a hazard because the underlying material is rapidly permeable. Capability unit IIIs–1; woodland group 4; community development group 3; outdoor recreation group 11.

Estherville soils, 6 to 18 percent slopes (EsC).—These soils are on escarpments of broad benches along major streams. Areas range from 2 to 15 acres in size. Slopes range from 50 to 150 feet in length. The profiles of these soils are similar to the representative profile, but some are loamy throughout and others contain more sand. Included in mapping are numerous small areas of Salida soils.

The main limitations are moderate hazards of erosion and drought. These soils are susceptible to soil blowing and water erosion. They are droughty because available water capacity is low. The main management need is to control erosion by establishing permanent vegetation.

These soils are used for crops, pasture, and woodland. They are well suited to permanent vegetation such as trees. Some areas are being developed for housing and are used as a source of sand and gravel. Where septic tank absorption fields are planned, pollution of ground water tables is a hazard because the underlying material is rapidly permeable. Capability unit IVe–4; woodland group 4; community development group 9; outdoor recreation group 13.

Fairhaven Series

The Fairhaven series consists of nearly level to moderately steep, well-drained soils on broad benches along streams. These soils formed in loamy material underlain by sandy or gravelly outwash. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is very dark brown and very dark grayish-brown silt loam about 12 inches thick. The upper 21 inches of the subsoil is dark-brown, dark yellowish-brown, and yellowish-brown, friable silt loam and loam; the lower 5 inches is yellowish-brown gravelly sandy loam. The underlying material is grayish-brown gravelly coarse sand.

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

Most areas are used for crops or pasture. The main limitations are hazards of drought and some erosion.

Representative profile of Fairhaven silt loam, 0 to 3 percent slopes, 60 feet north and 400 feet west of the southeast corner of SW¼ sec. 25, T. 110 N., R. 17 W.

Ap—0 to 8 inches, very dark brown (10YR 2/2) silt loam; fine granular structure; friable; neutral; abrupt, smooth boundary.

A3—8 to 12 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, fine, subangular blocky structure parting to moderate, very fine, granular; friable; many, very fine and fine, tubular pores; neutral; clear, wavy boundary.

B21—12 to 15 inches, dark-brown (10YR 4/3) silt loam; dark grayish-brown (10YR 4/2) coatings on faces of peds; weak, medium, subangular blocky structure; friable; many, very fine and fine, tubular pores; medium acid; abrupt, wavy boundary.

B22—15 to 22 inches, dark yellowish-brown (10YR 4/4) silt loam; coatings of dark brown (10YR 4/3) on faces of peds; moderate, fine and medium, subangular blocky structure; friable; many, very fine and fine, tubular pores; strongly acid; abrupt, wavy boundary.

IIB23—22 to 28 inches, yellowish-brown (10YR 5/4) loam; moderate, medium, subangular blocky structure; friable; many, very fine and fine, tubular pores; about 4 percent gravel; few, very thin clay films on faces of peds; strongly acid; abrupt, wavy boundary.

IIB24—28 to 33 inches, yellowish-brown (10YR 5/4) loam; moderate, medium, subangular blocky structure; friable; many, very fine and fine, tubular pores; about 10 percent gravel; strongly acid; abrupt, wavy boundary.

IIB3—33 to 38 inches, yellowish-brown (10YR 5/4) gravelly sandy loam; weak, coarse, subangular blocky structure; very friable; about 10 percent gravel and cobblestones; strongly acid; abrupt, wavy boundary.

IIIC—38 to 60 inches, grayish-brown (10YR 5/2) gravelly coarse sand; single grained; loose; about 5 percent cobblestones and gravel; mildly alkaline; slightly effervescent.

The solum is 30 to 45 inches thick. Depth to underlying sand and gravel ranges from 25 to 40 inches. Depth to free carbonates ranges from 30 to 45 inches. The A and B2 horizons range from 1 to 10 percent coarse fragments in some places, but in most places they have none. The A horizon ranges from 10 to 20 inches in thickness. It is silt loam or loam, and the content of silt and very fine sand is very high. The thickness of the combined B21 and B22 horizons ranges from 10 to 20 inches. These horizons are dark brown or dark yellowish brown. They are silt loam high in content of sand or loam. The IIB2 horizon ranges from 5 to 15 inches in thickness. It ranges from heavy loam to sandy loam and is 2 to 15 percent gravel. The IIC horizon is gravelly coarse sand or stratified sand and gravel.

Fairhaven soils are near Dakota soils and Waukegan soils. They do not have the appreciable amounts of translocated clay in the B horizon that is characteristic of Dakota soils. They contain more sand and less silt in the solum than Waukegan soils.

Fairhaven silt loam, 0 to 3 percent slopes (FaA).—This soil is on broad benches of major streams. Areas range from 2 to 100 acres in size.

Because available water capacity is moderate, the main limitation is the moderate hazard of drought. Surface runoff is medium or slow, and much of it is absorbed because the rate of infiltration is moderate and permeability is moderately rapid. The main management needs are to schedule fieldwork and to select early maturing crops to best utilize available water in the soil and the more frequent seasonal rains.

This soil is used mostly for crops. Some areas are in pasture or used as a source of sand and gravel. It is well suited to row crops, especially corn and soybeans. Some irrigation can be used where considered feasible. Where septic tank absorption fields are planned, pollution of ground water at a depth below 10 feet is a hazard because the underlying material is rapidly permeable. Capability unit IIs–1; woodland group 3; community development group 3; outdoor recreation group 10.

Frontenac Series

The Frontenac series consists of steep and very steep, well-drained soils on valley walls. These soils formed in loess and residuum from limestone. The native vegetation was deciduous hardwood.

In a representative profile the surface layer is very dark brown and very dark grayish-brown silt loam about 12 inches thick. The subsoil is dark yellowish-brown, friable silt loam about 18 inches thick. The underlying material is very pale brown, friable channery and cobbly loam.

Permeability and available water capacity are moderate. The content of organic matter is moderate. The content of available phosphorus is medium, and that of potassium is low.

Most areas are woodland and are in the Memorial Hardwood State Forest. The main limitations are the hazard of erosion and the steepness of slope.

Representative profile of Frontenac soils, very steep, in an area of Frontenac silt loam, 1,155 feet south and 1,150 feet east of the northwest corner of NE¼ sec. 21, T. 113 N., R. 15 W.

A1—0 to 7 inches, very dark brown (10YR 2/2) silt loam; moderate, very fine, granular structure; very friable; many roots; neutral; clear, wavy boundary.

A3—7 to 12 inches, very dark grayish-brown (10YR 3/2) silt loam and mixings of dark brown (10YR 4/3); moderate, fine, granular structure; very friable; many roots; neutral; clear, wavy boundary.

B21—12 to 20 inches, dark yellowish-brown (10YR 4/4) silt loam; dark-brown (10YR 4/3) coatings on faces of peds; moderate, very fine, subangular blocky structure; friable; many, very fine and fine, tubular pores; about 5 percent coarse fragments, mostly flagstones and channers; many roots; neutral; clear, wavy boundary.

B22—20 to 30 inches, yellowish-brown (10YR 5/4) silt loam; some dark-brown (10YR 4/3) coatings on faces of peds; moderate, fine, subangular blocky structure; friable; many, very fine and fine, tubular pores; about 10 percent coarse fragments, mostly flagstones and channers; neutral; abrupt, wavy boundary.

IIC1—30 to 40 inches, very pale brown (10YR 8/3) channery loam; weak, coarse, subangular blocky structure; friable; about 45 percent coarse fragments, mostly channers and about 10 percent flagstones; mildly alkaline; slightly effervescent; abrupt, wavy boundary.

IIC2—40 to 120 inches, very pale brown (10YR 8/3) cobbly loam; massive; friable; about 60 percent rock fragments, mostly cobblestones and about 25 percent stones; mildly alkaline; strongly effervescent.

The solum ranges from 20 to 40 inches in thickness. Depth to free carbonates ranges from 20 to 60 inches. The solum ranges from 25 to 50 percent sand and from 18 to 25 percent clay.

The A horizon typically does not have coarse fragments, but in some places it is as much as 10 percent coarse fragments. The B horizon is 2 to 15 percent coarse fragments. The IIC horizon is 35 to 70 percent coarse fragments. The A and B horizons range from medium acid to neutral. The IIC horizon is neutral to mildly alkaline.

The A horizon ranges from very dark brown to very dark grayish brown. It is loam or silt loam and has weak or moderate, granular structure. The B horizon ranges from brown or dark brown to dark yellowish brown or yellowish brown. It is silt loam or loam. The B horizon has weak or moderate, subangular blocky structure. Few patchy clay films on faces of peds or in lining of pores are in the B

horizon in some places. The IIC horizon is flaggy, channery, or cobbly silt loam, sandy loam, or loam.

Frontenac soils are near Brodale, Dubuque, and Marlean soils. They have a thicker profile than Brodale or Marlean soils. They are not shallow over bedrock, which is characteristic of Dubuque soils.

Frontenac soils, steep (25 to 40 percent slopes) (FrE).—These soils are on north-facing and east-facing sides of valley walls, mainly upstream from major rivers. Elevations from the base of ridgetops to the valley floor vary from 75 to 150 feet.

Frontenac soils make up about 50 percent of this unit, soils similar to Frontenac soils about 25 percent, and Dubuque or Marlean soils about 25 percent. The similar soils formed in a similar material to that in which Frontenac soils formed, but they have a thin subsurface layer or they contain more sand in the upper part of the profile. The Dubuque or Marlean soils are on shoulders or the upper part of sides of steep hills. Included in mapping are some areas of rock outcrop that are indicated on the detailed soil map by the symbol for rock outcrop. These outcrops are of the Galena, Platteville, and Shakopee Formations.

Surface runoff is rapid and very rapid and depends on the condition of vegetative cover. It can be released at a very high velocity in areas that have been grazed or have had excessive traffic, and it causes gullies in adjoining soils along lower foot slopes and toe slopes. This runoff can be slowed and controlled if good stands of woodland are maintained and grazing is not permitted. This type of management adds a mulch of leaves that combines with an understory growth on the forest floor. Woodlands are very spongelike and absorb a large amount of precipitation and runoff, and also aid in the recharge of ground water reservoirs in the various bedrock outcrops in this unit. The woodland can be harvested for timber. Capability unit VIIe–2; woodland group 5; community development group 7; outdoor recreation group 12.

Frontenac soils, very steep (40 to 80 percent slopes) (FrF).—These soils are on north-facing and east-facing walls of river valleys. Elevations from the base of ridgetops to the valley floor vary from 150 to 400 feet.

Frontenac soils make up 50 percent of this unit, other soils about 45 percent, and Dubuque and Marlean soils about 5 percent. The Frontenac soils have the profile described as representative of the series (fig. 7). The other soils have a thinner surface layer, have a subsurface layer, and contain more clay in the subsoil or they contain more sand. Included in mapping are some areas of rock outcrop on the upper part of slopes. These outcrops are of the Jordan, Oneota, Shakopee, St. Peter, Platteville, and Galena Formations.

Surface runoff is rapid and very rapid and depends on the condition of vegetative cover. Runoff is highest in areas that have been grazed or have had excessive traffic. It can be released at a very high velocity and cause gullies in adjoining soils along lower foot slopes and toe slopes. This runoff can be slowed and controlled if good stands of timber are maintained and grazing and excessive traffic are not permitted. This type of management adds a mulch of leaves and allows an understory growth that is very spongelike and absorbs a large amount of precipitation and runoff. This also aids in the recharge of ground water reservoirs in the various bedrock outcrops in this unit. The woodland can be harvested for timber. Capability unit VIIe–2; woodland group 5; community development group 7; outdoor recreation group 12.

Figure 7.—**Profile of Frontenac silt loam in an area of Frontenac soils, very steep, shows loamy rock debris.**

Gale Series

The Gale series consists of nearly level and gently sloping, well-drained soils slightly above natural drainageways, on lower foot slopes of broad uplands. These soils formed in loess underlain by sandstone. The native vegetation was deciduous forest.

In a representative profile the surface layer is dark grayish-brown silt loam about 8 inches thick, and the subsurface layer is dark-brown silt loam about 3 inches thick. The subsoil is yellowish-brown and brown, friable silt loam about 27 inches thick. The underlying material is yellow, soft sandstone and fine sand.

Permeability and available water capacity are moderate. The content of organic matter is moderate. The content of available phosphorous is medium, and that of potassium is low.

Most areas are used for crops or pasture. The main limitations are hazards of drought and some erosion.

Representative profile of Gale silt loam, 0 to 3 percent slopes, about 680 feet south and 200 feet east of

the northwest corner of NE¼NW¼ sec. 21, T. 111 N., R. 15 W.

Ap—0 to 8 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; weak, very fine, granular structure; friable; neutral; abrupt, smooth boundary.

A2—8 to 11 inches, dark-brown (10YR 4/3) silt loam, dark grayish-brown (10YR 4/2) coatings on faces of peds; moderate, medium, platy structure; friable; slightly acid; clear, irregular boundary.

B1—11 to 27 inches, yellowish-brown (10YR 5/4) heavy silt loam; moderate, very fine, subangular blocky structure; friable; thin, continuous, brown (10YR 5/3) coatings of silt particles on faces of peds; common, very fine and fine, tubular pores; strongly acid; clear, wavy boundary.

B22t—27 to 32 inches, yellowish-brown (10YR 5/4) silt loam; weak, thick, platy structure parting to moderate, fine, subangular blocky; friable; thin patches of brown (10YR 5/3) silt and very fine sand particles on faces of peds; common, very fine and fine, tubular pores; strongly acid; clear, wavy boundary.

B3—32 to 38 inches, brown (10YR 5/3) silt loam, few thin strata of sand; weak, coarse, subangular blocky structure; friable; very porous; thin patchy coatings of bleached very fine sand and coarse silt particles on faces of peds; strongly acid; abrupt, wavy boundary.

IIC—38 to 60 inches, yellow (10YR 7/6) soft sandstone that has pockets of loose fine sand.

The solum ranges from 24 to 40 inches in thickness. Depth to underlying sandstone ranges from 24 to 40 inches. The solum typically does not have coarse fragments, but the B3 horizon has a few coarse fragments in some places. The Ap or A1 horizon is very dark grayish brown or dark grayish brown. The B horizon is brown or yellowish-brown silt loam or silty clay, and clay films are few to common. The IIC horizon or underlying sandstone ranges from soft to hard.

Gale soils are near Seaton soils and are similar to Eleva soils. They formed in a thinner mantle of loess than Seaton soils. They contain more silt and less sand than the Eleva soils.

Gale silt loam, 0 to 3 percent slopes (GaA).—This soil is on very low side slopes above long, natural drainageways and in saddlelike areas between knolls of sandstone outcrop. Areas range from 2 to 40 acres in size. Included in mapping are areas of sandstone outcrops that are generally less than one-fifth of an acre in size.

Because available water capacity is moderate, the main limitation is the moderate hazard of drought. Surface runoff is medium. Fertility is low to medium. The main management needs are to schedule fieldwork and to select early maturing crops to best utilize available water in the soil and periods of more frequent seasonal rain.

This soil is used mostly for crops or pasture, and some areas are woodland. It is well suited to small grain, corn, and legumes. Where septic tank absorption fields are planned, pollution of ground water in the underlying sandstone is a hazard. Capability unit IIs–1; woodland group 3; community development group 4; outdoor recreation group 7.

Garwin Series

The Garwin series consists of nearly level or depressional, poorly drained and very poorly drained soils in concave parts of drainageways on broad uplands. These soils formed in loess. The native vegetation was sedges and tall prairie grasses.

In a representative profile the surface layer is black silty clay loam about 14 inches thick. The upper 6 inches of the subsoil is dark grayish-brown, slightly sticky silty clay loam; the lower 27 inches is dark grayish-brown and grayish-brown, friable and very friable silt loam. The underlying material is grayish-brown silt loam.

Permeability is moderately slow, and available water capacity is very high. The content of organic matter is high. The content of available phosphorus is medium, and that of potassium is low. A seasonal water table is at a depth of 1 foot to 3 feet.

Most areas are used for crops or pasture or are idle. The main limitation is the hazard of wetness.

Representative profile of Garwin silty clay loam, in a field 75 feet north of the southeast corner of SE¼ sec. 6, T. 110 N., R. 16 W.

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

A12—8 to 14 inches, black (N 2/0) silty clay loam; moderate, medium, granular structure; sticky; neutral; clear, wavy boundary.

B21g—14 to 20 inches, dark grayish-brown (2.5Y 4/2) silty clay loam; many, very dark grayish-brown (2.5Y 3/2) coatings on faces of peds, many, distinct, dark-brown (7.5YR 4/2) mottles, common mixings of black (N 2/0); moderate, very fine, subangular blocky structure, slightly sticky; common, very fine and fine pores; neutral; clear, wavy boundary.

B22g—20 to 27 inches, dark grayish-brown (2.5Y 4/2) silt loam; many, fine, distinct, yellowish-brown (10YR 5/4) mottles; weak, coarse, subangular blocky structure; friable; common fine and medium pores; neutral; clear, wavy boundary.

B23g—27 to 38 inches, grayish-brown (2.5Y 5/2) silt loam; many, fine, distinct, yellowish-brown (10YR 5/4) mottles; weak, coarse, subangular blocky structure; friable; neutral; clear, wavy boundary.

B3g—38 to 47 inches, grayish-brown (2.5Y 5/2) silt loam high in content of coarse silt and very fine sand; weak, coarse, prismatic structure; very friable; mildly alkaline; diffuse, wavy boundary.

C—47 to 86 inches, grayish-brown (2.5Y 5/2) silt loam high in content of coarse silt and very fine sand; massive; very friable; mildly alkaline.

The solum typically ranges from 35 to 55 inches in thickness. Carbonates are at a depth ranging from 60 to 100 inches. The A horizon ranges from 10 to 24 inches in thickness. It is silt loam or silty clay loam. The B horizon ranges from dark gray or gray, dark grayish brown or grayish brown to olive gray or olive. The B2 horizon has common to many, faint to prominent mottles. It is silty clay loam or silt loam. The C horizon is grayish brown, olive gray, or gray. It is neutral to mildly alkaline.

Garwin soils are near Joy and Port Byron soils and are similar to Maxfield soils. They are wetter and grayer than Joy or Port Byron soils. They do not have glacial till in the substratum, which is characteristic of Maxfield soils.

Garwin silty clay loam (0 to 2 percent slopes) (Gm).—This soil is at concave heads of upland drainageways that collect runoff from upslope areas. It is above Garwin silty clay loam, swales, and Colo soils all of which are in the drainageways. Areas are bulb shaped—they are widest at the head and blend into the drainageway downslope. They range from 2 to 20 acres in size. This soil has the profile described as representative of the series. Included in mapping are small areas of Joy soils.

The main limitation is the hazard of wetness. Surface runoff is medium.

Adequately drained areas of this soil are suited to corn and soybeans. Some areas are pasture. Capability

unit IIw–1; woodland group 9; community development group 2; outdoor recreation group 3.

Garwin silty clay loam, swales (0 to 1 percent slopes) (Gr).—This soil is in long, narrow drainageways on broad uplands. Surface runoff collects from adjoining soils and floods this soil. Pasture and idle areas remain ponded for brief periods. This soil has a profile similar to that described as representative of the series, but the surface layer is slightly thicker in most areas. Included in mapping are some areas of Orion soils on the lower reaches of the drainageways and some areas of soils similar to Garwin soils that have a mucky surface layer.

The main limitation is the severe hazard of wetness.

Adequately drained areas of this soil are suited to crops; flooding, however, is a hazard. Some areas can be developed as impoundments for wildlife or left idle for food and natural cover. Capability unit IIIw–1; woodland group 9; community development group 2; outdoor recreation group 3.

Gotham Series

The Gotham series consists of gently sloping to very steep, somewhat excessively drained soils on concave foot slopes near the base of valley walls. These soils formed in sandy outwash. The native vegetation was deciduous hardwoods.

In a representative profile the surface layer is very dark brown and dark-brown fine sand about 5 inches thick. The subsoil is about 38 inches thick. The upper 31 inches is dark-brown and brown, structureless fine sand that has thin bands of loamy fine sand in the lower part; the lower 7 inches is dark yellowish-brown loamy fine sand. The underlying material is brown sand.

Permeability is rapid, and available water capacity is low. The content of organic matter is low. The content of available phosphorous and potassium is low.

Most areas are used for woodland, pasture, or crops. These soils are well suited to woodland. The main limitation is the hazard of drought.

Representative profile of Gotham fine sand, 12 to 35 percent slopes, 495 feet south of the northeast corner of NE¼SW¼ sec. 5, T. 111 N., R. 17 W.

A11—0 to 2 inches, very dark brown (10YR 2/2) fine sand; single grained; loose; strongly acid; clear, wavy boundary.

A12—2 to 5 inches, dark-brown (10YR 3/3) fine sand, tongues and masses of very dark brown (10YR 2/2); single grained; loose; strongly acid; clear, irregular boundary.

B1—5 to 15 inches, dark-brown (10YR 4/3) fine sand, large masses and mixings of very dark grayish brown (10YR 3/2); single grained; loose; strongly acid; clear, wavy boundary.

B21—15 to 36 inches, brown (10YR 5/3) fine sand; single grained; loose; few ½-inch bands of dark-brown loamy fine sand in lower part; strongly acid; clear, wavy boundary.

B22t—36 to 43 inches, dark yellowish-brown (10YR 4/4) loamy fine sand; massive; thin, continuous clay bridgings between sand grains; strongly acid; abrupt, wavy boundary.

C—43 to 60 inches, brown (10YR 4/3) sand; single grained; loose; medium acid.

The solum ranges from 30 to 45 inches in thickness. The A horizon ranges from very dark grayish brown to dark brown. It is fine sand, sand, loamy sand, or loamy fine sand. The B horizon ranges from 25 to 40 inches in thickness. It is dark-brown, brown, or dark yellowish brown and is medium acid to strongly acid. The B horizon is mainly sand or fine sand. The B2t horizon typically is loamy fine sand or loamy sand, but it ranges to sand or fine sand that has appreciable amounts of clay. This horizon commonly occurs as one or more bands of lamellae within the B horizon. The C horizon is sand or fine sand.

Gotham soils are near Marlean and Plainfield soils. They have appreciable amounts of translocated clay in the B horizon, and those soils do not. They do not have coarse fragments, and Marlean soils have appreciable amounts.

Gotham fine sand, 2 to 12 percent slopes (GtB).—This soil is on smooth to concave foot slopes that extend around the base of valley walls. It adjoins some areas of Plainfield soils along the lower toe slopes. Areas range from 2 to 80 acres in size. Slopes range from 75 to 300 feet in length. Included in mapping are some areas of Plainfield soils and some areas of soils that have sandstone bedrock at a depth of 40 inches or less.

Because available water capacity is low, the main limitation is droughtiness. Natural fertility and content of organic matter are low. This soil is also subject to soil blowing in areas that lack plant cover. Surface runoff is very slow, and most of it is absorbed because the rate of infiltration is high and permeability is rapid.

This soil is used for crops, pasture, or woodland. It is poorly suited to grain crops because it is droughty. It is better suited to permanent pasture and trees, but pastures go dormant rather early in the season. Where the soil is used as a septic tank absorption field and the water table is below a depth of 10 feet, pollution of ground water is a hazard because the underlying material is rapidly permeable. Capability unit IVs–1; woodland group 4; community development group 3; outdoor recreation group 11.

Gotham fine sand, 12 to 35 percent slopes (GtD).—This soil is on smooth to concave upper foot slopes that extend around the base of valley walls. Bedrock is mostly at a depth of 5 to 8 feet. Areas range from 2 to 20 acres in size. Slopes range from 75 to 300 feet in length. This soil has the profile described as representative of the series. Included in mapping are some areas of soils that have sandstone or limestone bedrock at a depth of 40 inches or less.

Because available water capacity is low, the main limitation is droughtiness. Natural fertility and content of organic matter are low. The hazards of soil blowing and water erosion are moderate in areas that lack plant cover. Surface runoff is medium, and most of it is absorbed because the rate of infiltration is high and permeability is rapid.

This soil is used mostly for pasture or woodland and is well suited to these uses. Some of it is cropped. It is poorly suited to grain crops because it is droughty. Where the soil is used as a septic tank absorption field and the water table is below a depth of 10 feet, pollution of ground water is a hazard because the underlying material is rapidly permeable. Capability unit VIIs–1; woodland group 4; community development group 9; outdoor recreation group 13.

Houghton Series

The Houghton series consists of very poorly drained, depressional and gently sloping, organic soils that formed in bogs and in seep areas on hillsides. The na-

tive vegetation was primarily grasses, sedges, reeds, and cattails.

In a representative profile the surface layer is black muck about 19 inches thick. Lower layers to a depth of 72 inches are black and dark-brown peaty muck and are 15 to 30 percent undecomposed plant fibers and 20 to 30 percent soil mineral.

Permeability is moderately rapid, and available water capacity is very high. The content of available phosphorus and potassium is low. The water table is at a depth of 1 to 3 feet.

Most areas are idle. These soils are too wet for most uses, but they are well suited to vegetable crops if a market is available and the water level is controlled.

Representative profile of Houghton muck, about 50 feet east and 405 feet north of the southwest corner of sec. 36, T. 113 N., R. 14 W.

Oap—0 to 9 inches, black (N 2/0) sapric material; about 5 percent fiber, rubbed; weak, very fine, granular structure; about 15 percent mineral material; mildly alkaline; gradual, smooth boundary.

Oa2—9 to 19 inches, black (N 2/0) sapric material; about 2 percent fiber, rubbed; weak, very fine, subangular blocky structure; about 10 percent mineral material; mildly alkaline; gradual, smooth boundary.

Oa3—19 to 24 inches, sapric material, black (N 2/0) and dark-brown (7.5YR 4/4) broken face, black (N 2/0) rubbed; about 10 percent fiber, rubbed; weak, medium, platy structure; about 15 percent mineral material; mildly alkaline; gradual, smooth boundary.

Oe1—24 to 51 inches, hemic material, about 60 percent black (10YR 2/1) and 40 percent dark-brown (10YR 3/3) broken face; about 70 percent fiber, about 30 percent rubbed; weak, medium, platy structure; about 10 percent mineral material; mildly alkaline; gradual, smooth boundary.

Oe2—51 to 72 inches, hemic material, about 70 percent black (N 2/0) and 30 percent dark brown (7.5YR 4/4) broken face and black (N 2/0) rubbed; massive; about 40 percent fiber, 10 percent rubbed; about 10 percent mineral material; mildly alkaline.

The organic soil material ranges from 55 inches to more than 70 inches in thickness. This material ranges from neutral to mildly alkaline. It is largely sapric, but in some places it is mostly hemic.

Houghton soils in Goodhue County contain more undecomposed plant fibers and Houghton muck, seepy, is more sloping than is defined in the range for this series. These differences do not alter use or behavior of the soils.

Houghton soils are near Maxfield soils, Alluvial land, and Marsh. They formed in thick deposits of organic soil material, whereas Maxfield soils and Alluvial land formed in mineral soil material. They do not have the nearly continuous mantle of shallow water that is characteristic of Marsh.

Houghton muck (0 to 1 percent slopes) (Ho).—This soil is in low, wet areas along the edges of marshes, flood plains, or stream benches. This soil has the profile described as representative of the series. Stratified silt and clay are at a depth below 72 inches. A water table is at a depth of about 20 inches. Included in mapping are areas where the muck is less than 55 inches thick. Also included are some ponded areas and areas of Houghton soils that have silty overwash.

Areas of this soil are seasonally ponded and have reeds, sedges, and marsh grasses growing on them. Wetness severely limits use. Frost is a hazard because this soil is low lying.

Undrained areas are poorly suited to pasture, but some wild hay grows. Adequately drained and properly fertilized areas are well suited to vegetable crops. Capability unit VIw–1; woodland group 9; community development group 2; outdoor recreation group 3.

Houghton muck, seepy (1 to 8 percent slopes) (Hs).—This soil is near the base of seepy hillsides. Areas range from 2 to 10 acres in size.

The main limitation is the severe hazard of wetness. Any needed drainage should be installed along the upper slopes to intercept seepage.

Most of this soil is idle or pasture. It is poorly suited to pasture because it tends to be very hummocky. It can be developed for wildlife habitat. Capability unit VIw–1; woodland group 9; community development group 2; outdoor recreation group 3.

Joy Series

The Joy series consists of nearly level, somewhat poorly drained soils on concave heads of drainageways in loess-covered uplands. These soils formed in loess. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is black and very dark grayish-brown silt loam about 11 inches thick. The subsoil is dark grayish-brown to brown, friable silt loam about 29 inches thick. The underlying material is grayish-brown and light-gray silt loam and, at a depth of about 63 inches, yellowish-brown loam.

Permeability is moderately slow, and available water capacity is very high. The content of organic matter is high. The content of available phosphorus is medium, and that of potassium is low.

Most areas are used for crops or pasture. The main limitation is the hazard of wetness.

Representative profile of Joy silt loam, 0 to 3 percent slopes, 395 feet north and 495 feet east of the southwest corner of sec. 14, T. 109 N., R. 16 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam; weak, fine, granular structure; friable; slightly acid; abrupt, wavy boundary.

A3—8 to 11 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, fine, subangular blocky structure; friable; neutral; abrupt, wavy boundary.

B21—11 to 16 inches, dark grayish-brown (10YR 4/2) silt loam; moderate, very fine, subangular blocky structure; friable; many, very fine and fine, tubular pores; few thin clay films lining fine pores; neutral; clear, wavy boundary.

B22—16 to 22 inches, grayish-brown (10YR 5/2) silt loam; dark grayish-brown (10YR 4/2) coatings on faces of peds; moderate, fine, subangular blocky structure; friable; many, very fine and fine, tubular pores; few thin clay films lining fine pores; neutral; clear, wavy boundary.

B23—22 to 33 inches, brown (10YR 5/3) silt loam; grayish-brown (10YR 5/2) coatings on faces of peds; many, medium, faint, grayish-brown (10YR 5/2) mottles; moderate, fine, subangular blocky structure; friable; common, very fine and fine, tubular pores; few thin clay films lining fine pores; neutral; clear, wavy boundary.

B3—33 to 40 inches, brown (10YR 5/3) silt loam high in content of coarse silt and very fine sand; many, medium, distinct, gray (10YR 5/1) mottles; weak, medium, subangular blocky structure; friable; common, very fine and fine, tubular pores; mildly alkaline; clear, wavy boundary.

C1—40 to 45 inches, grayish-brown (10YR 5/2) silt loam high in content coarse silt and very fine sand; many, medium, distinct, yellowish-brown (10YR 5/4) mottles; weak, coarse, subangular blocky structure; friable; common, very fine and fine, tubular pores; mildly alkaline; gradual, wavy boundary.

C2—45 to 63 inches, light-gray (10YR 6/1) silt loam high

in content of coarse silt and very fine sand; many, medium, prominent, yellowish-brown (10YR 5/6) mottles; massive; friable; mildly alkaline; abrupt, wavy boundary.

IIC3—63 to 70 inches, yellowish-brown (10YR 5/4) loam; massive; firm; moderately alkaline; slightly effervescent.

The solum ranges from 36 to 50 inches in thickness. Depth to glacial till ranges from 5 to 8 feet or more. The A horizon ranges from 10 to 17 inches in thickness. The B horizon ranges from dark grayish brown or grayish brown to dark brown or brown. It has common or many, faint, gray or grayish-brown mottles. The solum is silt loam that is 20 to 26 percent clay.

Joy soils are near Garwin, Mt. Carroll, and Port Byron soils and are similar to Vasa soils. They have a brighter colored B horizon and are better drained than Garwin soils. They have mottles in the B horizon, and Mt. Carroll and Port Byron soils do not, and they are not so well drained as those soils. They have a thicker A1 horizon than Vasa soils.

Joy silt loam, 0 to 3 percent slopes (JoA).—This soil is in the upper reaches of wet drainageways on broad uplands. Areas are slightly concave and collect runoff from adjoining soils. They range from 2 to 30 acres in size. Included in mapping are some areas of Garwin soils.

The hazard of wetness is slight to moderate, and surface runoff is slow to medium. Some drainageways need artificial drainage and outlets to control wetness. Fertility also needs to be maintained.

Most of the acreage is used for crops. This soil is well suited to corn and soybeans. Capability unit I–2; woodland group 2; community development group 5; outdoor recreation group 4.

Kasson Series

The Kasson series consists of very gently sloping, moderately well drained soils on convex crests of broad uplands. These soils formed in loess and dense glacial till. The native vegetation was mixed hardwood forest and grasses.

In a representative profile the surface layer is very dark brown silt loam about 9 inches thick. The upper 11 inches of the subsoil is dark-brown and brown, friable silty clay loam; the lower 41 inches is mottled dark yellowish-brown, brown, and yellowish-brown, mainly firm loam. The underlying material is mottled yellowish-brown loam.

Permeability is moderately slow, and available water capacity is high. The content of organic matter is moderate. The content of available phosphorus is medium, and that of potassium is low.

Most areas are used for crops or pasture. The main limitations are the hazard of drought during seasonal dry periods and the hazard of wetness.

Representative profile of Kasson silt loam, 1 to 3 percent slopes, 100 feet north and 200 feet west of the southeast corner of sec. 31, T. 109 N., R. 17 W.

Ap—0 to 9 inches, very dark brown (10YR 2/2) silt loam; weak, fine, granular structure; friable; slightly acid; abrupt, smooth boundary.

B1—9 to 12 inches, dark-brown (10YR 4/3) silty clay loam; few masses of very dark brown (10YR 2/2); weak, very fine, subangular blocky structure; medium acid; clear, wavy boundary.

B21—12 to 15 inches, dark-brown (10YR 4/3) silty clay loam; moderate, fine, subangular blocky structure; friable; many, very fine and fine, continuous, tubular pores; common, thin coatings of bleached silt particles on faces of peds; medium acid; clear, wavy boundary.

B22—15 to 20 inches, brown (10YR 5/3) silty clay loam; common, fine, faint, grayish-brown (10YR 5/2) mottles; moderate, very fine, subangular blocky structure; friable; many, very fine and fine, continuous, tubular pores; common, thin coatings of bleached silt particles on faces of peds; strongly acid; abrupt, wavy boundary.

IIB23—20 to 24 inches, dark yellowish-brown (10YR 4/4) loam; many, medium, distinct, grayish-brown (10YR 5/2) mottles; moderate, medium, subangular blocky structure; friable; many very fine, fine, and medium, continuous tubular pores; many thin coatings of bleached silt particles on faces of peds; about 15 fragments; a thin stone line in upper part; strongly acid; clear, wavy boundary.

IIB24t—24 to 33 inches, brown (10YR 5/3) loam; grayish-brown (10YR 5/2) coatings on faces of peds and in pores; moderate, medium, prismatic structure parting to strong, medium, subangular blocky; firm; few very fine, fine, and medium, closed and open tubular pores; about 4 percent gravel; common coatings of bleached sand and silt particles, 1 to 2 millimeters thick, on faces of peds and in pores; few, moderately thick clay films in pores; strongly acid; clear, wavy boundary.

IIB25t—33 to 42 inches, yellowish-brown (10YR 5/4) loam; grayish-brown (10YR 5/2) coatings on faces of peds and in pores; strong, medium, prismatic structure parting to moderate, medium, subangular blocky; firm; few very fine, fine, and medium pores; common, thin coatings of bleached silt and sand particles on faces of peds; few, moderately thick clay films in pores; about 4 percent gravel; few, very dark, soft masses 1 to 2 millimeters thick; medium acid; gradual, irregular boundary.

IIB26t—42 to 52 inches, 60 percent yellowish-brown (10YR 5/4) loam, grayish-brown (10YR 5/2) coatings on faces of peds; common, medium, distinct, strong-brown (7.5YR 5/6) mottles; moderate, coarse, prismatic structure; firm; common very fine, fine, and medium pores; common, vertical, threadlike accumulations of silt and very fine sand-sized grains; few medium clay films in fine pores in peds; about 4 percent gravel; medium acid; clear, wavy boundary.

IIB3t—52 to 61 inches, yellowish-brown (10YR 5/4) loam; common, fine, distinct, grayish-brown (10YR 5/2) mottles; moderate, coarse, prismatic structure; firm; common very fine, fine, and medium, tubular pores; common threadlike fine clay masses, 1 millimeter to 3 millimeters in diameter; about 4 percent gravel; neutral; clear, wavy boundary.

IIC—61 to 70 inches, yellowish-brown (10YR 5/4) loam; many, coarse, prominent, light-gray (10YR 6/1) and strong-brown (7.5YR 5/6) mottles; massive and oblique cleavages; very firm; about 4 percent pebbles; few, 1- to 3-millimeter threads of clayey masses; moderately alkaline; slightly effervescent.

The solum ranges from 50 to 65 inches in thickness. Depth to free lime ranges from 50 to 72 inches. The loess mantle ranges from 15 to 24 inches in thickness.

The A1 horizon is very dark brown or very dark grayish brown. An A2 horizon as much as 6 inches thick is in some places. It is dark grayish brown or grayish brown. The A horizon ranges from medium acid to neutral. The B2 horizon is dark brown or brown. The B22 horizon has few to common, faint, fine or medium, gray or grayish-brown mottles. It is heavy silt loam or light silty clay loam and ranges from strongly acid to medium acid. Medium to thick coatings of bleached fine or very fine sands are on most faces of peds. The IIC horizon ranges from yellowish brown or brown to light olive brown. It is heavy loam or light clay loam. It has common to many, faint to prominent, light-gray to grayish-brown or strong-brown mottles. The IIB and IIC horizons range from 2 to 8 percent coarse fragments.

Kasson soils are near Skyberg and Maxfield soils and are similar to Racine soils. They are better drained and have a brighter colored B horizon than Skyberg and Maxfield

soils. They are moderately well drained, whereas Racine soils are well drained.

Kasson silt loam, 1 to 3 percent slopes (KaA).—This soil is on slightly convex crests of broad glacial uplands and on side slopes adjacent to wet drainageways. Areas range from 2 to 40 acres in size. Included in mapping are some areas of Skyberg and Racine soils.

This soil has a slight wetness limitation in spring and a hazard of drought during drier periods in summer. Wetness can delay early fieldwork needed to meet planting schedules, limit fieldwork needed to control weeds and pests, and delay harvesting in extended rainy seasons in fall. Droughtiness hinders plants from establishing good root systems. Surface runoff is medium to slow. The main management need is to improve internal drainage and thus encourage deeper root growth. Artificially draining the adjoining somewhat poorly and very poorly drained soils may be sufficient, but some areas of Kasson soils require specific drainage.

Adequately drained areas of this soil are well suited to and used for crops grown in the county, especially corn, small grain, and red clover. Septic tank absorption fields are difficult to maintain because permeability is moderately slow. Capability unit IIs–2; woodland group 2; community development group 5; outdoor recreation group 4.

Kegonsa Series

The Kegonsa series consists of nearly level and sloping to moderately steep, well-drained soils on level benches along major rivers. These soils formed in a mantle of loess or silty outwash and sand and gravel. The native vegetation was mixed hardwoods and grasses.

In a representative profile the surface layer is very dark brown silt loam about 9 inches thick, and the subsurface layer is dark grayish-brown silt loam about 5 inches thick. The upper 15 inches of the subsoil is dark yellowish-brown and yellowish-brown, friable silt loam and silty clay loam; the lower 26 inches is yellowish-brown loam grading with depth to dark yellowish-brown gravelly coarse sand. The underlying material is brown gravelly coarse sand.

Permeability is moderate, and available water capacity is high and moderate. The content of organic matter is moderate. The content of available phosphorus is medium, and that of potassium is low.

Most areas are used for crops or pasture. These soils are suited to most row crops commonly grown in the county. The main limitation is the hazard of drought.

Representative profile of Kegonsa silt loam, 0 to 3 percent slopes, in a cultivated field 240 feet east and 200 feet north of the southwest corner of NW¼NE¼ sec. 31, T. 109 N., R. 15 W.

Ap—0 to 9 inches, very dark brown (10YR 2/2) silt loam; weak, very fine, granular structure; very friable; about 2 percent gravel; slightly acid; abrupt, wavy boundary.

A2—9 to 14 inches, dark grayish-brown (10YR 4/2) silt loam; common, very dark brown (10YR 2/2), tubular fillings; weak, very fine, subangular blocky structure; very friable; many, very fine and fine, tubular pores; about 2 percent gravel; slightly acid; clear, wavy boundary.

B1—14 to 21 inches, dark yellowish-brown (10YR 4/4) silt loam; dark grayish-brown (10YR 4/2) coatings on faces of peds; moderate, fine, subangular structure; friable; many, very fine and fine, tubular pores; common, thin, discontinuous, light-gray (10YR 7/2) coatings on faces of peds; few threads of clay films in fine tubular pores; medium acid; clear, wavy boundary.

B21t—21 to 29 inches, yellowish-brown (10YR 5/4) silty clay loam; dark-brown (10YR 4/3) coatings; moderate, fine and medium, subangular blocky structure; friable; many, very fine and fine, tubular pores; few thin clay films on faces of peds and moderately thick clay films in fine pores; few bleached silt and sand grains on faces of peds; common, fine, tubular pores; strongly acid; clear, wavy boundary.

IIB22t—29 to 33 inches, yellowish-brown (10YR 5/4) loam; dark-brown (10YR 4/3) coatings; weak, medium, subangular blocky structure; friable; common, very fine and fine, tubular pores; few bleached silt and sand grains on faces of peds; few thin clay films in fine pores; about 10 percent gravel; strongly acid; abrupt, wavy boundary.

IIB23t—33 to 41 inches, yellowish-brown (10YR 5/4) gravelly sandy loam; weak, coarse, subangular blocky structure; very friable; common, fine, tubular pores; continuous, moderately thick clay bridgings between sand grains; about 20 percent gravel; strongly acid; clear, wavy boundary.

IIB3t—41 to 55 inches, dark yellowish-brown (10YR 4/4) gravelly coarse sand; single grained; loose; many thin clay bridgings between sand grains; neutral; abrupt, wavy boundary.

IIC—55 to 65 inches, brown (10YR 5/3) gravelly coarse sand; single grained; loose; about 35 percent gravel; moderately alkaline; slightly effervescent.

The solum ranges from 30 to 60 inches in thickness. The silty sediment ranges from 24 to 40 inches in thickness. Depth to free carbonates ranges from 40 to 70 inches. The silty sediment either does not have any gravel or has a few percent gravel. The Ap or A1 horizon is very dark brown or very dark grayish brown. The A2 horizon ranges from 3 to 6 inches in thickness. It is dark grayish brown or grayish brown. The B1 and B22t horizons range from 15 to 20 inches in combined thickness. They are dark-brown to yellowish-brown silt loam or silty clay loam. The IIB2 horizon ranges from 5 to 15 inches in thickness. It ranges from 5 to 20 percent gravel. The IIB3 horizon is gravelly coarse sand or gravelly loamy coarse sand. The IIC horizon is gravelly coarse sand, coarse sand, or stratified gravel and sand.

Kegonsa soils are near Dakota and Fairhaven soils. They have an A2 horizon, and Dakota and Fairhaven soils do not. They contain less sand in the solum than Dakota soils.

Kegonsa silt loam, 0 to 3 percent slopes (KeA).—This soil is on broad benches of major streams. Areas range from 5 to 100 acres in size. This soil has the profile described as representative of the series.

The main limitation is that this soil tends to be slightly droughty in areas where available water capacity is moderate. The main management need is to schedule fieldwork and to select early maturing crops that can be planted early to best utilize available water in the soil and most of the seasonal rain. Surface runoff is slow, and much of it is absorbed in the soil because infiltration and permeability are moderate.

This soil is used mostly for crops. Some areas are pasture or are used as a source of sand and gravel. This soil is well suited to row crops, especially corn. Irrigation can be used where feasible. Where the soil is used as a septic tank absorption field and the water table is below a depth of 10 feet, pollution of ground water is a hazard because the underlying material is rapidly permeable. Capability unit IIs–1; woodland group 3; community development group 3; outdoor recreation group 10.

Kegonsa and Fairhaven silt loams, 6 to 18 percent slopes (KfD).—These soils are on escarpments of silty stream benches. Areas are narrow. Slopes range from 50 to 100 feet in length. These soils adjoin soils on flood plains along lower slopes.

Kegonsa silt loam makes up about 60 percent of this unit, and Fairhaven silt loam about 40 percent. Fairhaven silt loam is near other Fairhaven soils or Waukegan soils, and Kegonsa silt loam is near other Kegonsa soils. Included in mapping are some areas of very steep soils that are indicated on the detailed soil map by the symbol for escarpments.

Surface runoff is medium. The hazards of erosion and drought are moderate. Some areas where runoff collects and spills over are subject to gullying. The main management need is to control erosion.

These soils are used for crops, pasture, or woodland, and use is determined by the use of adjacent soils and the depth of the workable area. They are well suited to permanent woodland or pasture because areas are quite narrow. Where the soil is used as a septic tank absorption field and the water table is below a depth of 10 feet, pollution of ground water is a hazard because the underlying material is rapidly permeable. Capability unit IIIe–2; woodland group 3; community development group 9; outdoor recreation group 13.

Klinger Series

The Klinger series consists of very gently sloping, somewhat poorly drained soils on crests and sides of broad uplands. These soils formed in loess and glacial till. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is very dark brown silty clay loam about 10 inches thick. The upper 15 inches of the subsoil is mottled dark-brown and brown, friable silty clay loam and silt loam; the lower 23 inches that formed in glacial till is firm yellowish-brown loam. The underlying material is yellowish-brown loam.

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

Most areas are used for crops and some pasture. These soils are well suited to corn and soybeans. The main limitation is the hazard of wetness.

Representative profile of Klinger silty clay loam, 1 to 3 percent slopes, 250 feet north of the southwest corner of sec. 19, T. 110 N., R. 18 W.

Ap—0 to 8 inches, very dark brown (10YR 2/2) silty clay loam; weak, very fine, granular structure; friable; slightly acid; abrupt, wavy boundary.

A3—8 to 10 inches, very dark grayish-brown (10YR 3/2) silty clay loam; very dark brown (10YR 2/2) coatings on faces of peds; moderate, fine, granular structure; friable; medium acid; clear, wavy boundary.

B21—10 to 14 inches, dark-brown (10YR 4/3) silty clay loam; very dark grayish-brown (10YR 3/2) coatings on faces of peds; moderate, fine, granular structure; friable; common, very fine and fine, tubular pores; strongly acid; clear, wavy boundary.

B22—14 to 19 inches, dark-brown (10YR 4/3) silty clay loam; dark grayish-brown (10YR 4/2) coatings on faces of peds; common, medium, faint, grayish-brown (10YR 5/2) mottles; moderate, fine, subangular blocky structure; friable; strongly acid; clear wavy boundary.

B23—19 to 25 inches, brown (10YR 5/3) heavy silt loam; common, medium, faint, grayish-brown (10YR 5/2) mottles; weak, medium, subangular blocky structure; friable; common, very fine and fine, tubular pores; strongly acid; abrupt, wavy boundary.

IIB24—25 to 30 inches, yellowish-brown (10YR 5/4) loam; thick, grayish-brown (2.5Y 5/2) coatings on faces of peds and in pores; moderate, medium, subangular blocky structure; firm; common, very fine and fine, tubular pores; about 10 percent coarse fragments; thin stone line in upper part; strongly acid; clear, wavy boundary.

IIB25—30 to 38 inches, yellowish-brown (10YR 5/4) loam; thick, grayish-brown (2.5Y 5/2) coatings on faces of peds and in pores; weak, medium, prismatic structure parting to moderate, medium, subangular blocky; firm; few, very fine, fine, and medium, tubular pores; about 4 percent coarse fragments; medium acid; clear, wavy boundary.

IIB3—38 to 48 inches, yellowish-brown (10YR 5/6) loam; thick, grayish-brown (2.5Y 5/2) coatings on faces of peds and in pores; common, fine, distinct, strong-brown (7.5YR 5/8) mottles; weak, coarse, prismatic structure; few very fine, fine, and medium pores; medium acid; gradual, irregular boundary.

IIC—48 to 60 inches, yellowish-brown (10YR 5/6) loam; grayish-brown (2.5Y 5/2) coatings along oblique partings; massive; firm; moderately alkaline; slightly effervescent.

The solum thickness, or the depth to free carbonates, ranges from 40 to 55 inches. The loess mantle ranges from 22 to 28 inches in thickness. The A horizon ranges from 10 to 16 inches in thickness. The Ap or A1 horizon is black or very dark brown silt loam or silty clay loam. The B2 horizon ranges from grayish brown or dark grayish brown to dark brown or brown. It has few to many, faint, grayish-brown or gray mottles. It is heavy silt loam or silty clay loam. The IIB horizon ranges from yellowish brown to brown. It is loam or light clay loam. The content of gravel below the stone line ranges from to 4 to 8 percent.

The Klinger soils in Goodhue County do not have the appreciable amount of translocated clay in the B horizon that is defined in the range for the series. This difference does not appreciably affect use or behavior of the soils.

Klinger soils are near Maxfield and Kasson soils. They are better drained than Maxfield soils and lack the gray colors in the B horizon that Maxfield soils have. They have a thicker A1 horizon, A3 horizon, and overall silty mantle than Kasson soils.

Klinger silty clay loam, 1 to 3 percent slopes (KnA).—This soil is on broad glacial uplands. Most areas are on side slopes adjoining wet soils in drainageways, but some are on slightly convex rises surrounded by Maxfield soils. Areas range from 2 to 100 acres in size. Slopes are mostly smooth and range from 100 to 600 feet in length. Included in mapping are areas of Maxfield soils in some low areas.

Wetness can delay early fieldwork needed to meet planting schedules, limit fieldwork needed to control weeds and pests, and delay harvesting. Because of wetness, artificial drainage is used in some areas.

This soil is well suited to and used for most crops grown in the county, especially corn and soybeans. Septic tank absorption fields are difficult to maintain because permeability is moderately slow. Capability unit I–2; woodland group 2; community development group 5; outdoor recreation group 4.

Lawson Series

The Lawson series consists of nearly level, somewhat poorly drained soils on flood plains of major streams.

These soils formed in alluvium. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is very dark brown and very dark grayish-brown silt loam about 28 inches thick. The subsoil is grayish-brown, friable silt loam about 15 inches thick. The underlying material is grayish-brown silt loam.

Permeability is moderate, and available water capacity is very high. The content of organic matter is high. The content of available phosphorus is medium, and that of potassium is low. A water table is at a depth of 5 to 7 feet.

Most areas are used for crops. These soils are well suited to corn and soybeans. The main limitation is the hazard of flooding.

Representative profile of Lawson silt loam, 365 feet south and 330 feet west of the northeast corner of NW¼NW¼ sec. 17, T. 111 N., R. 16 W.

Ap—0 to 7 inches, very dark brown (10YR 2/2) silt loam; weak, very fine, granular structure; friable; neutral; abrupt, wavy boundary.

A12—7 to 17 inches, very dark brown (10YR 2/2) silt loam; weak, very fine, granular structure; friable; neutral; clear, wavy boundary.

A13—17 to 23 inches, very dark grayish-brown (10YR 3/2) silt loam; very dark brown (10YR 2/2) coatings on faces of peds; moderate, very fine, angular blocky structure; many, very fine, fine, and medium, tubular pores; neutral; clear, wavy boundary.

A3—23 to 28 inches, very dark grayish-brown (10YR 3/2) silt loam; many, very dark brown (10YR 2/2) and dark grayish-brown (10YR 4/2) worm casts and fillings in burrows of rodents; moderate, very fine, angular blocky structure; friable; many, very fine and fine, tubular pores; neutral; clear, wavy boundary.

B21—28 to 33 inches, grayish-brown (10YR 5/2) silt loam; dark grayish-brown coatings on faces of peds; moderate, fine, subangular blocky structure; friable; common, very fine and fine, tubular pores; neutral; clear, wavy boundary.

B22—33 to 43 inches, grayish-brown (2.5Y 5/2) silt loam; weak, medium and coarse, subangular blocky structure; friable; common, very fine and fine, tubular pores; neutral; clear, wavy boundary.

C—43 to 60 inches, grayish-brown (2.5Y 5/2) silt loam; massive; very friable; moderately alkaline; slightly effervescent.

The solum ranges from 40 to 60 inches in thickness. Depth to free carbonates ranges from 40 to 70 inches. The A horizon ranges from 25 to 40 inches in thickness. The Ap or A1 horizon ranges from black or very dark brown to very dark gray or very dark grayish brown. It is silt loam or silty clay loam. The B horizon is grayish brown, dark grayish brown, or in some places, brown. The C horizon is grayish brown or brown. It ranges from neutral to moderately alkaline. In some places, a sandy or gravelly substratum begins at a depth that ranges from 60 to 80 inches.

Lawson soils are near Bremer and McPaul soils. They are not so wet as Bremer soils. They do not have the free carbonates in the A horizon, which are characteristic of McPaul soils.

Lawson silt loam (0 to 2 percent slopes) (La).—This soil is on high bottoms of flood plains along major streams. It is adjacent to McPaul soils and Alluvial land on first bottoms. Areas range from 2 to 50 acres in size.

The main limitation is the moderate hazard of flooding. Flooding is infrequent and occurs after heavy rain or heavy spring snowmelt.

This soil is well suited to and used for crops, especially corn and soybeans. Flood damage has not been severe enough to prevent cropping. Capability unit IIw–2; woodland group 8; community development group 1; outdoor recreation group 2.

Lilah Series

The Lilah series consists of nearly level to very steep, excessively drained soils. These soils are on stream benches along major rivers and on some isolated knolls in loess and glacial uplands. They formed in gravelly and sandy outwash. The native vegetation was hardwood forest.

In a representative profile the surface layer is very dark brown sandy loam about 7 inches thick. The subsoil, about 38 inches thick, is dark reddish-brown, very friable and loose loamy coarse sand in the upper part and dark-brown gravelly coarse sand in the lower part. The underlying material is brown and grayish-brown gravelly coarse sand.

Permeability is rapid, and available water capacity is very low and low. The content of organic matter is moderate. The content of available phosphorus and potassium is low.

Most areas are used for crops, pasture, woodland, or residential areas. The main limitations are hazards of drought and erosion.

Representative profile of Lilah sandy loam, 0 to 6 percent slopes, in an idle area 1,210 feet south and 1,190 feet west of the northwest corner of NW¼ sec. 31, T. 112 N., R. 12 W.

Ap—0 to 7 inches, very dark brown (10YR 3/2) sandy loam; weak, very fine, granular structure; very friable; about 5 percent gravel; slightly acid; abrupt, smooth boundary.

B21t—7 to 13 inches, dark reddish-brown (5YR 3/2) loamy coarse sand; weak, fine, subangular blocky structure; very friable; common, black (10YR 2/1) root mixings 2 to 5 millimeters in diameter; many moderately thick clay bridgings between sand grains; about 15 percent gravel; slightly acid; abrupt, wavy boundary.

B22t—13 to 20 inches, dark reddish-brown (5YR 3/3) loamy coarse sand; weak, coarse, subangular blocky structure; loose; many thin clay bridgings between sand grains; about 5 percent gravel; medium acid; abrupt, wavy boundary.

B3—20 to 45 inches, dark-brown (2.5YR 4/4) gravelly coarse sand; single grained; loose; medium acid; clear, wavy boundary.

C1—45 to 55 inches, brown (7.5YR 5/4) gravelly coarse sand; single grained; loose; slightly acid; clear, wavy boundary.

C2—55 to 65 inches, brown (7.5YR 5/4) and grayish-brown (10YR 5/2) gravelly coarse sand; single grained; loose; mildly alkaline.

The solum ranges from 30 to 50 inches in thickness. The Ap or A1 horizon is very dark brown, very dark grayish-brown, or dark-brown sandy loam or loam. It ranges from 4 to 8 inches in thickness. It is medium acid to neutral. The B horizon ranges from 5 to 30 percent gravel. The B2 horizon ranges from dark brown to dark reddish brown. It is loamy sand, loamy coarse sand, gravelly loamy sand, or gravelly loam. It ranges from strongly acid to slightly acid. The B3 horizon is gravelly loam, loamy coarse sand, or gravelly coarse sand. The C horizon is brown, grayish brown, or yellowish brown. It ranges from gravelly coarse sand to gravel or coarse sand. It ranges from medium acid to mildly alkaline.

The Lilah soils in Goodhue County are less acid in the solum and C horizon than is defined in the range for the series. This difference does not appreciably alter their use or behavior.

Lilah soils are near Burkhardt and Dakota soils and are similar to Salida soils. They contain less clay and more

sand in the B horizon than Dakota soils. They have appreciable amounts of translocated clay in the B horizon, whereas Burkhardt soils do not. They have a thicker solum that contains more silt and clay than Salida soils.

Lilah sandy loam, 0 to 6 percent slopes (LlA).—This soil is on parts of broad benches along major streams. It is adjacent to Burkhardt soils. Areas range from 2 to 50 acres in size. This soil has the profile described as representative of the series.

Because available water capacity is very low and low, the main limitation is the severe hazard of drought. Runoff is slow, and most of it is absorbed because the rate of infiltration is high and permeability is very rapid. This soil is susceptible to soil blowing in areas that lack sufficient vegetation. Natural fertility is low.

This soil is woodland, pasture, or idle, and some areas are used as a source of sand or gravel. It is poorly suited to crops. Where the soil is used as a septic tank absorption field and the water table is below a depth of 20 feet, pollution of ground water is a hazard because the underlying material is rapidly permeable. Capability unit IVs–1; woodland group 4; community development group 3; outdoor recreation group 11.

Lilah sandy loam, 6 to 35 percent slopes (LlD).—This soil is on escarpments and sides of gravelly knolls on broad uplands. Areas range from 2 to 20 acres in size. This soil has a profile similar to that described as representative of the series, but the surface layer and subsoil contain more gravel and cobblestones.

The main limitation is the severe hazard of drought, caused by the low and very low available water capacity and the hazard of erosion in areas exposed by deep cuts or excavations. Surface runoff is medium or rapid. Natural fertility is low.

Most of the acreage is idle or in pasture. Some areas are woodland or are used for crops. This soil should be converted to woodland. Some areas are used as a source of sand and gravel, although they contain a high quantity of plastic fines that limits use. Capability unit VIIs–1; woodland group 4; community development group 9; outdoor recreation group 13.

Lindstrom Series

The Lindstrom series consists of gently sloping to steep, well-drained soils on concave foot slopes at the base of walls of stream valleys. These soils formed in loess. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is black, very dark brown, and very dark grayish-brown silt loam about 29 inches thick. The subsoil is dark-brown and dark yellowish-brown, friable silt loam about 31 inches thick. The underlying material is yellowish-brown loam.

Permeability is moderate, and available water capacity is very high. The content of organic matter is high. The content of available phosphorus is medium, and that of potassium is low.

Most areas are used for crops or pasture. The main limitation is the hazard of erosion.

Representative profile of Lindstrom silt loam, 6 to 12 percent slopes, in an orchard 240 feet east and 1,040 feet north of the center of sec. 11, T. 112 N., R. 14 W.

Ap—0 to 9 inches, black (10YR 2/1) silt loam; weak, very fine, granular structure; friable; slightly acid; abrupt, wavy boundary.

A12—9 to 22 inches, very dark brown (10YR 2/2) silt loam; black (10YR 2/1) coatings on faces of peds; moderate, very fine, granular structure; friable; slightly acid; clear, wavy boundary.

A3—22 to 29 inches, very dark grayish-brown (10YR 3/2) silt loam; very dark brown (10YR 2/2) coatings on faces of peds; moderate, fine, subangular blocky structure; friable; common black tongues; common pores; few, patchy, porous coatings on faces of peds; medium acid; gradual, wavy boundary.

B21—29 to 38 inches, dark-brown (10YR 3/3) silt loam; very dark grayish-brown (10YR 3/2) coatings on faces of peds; moderate, medium, subangular blocky structure; friable; common pores; common black fillings in old root channels and worm holes; medium acid; clear, wavy boundary.

B22—38 to 44 inches, dark-brown (10YR 4/3) silt loam; very dark grayish-brown (10YR 3/2) coatings on faces of peds; moderate, medium, subangular blocky structure; friable; common, variable-sized pores; medium acid; clear, wavy boundary.

B23—44 to 60 inches, dark yellowish-brown (10YR 4/4) silt loam; moderate, medium, subangular blocky structure; friable; common, variable-sized pores; few thin clay films in old root channels; slightly acid; abrupt, wavy boundary.

C—60 to 70 inches, yellowish-brown (10YR 5/4) loam; massive; very friable; neutral.

The solum ranges from 50 to 70 inches in thickness. Depth to free carbonates ranges from 50 to 80 inches. The A horizon is medium acid to neutral. The Ap or A1 horizon is black or very dark brown. The A3 horizon is commonly silt loam, but in some places it is loam that has a high content of very fine sand. The B horizon is very dark grayish brown to dark grayish brown. It has moderate to weak, medium, subangular blocky structure. The B horizon is mainly slightly acid to medium acid. The C horizon is yellowish brown or pale brown. It is silt loam that has a high content of coarse silt and very fine sand or loam.

Lindstrom soils are near Terril and Port Byron soils. They contain more silt and less sand than Terril soils. They have a thicker A horizon than Port Byron soils.

Lindstrom silt loam, 2 to 6 percent slopes (LnB).—This soil is on foot slopes near the base of valley walls. Areas are concave and saucer shaped and collect runoff from soils upslope. They range from 2 to 30 acres in size. Slopes range from 100 to 300 feet in length. Included in mapping are some areas of Chaseburg soils on toe slopes and in natural drainageways.

Because runoff from soils upslope collects on areas of this soil, the main limitation is the moderate hazard of erosion. Surface runoff is medium. Fertility is medium, and tilth is easy to maintain. The main management need is to contain runoff from soils upslope by terracing. Erosion control, maintenance of fertility, and properly managed vegetation on the valley walls are needed.

Most of the acreage is used for crops, pasture, or woodland. The soil is well suited to crops. Capability unit IIe–1; woodland group 1; community development group 6; outdoor recreation group 5.

Lindstrom silt loam, 6 to 12 percent slopes (LnC).—This soil is on concave foot slopes at the base of valley walls. Most areas are just above and contiguous with less sloping Lindstrom soils or Chaseburg soils in natural drainageways. Areas range from 2 to 30 acres in size. Slopes range from 100 to 300 feet in length. This soil has the profile described as representative of the series.

The main limitations are the hazards of erosion from runoff that collects on areas of this soil and erosion from rilling in cultivated fields. Surface runoff is me-

dium. Fertility is medium, and tilth is easy to maintain. The main management need is to contain surface runoff from soils upslope by use of terraces and dams. Soil conserving practices and maintenance of fertility are also needed.

Most of the acreage is used for crops, pasture, or woodland. The soil is well suited to corn and small grain. Capability unit IIIe–1; woodland group 1; community development group 6; outdoor recreation group 6.

Lindstrom silt loam, 12 to 25 percent slopes (LnD).—This soil is on concave foot slopes at the base of valley walls. Most areas are above or surround less sloping Lindstrom soils. They collect runoff from soils upslope. Areas range from 2 to 30 acres in size. Slopes range from 100 to 300 feet in length. This soil has a profile similar to that described as representative of the series, but the surface layer is thinner. Included in mapping are areas of very steep Lindstrom soils and some areas of Terril, Bold, and Timula soils.

The main limitations are the severe hazards of erosion from runoff that collects on areas of this soil and erosion from rilling in cultivated fields. Surface runoff is medium to rapid. Fertility is medium. The main management need is to contain surface runoff from soils upslope by use of terraces and dams. Conservation and maintenance of fertility are needed also.

Most of the acreage is used for crops, pasture, or woodland. The soil is better suited to pasture than to crops, but it is well suited to corn, small grain, and hay if properly managed. Capability unit IVe–1; woodland group 1; community development group 8; outdoor recreation group 6.

Marlean Series

The Marlean series consists of steep and very steep, well-drained soils on convex slopes of valley walls. These soils formed in a thin loamy mantle and bedrock residuum. The native vegetation was deciduous forest.

In a representative profile the surface layer is black and very dark grayish-brown silt loam about 12 inches thick. The subsoil is dark yellowish-brown, friable flaggy sandy loam about 6 inches thick. The underlying material is dark-brown, friable flaggy sandy loam. Bedrock is at a depth of 4 to 10 feet (fig. 8).

Permeability is moderately rapid, and available water capacity is low. The content of organic matter is moderate. The content of available phosphorus and potassium is low.

Most areas are forest or pasture. The main limitation is the hazard of erosion.

Representative profile of Marlean soils, very steep, in an area of Marlean silt loam, in a wooded area 370 feet west and 240 feet north of the southwest corner of SE¼ sec. 23, T. 112 N., R. 13 W.

A1—0 to 6 inches, black (10YR 2/1) silt loam; weak, very fine, granular structure; friable; many roots; mildly alkaline; clear, wavy boundary.

A3—6 to 12 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; friable; many roots; mildly alkaline; clear, irregular boundary.

IIB2—12 to 18 inches, dark yellowish-brown (10YR 3/4) flaggy sandy loam; dark-brown (7.5YR 4/4) coating on fragments; massive; friable; common roots; about 50 percent coarse fragments, mostly flagstones and some channers; mildly alkaline; gradual, irregular boundary.

IIC—18 to 60 inches, dark-brown (7.5YR 4/4) flaggy sandy loam; massive; friable; 50 percent coarse fragments, mostly flagstones and some channers; moderately alkaline; slightly effervescent.

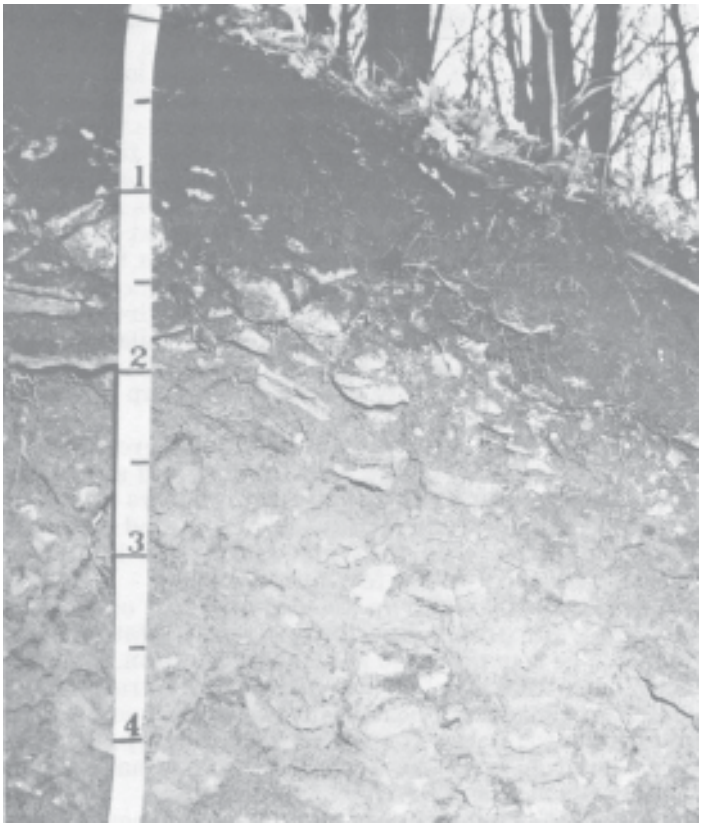

Figure 8.—**A typical profile of Marlean soils, very steep.**

The solum ranges from 15 to 25 inches in thickness. Depth to bedrock ranges from 4 to 10 feet. The A horizon is loam, silt loam, or sandy loam. The A1 horizon ranges from 5 to 10 inches in thickness and from black to very dark brown in color. The A3 horizon is 4 to 6 inches thick. A thin, dark-brown loam or sandy loam B2 horizon is in some places. The IIB and IIC horizons are flaggy loam or flaggy sandy loam. They range from 35 to 60 percent coarse fragments. The IIC horizon is dark brown, brown, or yellowish brown.

Marlean soils are near Brodale, Copaston, Dubuque, and Frontenac soils. They do not have free carbonates in the upper part of the profile, which is characteristic of Brodale soils. They are deeper over limestone bedrock than Copaston and Dubuque soils. They have a thinner B horizon than Frontenac soils.

Marlean soils, steep (25 to 40 percent slopes) (MaE).—These soils are on north-facing and east-facing valley walls that are mostly upstream from major rivers. Areas extend from the base of the ridgetop to the valley floor, and elevations vary from 75 to 150 feet.

Marlean soils make up about 60 percent of this unit, and Copaston, Dubuque, Frontenac, and Whalan soils, about 40 percent. The Copaston, Dubuque, or Whalan soils are on the upper part of the valley walls and the Frontenac soils are on the lower part. Included in mapping are some areas of Alluvial land, sloping, in

small ravines; areas of bedrock outcrop; and areas of more sloping soils. The bedrock outcrops are of the Galena, Platteville, and Shakopee Formations.

Runoff is rapid and very rapid, and it is highest in areas that are grazed or have had excessive traffic. The best means to slow and contain runoff is to maintain good stands of woodland. The forest floor is generally very spongelike because of a mulch of leaves and understory growth, and it absorbs a large amount of precipitation and runoff. Grazing greatly disturbs this mulch. The spongelike forest floor also aids in the recharge of ground water reservoirs of the various bedrock formations that outcrop in this unit. This woodland can be harvested for timber. Capability unit VIIs–2; woodland group 5; community development group 7; outdoor recreation group 12.

Marlean soils, very steep (40 to 80 percent slopes (MaF).—These soils are on north-facing and east-facing valley walls, principally along major rivers and along deep, side-valley tributaries. Areas extend from the base of ridgetops to the valley floor, and local relief varies from 150 to 400 feet in elevation.

Marlean soils make up about 60 percent of this unit and have the profile described as representative of the series. The remaining 40 percent is Copaston, Dubuque, or Whalen soils. Included in mapping are areas of rock outcrops that are indicated on the detailed soil map by the symbols for escarpment or rock outcrop. The bedrock outcrop is of the Jordan, Oneota, Shakopee, St. Peter, Platteville, and Galena Formations.

Runoff is rapid and very rapid, and it depends on the condition of plant cover. Areas that are grazed or have had excessive traffic release runoff at a very high velocity, which causes gullying in adjoining soils along the lower slopes. The best means to slow and contain runoff is to maintain good stands of woodland. The mulch of leaves from woodland and the understory growth on the forest floor is very spongelike and absorbs a large amount of precipitation or runoff. Grazing greatly disturbs this mulch. The spongelike forest floor also aids in the recharge of ground water reservoirs of the various bedrock formations that outcrop in this unit. The woodland can be harvested for timber. Capability unit VIIs–2; woodland group 5; community development group 7; outdoor recreation group 12.

Marsh

Marsh (Md) consists of a mixture of Bremer, Houghton, McPaul, and Orion soils and Alluvial land, frequently flooded. These soils make up the land bridges between areas of shallow lakes and ponds that are part of the water table. This land type is part of the flood plain of major rivers and is flooded by runoff in spring. Slope is less than 2 percent.

The central part of delineations is commonly open water, but vegetation is in the shallower areas in the center and around the edges. This vegetation consists of cattails, reeds, sedges, and other water-tolerant plants.

Marsh is suitable for wildlife. It is poorly suited to pasture, but wild hay can be cut along some of the edges. Capability unit VIIIw–1; woodland group 9; community development group 1; outdoor recreation group 3.

Maxfield Series

The Maxfield series consists of nearly level and depressional, poorly drained and very poorly drained soils in natural drainageways of very gently rolling glacial uplands. These soils formed in loess and glacial till. The native vegetation was wet prairie.

In a representative profile the surface layer is black and very dark gray silty clay loam about 11 inches thick. The upper 23 inches of the subsoil is dark-gray and olive-gray, mainly slightly sticky silty clay loam and silt loam; the lower 11 inches formed in glacial till and is mottled yellowish-brown, firm loam. The underlying material is yellowish-brown loam that has gray mottles.

Permeability is moderately slow, and available water capacity is high to very high. The content of organic matter is high. The content of available phosphorus and potassium is low. A seasonal water table is at a depth of 1 foot to 3 feet.

Most areas are used for crops or pasture. These soils are well suited to corn and soybeans. The main limitation is the hazard of wetness.

Representative profile of Maxfield silty clay loam, in a cultivated field about 250 feet south and 450 feet east of the northwest corner of SW¼ sec. 22, T. 109 N., R. 18 W.

Ap—0 to 8 inches, black (N 2/0) silty clay loam; moderate, fine, subangular blocky structure parting to weak, very fine, granular; slightly sticky; neutral; abrupt, wavy boundary.

A3—8 to 11 inches, very dark gray (5Y 3/1) silty clay loam; black (5Y 2/1) coatings on faces of peds; weak, medium, subangular blocky structure; slightly sticky; few, fine, tubular pores; neutral; abrupt, wavy boundary.

B21g—11 to 16 inches, dark-gray (5Y 4/1) silty clay loam; very dark gray (5Y 3/1) coatings on faces of peds; few, fine, distinct, very dark grayish-brown (10YR 3/2) mottles; weak, medium, subangular blocky structure; slightly sticky; few, fine, tubular pores; neutral; clear, wavy boundary.

B22g—16 to 23 inches, olive-gray (5Y 5/2) silt loam; common dark-gray (5Y 4/1) coatings on faces of peds; few, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; slightly sticky; few, fine, soft, dark-colored masses; mildly alkaline; clear, wavy boundary.

B23g—23 to 34 inches, olive-gray (5Y 5/2) silt loam; many, fine, distinct, yellowish-brown (10YR 5/4) mottles; weak, medium, subangular blocky structure; friable; common, fine, dark-colored masses; mildly alkaline; abrupt, wavy boundary.

IIB24—34 to 38 inches, yellowish-brown (10YR 5/4) loam; many, fine, distinct, gray (5Y 5/1) coatings on faces of peds; weak, coarse, subangular blocky structure; firm; about 10 percent coarse fragments; mottles; mildly alkaline; clear, wavy boundary.

IIB3—38 to 45 inches, yellowish-brown (10YR 5/4) loam; many, medium, distinct, gray (5Y 5/1) mottles; weak, coarse, prismatic structure; firm; about 5 percent coarse fragments; mildly alkaline; clear, wavy boundary.

IIC—45 to 70 inches, yellowish-brown (10YR 5/4) loam; common, medium, distinct, gray (5Y 5/1) mottles; massive; firm; about 5 percent coarse fragments; slightly effervescent; mildly alkaline.

The thickness of the solum, or depth to free carbonates, ranges from 35 to 50 inches. The silty mantle ranges from 24 to 40 inches in thickness. The A horizon ranges from 10 to 20 inches in thickness. It is silty clay loam or heavy silt loam. The B2g horizon ranges from gray or dark gray to olive gray. It has few to many, distinct or prominent mottles.

It ranges from neutral to mildly alkaline. The IIB and IIC horizons are brown or yellowish brown and have common to many, faint or distinct mottles. These horizons range from 3 to 10 percent gravel. In some places the upper part of the IIB horizon was gravelly sandy loam, gravelly loamy coarse sand, or gravelly coarse sand.

Maxfield soils are near Klinger and Skyberg soils and are similar to Garwin soils. They are wetter and have a grayer B horizon than Klinger and Skyberg soils. In contrast with Garwin soils, they do not have silty material in the C horizon.

Maxfield silty clay loam (0 to 2 percent slopes) (Mf).—This soil is on smooth side slopes adjacent to wet drainageways and broad flats in the glacial uplands. Areas range from 2 to 200 acres in size. This soil has the profile described as representative of the series. Included in mapping are some areas of Canisteo soils and Maxfield silty clay loam, swales.

The main limitation is the hazard of wetness. Surface runoff is slow. A seasonal water table at a depth of 1 foot to 3 feet restricts root development and makes this soil very difficult to manage in wet periods. The surface layer becomes hard and cloddy if worked when too wet. The main management needs are artificial drainage and improvement of tilth. Waterways are needed to contain and carry off surface runoff.

Most of the acreage is used for crops or pasture. Adequately drained areas are well suited to crops, especially corn and soybeans. Capability unit IIw–1; woodland group 9; community development group 2; outdoor recreation group 3.

Maxfield silty clay loam, swales (Mo).—This depressional soil is in hummocky, wet drainageways in glacial uplands. Areas are generally long and narrow, but they are wider in upper reaches of drainageways. This soil is subject to frequent overflow by runoff from adjacent, upland soils. This soil has a profile similar to that described as representative of the series, but the content of organic matter is higher. Also, gravelly coarse sandy loam or gravelly loamy coarse sand, 6 to 20 inches thick, is between the loess and the till. Included in mapping are some areas of soils that have 10 to 30 inches of muck over loess and glacial till.

The main limitation is the severe hazard of wetness. This soil is also subject to frequent flooding. Surface runoff is slow; some areas are ponded, and only small amounts of runoff are absorbed in the soil. This soil can be artificially drained. Waterways are needed to contain surface runoff.

Most of the acreage is used as pasture. Some areas are used for crops, especially corn and soybeans. A probable use of some of this soil is as an outlet for artificial drainage systems in uplands. This soil also has potential as wildlife habitat areas, and habitat and outlet areas should be developed together. Capability unit IIIw–1; woodland group 9; community development group 2; outdoor recreation group 3.

McPaul Series

The McPaul series consists of nearly level, moderately well drained soils on flood plains of major streams. These soils formed in recent alluvium. The native vegetation was grasses.

In a representative profile the surface layer is very dark grayish-brown silt loam about 12 inches thick. The underlying material is stratified very dark grayish-brown and grayish-brown silt loam about 18 inches thick. Below this is a buried soil that is black and very dark gray loam and silt loam and is about 30 inches thick.

Permeability is moderate, and available water capacity is very high. The content of organic matter is moderate. The content of available phosphorus and potassium is low. The content of lime is high. A water table is at a depth of 5 to 7 feet.

Most areas are used for pasture, and some areas are used for crops. The main limitation is the hazard of flooding.

Representative profile of McPaul silt loam, in a pasture 200 feet west and 150 feet south of the northeast corner of SE¼SW¼ sec. 20, T. 111 N., R. 16 W.

A1—0 to 12 inches, very dark grayish-brown (10YR 3/2) silt loam; common, thin strata of grayish brown (10YR 5/2); moderate, medium, platy structure parting to moderate, very fine, granular; very friable; many, very fine, fine, and medium, tubular pores; many roots; mildly alkaline; slightly effervescent; clear, wavy boundary.

C1—12 to 22 inches, very dark grayish-brown (10YR 3/2) silt loam; few, thin strata of grayish-brown (10YR 5/2); moderate, medium, platy structure parting to moderate, fine, granular; very friable; many, very fine, fine, and medium, tubular pores; mildly alkaline; slightly effervescent; clear, wavy boundary

C2—22 to 30 inches, very dark gray (10YR 3/1) silt loam; many, very thin strata of grayish brown (10YR 5/2); moderate, thin, platy structure parting to moderate, very fine, granular; very friable; mildly alkaline; slightly effervescent; clear, wavy boundary.

Ab—30 to 42 inches, black (10YR 2/1) loam, common; fine, distinct, dark-brown (7.5YR 3/2 or 4/4) mottles; weak, medium, subangular blocky structure; very friable; many, very fine and fine, tubular pores; mildly alkaline; slightly effervescent; clear, wavy boundary.

C3—42 to 60 inches, very dark gray (10YR 3/1) stratified loam and silt loam; many, medium, dark-brown (7.5YR 4/4) mottles; weak, medium, subangular blocky structure; very friable; many, fine and very fine, tubular pores; mildly alkaline; strongly effervescent.

The stratified sediment ranges from 30 to 65 inches in thickness. The matrix ranges from very dark gray to dark grayish brown. Lighter colored strata of gray or grayish brown are thin or very thin and range from few to many. Sediment mostly is silt loam, although in some places few to many thin strata of fine or very fine sandy loam or loam occur. A buried Ab horizon, as much as 30 inches thick, begins at a depth below 30 inches in some places. It is black or very dark brown loam, silt loam, or silty clay loam.

McPaul soils are near Lawson and Radford soils and are similar to Chaseburg soils. They have free lime throughout, and the other soils do not have free lime unless it is at a considerable depth. They contain less clay than Lawson and Radford soils.

McPaul silt loam (0 to 2 percent slopes) (Mp).—This soil is on narrow first bottoms along meandering stream channels. Areas range from 200 to 1,000 feet in width and from 5 to 100 acres in size. Along the outer edge of this soil are more sloping soils or soils on bottoms or terraces at higher elevations. Floods result from snow melt or heavy rain showers, during which runoff collects in watershed areas that are commonly larger than 2 square miles. Flooding is frequent, and periods range from 1 or 2 hours to as much as 1 or 2 days. The soil receives sediment from these floods

(fig. 9). Included in mapping are a few small areas of Chaseburg soils.

The main limitation is the severe hazard of flooding. This soil is also subject to scouring, stream-bank erosion, and sedimentation.

This soil is mostly used for pasture, and it is well suited to this use. Areas where runoff is controlled can be used for crops. Under proper management, some areas on bottom lands can be used for hardwoods. Capability unit 11w–3; woodland group 7; community development group 1; outdoor recreation group 1.

Mt. Carroll Series

The Mt. Carroll series consists of nearly level to moderately sloping, well-drained soils on summits of broad uplands and on benches of streams. These soils formed in loess. The native vegetation was deciduous hardwoods and grasses.

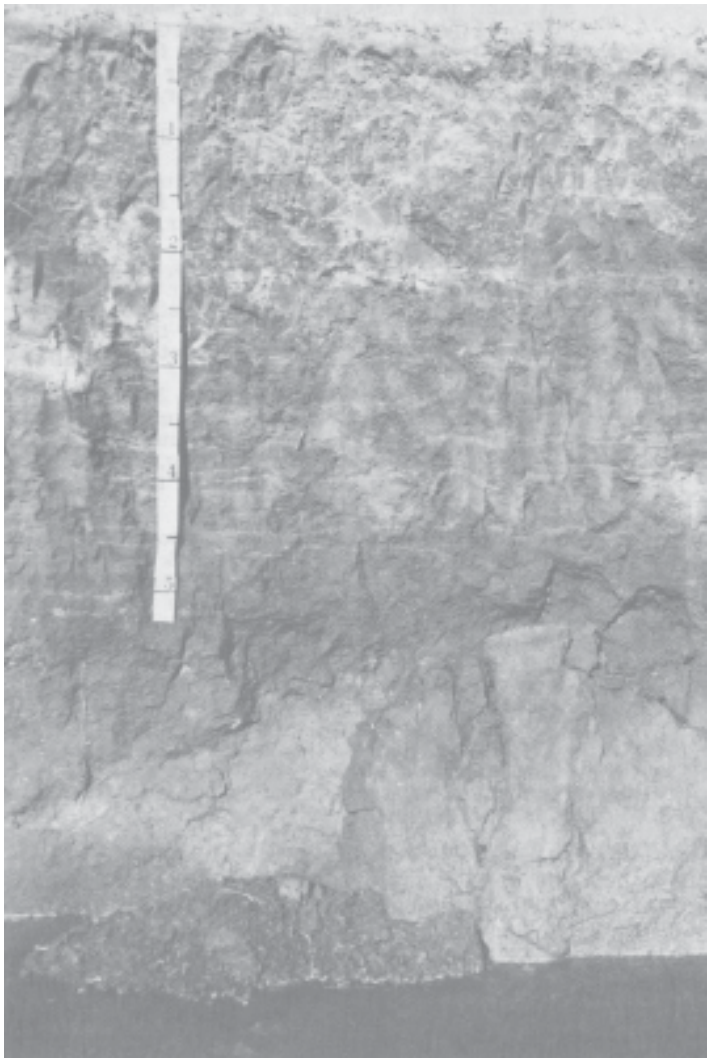

Figure 9.—**Profile of McPaul silt loam on a meandering channel exposure.**

In a representative profile the surface layer is very dark brown silt loam about 7 inches thick, and the subsurface layer is dark grayish-brown silt loam about 5 inches thick. The subsoil is dark-brown to yellowish-brown, mainly friable silt loam about 29 inches thick. The underlying material is mainly yellowish-brown silt loam.

Permeability is moderate, and available water capacity is very high. The content of organic matter is moderate. The content of available phosphorus is medium, and that of potassium is low.

Most areas are used for crops or pasture. These soils are well suited to most crops commonly grown in the county. The main limitation is the hazard of erosion.

Representative profile of Mt. Carroll silt loam, 2 to 6 percent slopes, in a cultivated field 120 feet north of the southeast corner of SW¼NE¼ sec. 19, T. 110 N., R. 17 W.

Ap—0 to 7 inches, very dark brown (10YR 2/2) silt loam; moderate, fine, granular structure; friable; neutral; abrupt, smooth boundary.

A2—7 to 12 inches, dark grayish-brown (10YR 4/2) silt loam; very dark grayish-brown (10YR 3/2) coatings on faces of peds; moderate, fine, granular structure and moderate, very fine, subangular blocky; friable; medium acid; clear, wavy boundary.

B21t—12 to 23 inches, dark-brown (10YR 4/3) heavy silt loam; moderate, fine, subangular blocky structure; friable; very thin, bleached, silty coatings and few thin clay films on faces of peds; many, very fine, fine, and medium, continuous, tubular pores; medium acid; clear, wavy boundary.

B22t—23 to 33 inches, dark yellowish-brown (10YR 4/4) silt loam; dark-brown (10YR 4/3) coatings on faces of peds; moderate, medium, subangular blocky structure; friable; very thin, bleached, silty coatings and few thin clay films on faces of peds; many, very fine, fine, and medium, continuous, tubular pores; medium acid; clear, wavy boundary.

B3—33 to 41 inches, yellowish-brown (10YR 5/4) silt loam high in content of coarse silt; weak, medium and coarse subangular blocky structure; common, medium and coarse, continuous, tubular pores; very friable; medium acid; diffuse, wavy boundary.

C1—41 to 68 inches, yellowish-brown (10YR 5/4) light silt loam; massive; very friable; slightly acid; clear, wavy boundary.

C2—68 to 83 inches, mottled yellowish-brown (10YR 5/4) and grayish-brown (2.5Y 5/2) light silt loam; massive; very friable; mildly alkaline; slightly effervescent.

The solum ranges from 30 to 50 inches in thickness. Depth to free carbonates ranges from 50 to 70 inches. About 50 to 65 percent of the silt-size fraction in the solum is fine silt less than 20 microns in diameter. However, in the lower 6 to 10 inches of the solum and in the C horizon, 50 to 70 percent of the silt fraction is coarse silt more than 20 microns in diameter. The Ap or A1 horizon ranges from 6 to 9 inches in thickness and ranges from medium acid to neutral. It is very dark brown or very dark grayish brown. The A2 horizon typically is 2 to 6 inches thick, but it is missing in some places. The B2 horizon is 20 to 35 inches thick, is dark brown to yellowish brown, and is heavy silt loam. It ranges from slightly to strongly acid. The C horizon is yellowish brown, brown, or light olive brown. In some places it has mottles at a depth below 60 inches.

Mt. Carroll soils are near Joy and Garwin soils and are similar to Port Byron and Seaton soils. They are better drained than Joy and Garwin soils. They do not have an A2 horizon or it is thinner than that of Seaton soils. They have a thinner, dark-colored A horizon than Port Byron soils.

Mt. Carroll silt loam, 0 to 2 percent slopes (MrA).—This soil is on crests of broad uplands and some side

slopes adjacent to long narrow drainageways. Areas range from 2 to 30 acres in size.

This soil has no serious limitations. Surface runoff is medium. Applications of fertilizer and lime are required for maximum production. Minimum tillage is very effective in containing surface runoff.

This soil is used mostly for crops, especially field corn and sweet corn. Capability unit I–1; woodland group 1; community development group 6; outdoor recreation group 5.

Mt. Carroll silt loam, 2 to 6 percent slopes (MrB).—This soil is on crests and partly extends onto side slopes of broad, loess-covered uplands. Most areas are slightly convex and range from 2 to 100 acres in size. This soil has the profile described as representative of the series. The loess is generally more than 6 feet thick. Included in mapping are some areas of Mt. Carroll soils that formed in 4 to 6 feet of loess underlain by firm loamy glacial till. These areas are mainly in Roscoe and Pine Island Townships.

The main limitation is the slight to moderate hazard of erosion. This hazard is most serious in areas on side slopes because they are susceptible to more runoff. Surface runoff is medium and can be controlled by minimum tillage. Fertility needs to be maintained also.

Most of the acreage is used for crops, and crops are well suited. Some areas are pasture or woodland. Capability unit IIe–1; woodland group 1; community development group 6; outdoor recreation group 5.

Mt. Carroll silt loam, 6 to 12 percent slopes, eroded (MrC2).—This soil is on side slopes adjacent to drainageways on broad uplands. Most areas are slightly convex. Slopes range from 100 to 300 feet in length. Areas range from 2 to 15 acres in size. This soil has a profile similar to that described as representative of the series, but most of the original surface layer has been lost through erosion. This soil formed chiefly in more than 6 feet of loess; however, some areas, mainly in Roscoe Township, formed in 4 to 6 feet of loess underlain by firm, loamy glacial till.

The main limitation is the moderate hazard of erosion. It is most serious in areas that lack plant cover, especially during seedbed preparation and early plant growth. The hazard of erosion is severe in areas that are extensively excavated or graded. The main management needs are to minimize erosion and contain surface runoff.

This soil is used for pasture, crops, or woodland. It is well suited to small grain, corn, and alfalfa-brome hay or pasture. Capability unit IIIe–1; woodland group 1; community development group 6; outdoor recreation group 6.

Mt. Carroll silt loam, benches, 0 to 3 percent slopes (MxA).—This soil is on benches along major streams and major, intermittent drainageways in uplands. Areas range from 20 to 30 acres in size. This soil has a profile similar to that described as representative of the series, but stratified sandy and loamy material is at a depth of 55 to 70 inches and loose sand is typically at a depth below 70 inches.

This soil has no serious limitations. Surface runoff is medium. Available water capacity is high. Applications of fertilizer and lime are required for maximum production. Minimum tillage is essential to minimize losses to runoff.

This soil is used mostly for crops, especially corn, small grain, and hay, and it is well suited to this use. Where the soil is used for a septic tank absorption field, pollution of ground water is a hazard. Capability unit I–1; woodland group 1; community development group 6; outdoor recreation group 5.

Orion Series

The Orion series consists of nearly level, poorly drained soils in drainageways of loess-covered uplands and on flood plains of some major streams. These soils formed in recent alluvium. The native vegetation was grasses.

In a representative profile the surface layer is stratified, very dark gray and very dark grayish-brown silt loam about 5 inches thick. The underlying material is stratified, dark grayish-brown and very dark gray silt loam about 21 inches thick. This is underlain to a depth of 60 inches or more by a buried soil that is black and very dark gray silt loam.

Permeability is moderate, and available water capacity is very high. The content of organic matter is moderate. The content of available phosphorus is medium, and that of potassium is low. A seasonal water table is at a depth of 1 foot to 3 feet.

Most areas are used for pasture and some crops. The main limitations are hazards of wetness and flooding.

Representative profile of Orion silt loam, wet, 270 feet east and 330 feet north of the southwest corner of SE¼SW¼ sec. 7, T. 112 N., R. 15 W.

A1—0 to 5 inches, stratified very dark grayish-brown (10YR 3/2) and very dark gray (10YR 3/1) silt loam; common, fine, distinct, dark reddish-brown (5YR 3/4) mottles; weak, very fine, granular structure; mildly alkaline; abrupt, wavy boundary.

C1—5 to 26 inches, stratified dark grayish-brown (10YR 4/2) and very dark gray (10YR 3/1) silt loam; many, medium, distinct, dark-brown (7.5YR 4/4) mottles; moderate, thin, platy structure; very friable; many, very fine and fine, tubular pores; mildly alkaline; clear, wavy boundary.

A11b—26 to 35 inches, black (10YR 2/1) silt loam; moderate, medium, platy structure parting to weak, very fine, granular; friable; common, very fine and fine, tubular pores; mildly alkaline; clear, wavy boundary.

A12b—35 to 42 inches, very dark gray (10YR 3/1) silt loam; moderate, fine, granular structure; friable; common, very fine and fine, tubular pores; mildly alkaline; gradual, wavy boundary.

A13b—42 to 60 inches, very dark gray (10YR 3/1) heavy silt loam; weak, medium, prismatic structure; firm; common very fine, fine, and medium, tubular pores; common thin clay films on pores; mildly alkaline.

Thickness of the stratified material, or depth to a buried A horizon, ranges from 20 to 40 inches. Reaction ranges from neutral to moderately alkaline. The Ab horizon ranges from 8 to 35 inches in thickness. It is black or very dark gray silt loam or silty clay cloam. A B2b horizon is in some places. It is dark gray or very dark gray.

Orion soils are near Chaseburg and Colo soils. They have a seasonal water table and Chaseburg soils do not. They are lighter colored and have a lower content of organic matter than Colo soils.

Orion silt loam, wet (Or).—This soil is on narrow first bottoms along meandering streams and some intermittent streams. Areas range from 200 to 1,000 feet in width and from 5 to 30 acres in size. More sloping soils on benches, higher bottoms, or foot slopes are along the outer edges of this soil. Floods result from snow

melt or from heavy runoff from rain showers that collects in watershed areas that are commonly more than 320 acres in size. Flooding is frequent, and periods range from 1 or 2 hours to as much as 1 day. This soil receives sediment from these floods.

This soil is used mostly for pasture and is well suited to that use. Flooding is almost too severe for any other use. The hazard of wetness is also severe, but some areas can be artificially drained if it is considered feasible. Capability unit IIIw–3; woodland group 9; community development group 1; outdoor recreation group 1.

Ostrander Series

The Ostrander series consists of nearly level to sloping, well-drained soils on crests and side slopes of broad uplands. These soils formed in loess and glacial till. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is very dark brown and very dark grayish-brown silt loam about 11 inches thick. The subsoil is dark-brown and yellowish-brown, friable loam about 30 inches thick. The underlying material is brown loam.

Permeability is moderate, and available water capacity is high. The content of organic matter is high. The content of available phosphorus is medium, and that of potassium is low.

Most areas are used for crops. These soils are suited to most row crops commonly grown in the county. The main limitation is the hazard of erosion.

Representative profile of Ostrander silt loam, 1 to 6 percent slopes, in a cultivated field, 90 feet north and 300 feet east of the southwest corner of SE¼ sec. 32, T. 111 N., R. 18 W.

Ap—0 to 8 inches, very dark brown (10YR 2/2) silt loam; moderate, very fine, granular structure; friable; neutral; abrupt, wavy boundary.

A3—8 to 11 inches, very dark grayish-brown (10YR 3/2) silt loam high in content of sand; common mixings of very dark brown (10YR 2/2); moderate, very fine and fine, granular structure; friable; neutral; abrupt, wavy boundary.

B21—11 to 15 inches, dark-brown (10YR 4/3) loam; very dark grayish-brown (10YR 3/2) coatings on faces of peds; moderate, fine, subangular blocky structure; friable; many, very fine and fine, tubular pores; slightly acid; abrupt, wavy boundary.

IIB22—15 to 25 inches, yellowish-brown (10YR 5/4) loam; dark-brown (10YR 4/3) coatings on faces of peds; moderate, fine, subangular blocky structure; friable; common very fine, fine, and medium, tubular pores; about 5 percent gravel; medium acid; clear, wavy boundary.

IIB23—25 to 30 inches, yellowish-brown (10YR 5/6) loam; yellowish-brown (10YR 5/4) coatings on faces of peds or partings; moderate, medium, prismatic structure parting to moderate, fine, subangular blocky; friable; common very fine, fine, and medium, tubular pores; about 5 percent gravel; medium acid; clear, wavy boundary.

IIB3—30 to 41 inches, yellowish-brown (10YR 5/8) loam; yellowish-brown (10YR 5/4) partings along faces of prisms; weak, coarse, prismatic structure; friable; common, very fine and medium, tubular pores; few thin strata of sand; about 7 percent pebbles; slightly acid; clear, wavy boundary.

IIC—41 to 65 inches, brown (10YR 5/3) loam; massive, random cleavages; firm; about 4 percent pebbles; common, very fine threads of free carbonates; mildly alkaline; slightly effervescent.

Thickness of the solum, or depth to free carbonates, ranges from 38 to 70 inches. The loess ranges from 14 to 24 inches in thickness. The glacial till typically is 2 to 6 percent coarse fragments. In some places, however, one or more stone lines that are as much as 30 percent coarse fragments are in the IIB horizon. The upper sediment is silt loam or loam.

The Ap or A1 horizon is black or very dark brown. The A3 horizon is very dark gray, very dark grayish brown, or dark brown. The part of the B horizon that formed in loess ranges from dark brown or brown to yellowish brown and is loam or silt loam. The IIB horizon is mostly loam, clay loam, or sandy clay loam, but it commonly is coarser textured in some places. The C horizon is brown, yellowish brown, or olive brown.

In some areas in the northern part of the county, the IIB and IIC horizons are strong brown and friable. This difference, however, does not significantly affect the use or behavior of the soil.

Ostrander soils are near Klinger and Maxfield soils and are similar to Racine soils. They contain more sand and less silt in their solum and are better drained than Klinger and Maxfield soils. They have a thicker, dark-colored A horizon than Racine soils.

Ostrander silt loam, 1 to 6 percent slopes (OtB).—This soil is on convex crests of broad glacial uplands, and it partly extends down onto side slopes. Slopes range from 100 to 600 feet in length. Areas range from 2 to 100 acres in size. This soil has the profile described as representative of the series. Bedrock is at a depth of 6 to 10 feet on some of the narrow upland ridges that are a part of the valleys of the Cannon River and its tributaries.

The main limitation is the moderate hazard of erosion, and the more susceptible areas are on side slopes. Surface runoff is medium. The main management need is to reduce the hazard of erosion.

Most of the acreage is used for crops. Corn, small grain, and hay are well suited. Some areas are pasture. Capability unit IIe–1; woodland group 1; community development group 6; outdoor recreation group 5.

Ostrander silt loam, 6 to 12 percent slopes, eroded (OtC2).—This soil is on convex sides of drainageways in glacial uplands. Slopes range from 100 to 300 feet in length. Areas range from 2 to 15 acres in size. This soil has a profile similar to that described as representative of the series, but the surface layer is thinner.

The main limitation is the moderate hazard of further erosion. Surface runoff is medium. Erosion is most serious in areas that lack plant cover, especially during seedbed preparation and early plant growth. Cropping systems are needed to reduce this hazard. Where feasible, terraces are very effective in minimizing erosion and containing runoff. Fertility also needs to be maintained.

This soil is used for pasture or crops. It is well suited to small grain, corn, and alfalfa-brome hay. Capability unit IIIe–1; woodland group 1; community development group 6; outdoor recreation group 6.

Plainfield Series

The Plainfield series consists of nearly level to steep, excessively drained soils on benches and escarpments along major rivers. These soils formed in sandy outwash. The native vegetation was deciduous forest.

In a representative profile the surface layer is very dark brown loamy sand about 5 inches thick. The subsoil is dark-brown and dark yellowish-brown, loose

sand about 29 inches thick. The underlying material is dark yellowish-brown and yellowish-brown sand.

Permeability is rapid, and available water capacity is low. The content of organic matter is low. The content of available phosphorus and potassium is low.

Most areas are woodland or pasture. The main limitation is the hazard of drought.

Representative profile of Plainfield loamy sand, 0 to 6 percent slopes, in a wooded area 890 feet west and 460 feet south of the northeast corner of sec. 36, T. 112 N., R. 18 W.

A1—0 to 5 inches, very dark brown (10YR 2/2) loamy sand; single grained; loose; strongly acid; clear, wavy boundary.
B21—5 to 22 inches, dark-brown (10YR 3/3) sand; many, large mixings of dark-brown (10YR 4/3) mottles; weak, coarse, subangular blocky structure; loose; medium acid; clear, wavy boundary.
B22—22 to 34 inches, dark yellowish-brown (10YR 4/4) sand; many tongues of dark brown (10YR 3/3); single grained; loose; slightly acid; clear, wavy boundary.
C1—34 to 58 inches, dark yellowish-brown (10YR 4/4) sand; few, dark yellowish-brown (10YR 3/4) sand lamellae; single grained; loose; slightly acid; clear, wavy boundary.
C2—58 to 65 inches, yellowish-brown (10YR 5/6) sand; single grained; loose; slightly acid.

The solum ranges from 20 to 40 inches in thickness. In some places the content of gravel ranges from 1 to 15 percent. The A horizon ranges from 3 to 8 inches in thickness and from very dark brown to brown in color. It is sand or loamy sand. The B horizon is dark-brown or dark yellowish-brown sand or coarse sand. The C horizon ranges from dark yellowish brown to light yellowish brown. It is sand or coarse sand. Reaction ranges from very strongly acid to neutral. Lamellae are lacking in some places.

Plainfield soils are near Gotham soils and are similar to Sparta soils. They lack the thick, finer textured bands that are characteristic of Gotham soils. They have a thinner dark-colored A horizon than Sparta soils.

Plainfield loamy sand, 0 to 6 percent slopes (PaB).—This soil occupies entire broad stream benches. Areas range from 5 to 200 acres in size. This soil has the profile described as representative of the series. Included in mapping are areas of somewhat poorly drained sandy soils in a few of the natural drainageways southwest of Cannon Falls. Also included are some very steep areas that are indicated on the detailed soil map by the symbol for escarpments.

Because available water capacity is low, the main limitation is the severe hazard of drought. Natural fertility and the content of organic matter are low. The hazard of soil blowing is moderate in areas that lack plant cover. Surface runoff is slow, and most of it is absorbed because the rate of infiltration is high and permeability is rapid.

This soil is used for crops, pasture, and woodland. It is poorly suited to most crops because it is too droughty, and it is better suited to permanent pasture and trees. Pastures, however, go dormant rather early in the season because of droughtiness. Where the soil is used as a septic tank absorption field, pollution of ground water is a hazard because of the rapid permeability of the underlying material. Capability unit IVs–1; woodland group 4; community development group 3; outdoor recreation group 11.

Plainfield loamy sand, 6 to 25 percent slopes (PaD).—This soil is on narrow escarpments of stream benches that adjoin flood plains or stream benches at lower elevations. Slopes range from 50 to 150 feet in length. Areas range from 2 to 40 acres in size. Included in mapping are some areas of Salida soils and some severely gullied areas. Also included are some very steep areas that are indicated on the detailed soil map by the symbol for escarpments.

Because available water capacity is low, the main limitation is the severe hazard of drought. Surface runoff is slow or medium, and much of it is absorbed because the rates of infiltration and permeability are rapid. This soil is subject to severe gullying in areas where surface runoff passes or where sufficient vegetation is lacking (fig. 10). Natural fertility and content of organic matter are low.

Most of the acreage is woodland or idle, and permanent vegetation is well suited. The hazards of erosion and drought make this soil very poorly suited to pasture or crops. Pollution of ground water is a hazard in areas used as septic tank absorption fields or as sanitary landfills. Capability unit VIIs–1; woodland group 4; community development group 9; outdoor recreation group 13.

Port Byron Series

The Port Byron series consists of nearly level to sloping, well-drained soils on crests and side slopes of broad uplands and nearly level benches. These soils formed in loess. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is about 19 inches thick. It is very dark brown silt loam that grades to very dark grayish brown in the lower part. The subsoil is dark-brown and brown, friable silt loam about 21 inches thick. The underlying material is yellowish-brown silt loam (fig. 11).

Permeability is moderate, and available water capacity is very high. The content of organic matter is high. The content of available phosphorus is medium, and that of potassium is low.

Most areas are used for crops or pasture. These soils are better suited to corn and soybeans than to most other crops. The main limitation is the hazard of erosion.

Representative profile of Port Byron silt loam, 2 to 6 percent slopes, in a cultivated area 200 feet south and 100 feet east of the northwest corner of NE¼ sec. 8, T. 110 N., R. 18 W.

Ap—0 to 9 inches, very dark brown (10YR 2/2) silt loam; moderate, very fine and fine, granular structure; friable; neutral; abrupt, wavy boundary.
A12—9 to 15 inches, very dark brown (10YR 2/2) silt loam; weak, fine, subangular blocky structure; friable; many, very fine, fine, and medium, tubular pores; medium acid; abrupt, wavy boundary.
A3—15 to 19 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, fine, subangular blocky structure; friable; many, very fine and medium, tubular pores; friable; medium acid; clear, wavy boundary.
B21—19 to 24 inches, dark-brown (10YR 4/3) silt loam; dark grayish-brown (10YR 4/2) coatings on faces of peds; moderate, fine, subangular blocky structure; friable; many very fine, fine, and medium, tubular pores; medium acid; clear, wavy boundary.
B22—24 to 30 inches, brown (10YR 5/3) silt loam; moderate, fine, subangular blocky structure; friable;

Figure 10.—**Plainfield loamy sand, 6 to 25 percent slopes, on gullied hillside.**

many very fine, fine, and medium, tubular pores; medium acid; abrupt, wavy boundary.

B3—30 to 40 inches, brown (10YR 5/3) silt loam; weak, coarse, subangular blocky structure; friable; common very fine, fine, and medium, tubular pores; slightly acid; clear, wavy boundary.

C—40 to 65 inches, yellowish-brown (10YR 5/4) silt loam; massive; very friable; moderately alkaline.

The solum ranges from 36 to 50 inches in thickness. The depth to free carbonates ranges from 40 to 70 inches. About 50 to 65 percent of the silt-size fraction in the solum is fine silt. However, the lower 6 to 10 inches of the solum and the C horizon are 50 to 70 percent coarse silt. The A horizon ranges from 10 to 20 inches in thickness. The B horizon range from 15 to 30 inches in thickness. The B2 horizon is dark brown, brown, or dark yellowish brown. It is medium acid or slightly acid. The B3 horizon is brown or yellowish brown.

Port Byron soils are near Garwin and Joy soils and are similar to Mt. Carroll soils. They are better drained than Joy soils and do not have mottles in the B horizon, which is characteristic of Joy soils. They are better drained than Garwin soils and have a brighter colored B horizon. They do not have appreciable amounts of translocated clay in the B horizon, which is characteristic of Mt. Carroll soils.

Port Byron silt loam, 0 to 2 percent slopes (PbA).—This soil is on crests of broad uplands and on some side slopes adjacent to long, narrow drainageways. Areas range from 2 to 30 acres in size.

This soil has no serious limitations. Surface runoff is medium. Applications of lime and fertilizers are needed for maximum production. Minimum tillage that leaves crop residue on the surface is very effective in containing surface runoff.

This soil is used mostly for crops, especially corn and soybeans, and it is well suited to this use. Capability unit I–1; woodland group 1; community development group 6; outdoor recreation group 5.

Port Byron silt loam, 2 to 6 percent slopes (PbB).—This soil is on convex crests and side slopes of broad, loess-covered uplands. Areas on the lower part of the side slopes adjoin sloping soils or soils in natural drainageways. Slopes range from 200 to 400 feet in length. This soil has the profile described as representative of the series.

The hazard of erosion is slight to moderate, and it is most serious on the lower part of side slopes. Sur-

Figure 11.—**Profile of Port Byron silt loam.**

face runoff is medium. Management is needed, especially minimum tillage that reduces losses to erosion and runoff. Where feasible, terraces are also very effective. Fertility also needs to be maintained.

Most of the acreage is used for crops. This soil is well suited to field corn, small grain, and alfalfa-brome hay. It is also well suited to canning crops, such as sweet corn and peas. Capability unit IIe–1; woodland group 1; community development group 6; outdoor recreation group 5.

Port Byron silt loam, 6 to 12 percent slopes, eroded (PbC2).—This soil is on convex side slopes adjacent to drainageways on broad uplands. Slopes range from 75 to 200 feet in length. Areas range from 2 to 15 acres in size. The profile of this soil is similar to that described as representative of the series, but it is thinner and more of the coarser textured, silt-size particles common to the substratum are in the upper part of the profile.

The hazard of further erosion is severe. It is most serious in areas that lack vegetation, especially during seedbed preparation and early plant growth. Surface runoff is medium. The main management need is to reduce losses to erosion and runoff. The hazard of erosion is also severe in areas planned for extensive excavations and grading.

This soil is used for pasture or crops. Under proper management it is well suited to corn, small grain, and hay crops. Capability unit IIIe–1; woodland group 1; community development group 6; outdoor recreation group 6.

Port Byron silt loam, benches, 0 to 3 percent slopes (PoA).—This soil is on benches along major streams. Areas commonly adjoin areas of Fairhaven or Waukegan soils. They range from 2 to 50 acres in size. This soil has a profile similar to that described as representative of the series, but the underlying material contains stratified sand and gravel at a depth of 50 to 70 inches, and in a few areas on uplands it contains soft sandstone at this depth.

This soil has no serious limitations. Surface runoff is slow to medium, and much of it is absorbed because infiltration rate is moderate.

Most of the acreage is used for crops. This soil is well suited to row crops, especially corn and soybeans. Where septic tank absorption fields are planned, pollution of ground water is a hazard because the underlying material is rapidly permeable. Capability unit I–1; woodland group 1; community development group 6; outdoor recreation group 5.

Racine Series

The Racine series consists of gently sloping to very steep, well-drained soils on convex crests and side slopes of broad uplands and narrow upland ridges. These soils formed in loess and loam till. The native vegetation was deciduous hardwoods.

In a representative profile the surface layer is very dark grayish-brown silt loam about 7 inches thick, and the subsurface layer is dark-brown silt loam about 4 inches thick. The upper 12 inches of the subsoil is brown, friable heavy silt loam; the lower 32 inches is yellowish-brown, friable and firm loam. The underlying material is light olive-brown loam.

Permeability is moderate, and available water capacity is high. The content of organic matter is moderate to low. The content of available phosphorus is medium, and that of potassium is low.

Most areas are used for crops or pasture. The main limitation is the hazard of erosion.

Representative profile of Racine silt loam, 1 to 6 percent slopes, in a cultivated field 75 feet south and 485 feet west of the northeast corner of NW¼NW¼ sec. 18, T. 109 N., R. 16 W.

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A2—7 to 11 inches, dark-brown (10YR 4/3) silt loam, dark grayish-brown (10YR 4/2) coatings on faces of peds; moderate, medium, platy structure; many, very fine, and fine, tubular pores; slightly acid; clear, wavy boundary.

B1—11 to 16 inches, brown (10YR 5/3) heavy silt loam; moderate, very fine, subangular blocky structure; friable; many, very fine and fine, tubular pores; many thin porous coatings on faces of peds; medium acid; clear, wavy boundary.

B21t—16 to 23 inches, brown (10YR 5/3) heavy silt loam;

moderate, very fine, subangular blocky structure; friable; many very fine, fine, and medium, tubular pores; many thin porous coatings on faces of peds and in larger pores; strongly acid; abrupt, wavy boundary.

IIB22t—23 to 30 inches, yellowish-brown (10YR 5/4) heavy loam, many grayish-brown (10YR 5/2) coatings on faces of peds; moderate, fine, prismatic structure parting to moderate, medium, subangular blocky; friable; common, very fine and fine, tubular pores; common thin porous coatings on faces of peds; about 7 percent coarse fragments; strongly acid; clear, wavy boundary.

IIB23t—30 to 38 inches, yellowish-brown (10YR 5/4) loam; many grayish-brown (10YR 5/2) coatings on faces of peds; moderate, fine, prismatic structure parting to strong, medium, angular blocky; firm; common, very fine and fine, tubular pores; many thin porous coatings on faces of peds; about 4 percent coarse fragments; strongly acid; clear, wavy boundary.

IIB24t—38 to 43 inches, yellowish-brown (10YR 5/4) loam; many grayish-brown (10YR 5/2) coatings on faces of peds; moderate, medium, prismatic structure; firm; common fine, medium, and large, tubular pores; many thin porous coatings on faces of peds; few thin clay films on faces of peds; about 4 percent coarse fragments; strongly acid; abrupt, wavy boundary.

IIB25t—43 to 55 inches, yellowish-brown (10YR 5/4) loam; common, faint, grayish-brown (10YR 5/2) mottles; moderate, medium, prismatic structure; firm; common, fine and medium, tubular pores; common moderately thick clay films in pores and on faces of peds; about 4 percent coarse fragments; medium acid; clear, wavy boundary.

IIC—55 to 65 inches, light olive-brown (2.5Y 5/4) loam; massive; firm; about 5 percent coarse fragments; mildly alkaline; slightly effervescent.

The solum ranges from 40 to 60 inches in thickness. Depth to free carbonates ranges from 40 to 70 inches. The loess ranges from 14 to 24 inches in thickness, and it mostly does not have coarse fragments. The underlying till typically contains 2 to 6 percent coarse fragments. A thin stone line, commonly less than 10 inches thick, underlies the loess and contains as much as 30 percent coarse fragments.

The Ap or A1 horizon ranges from very dark brown to very dark grayish brown. The A2 horizon typically ranges from 2 to 6 inches in thickness, but it is lacking in some places. It is dark brown or dark grayish brown. The B horizon in the loess is brown or yellowish brown. It is mostly silt loam, but it is loam, clay loam, or silty clay loam in some places. Few to common thin clay films are in this part of the B horizon in some places. The matrix of the IIB horizon ranges from brown to yellowish brown. It is mostly loam, but in some places it is clay loam, sandy loam, or sandy clay loam. Clay films are moderately thick or thin and range from few to many in part to all of this horizon.

In some areas in the northern part of the county, the IIB and IIC horizons are strong brown and friable. This difference, however, does not significantly affect the use or behavior of the soil.

Racine soils are near Kasson soils and are similar to Ostrander soils. They are better drained than Kasson soils. They have a thinner, dark-colored A horizon than Ostrander soils. They also have an appreciable increase in content of clay in the B horizon that Ostrander soils lack.

Racine silt loam, 1 to 6 percent slopes (RaB).—This soil is on slightly convex crests and side slopes of glacial uplands. Slopes range from 100 to 600 feet in length. Areas range from 2 to 100 acres in size and most are 1 mile to 4 miles from a major river valley. This soil has the profile described as representative of the series. Bedrock is at a depth of 6 to 10 feet on some narrow upland ridges adjacent to Cannon River and its tributary valleys.

The hazard of erosion is moderate, and it is most serious on side slopes. Surface runoff is medium. This soil is somewhat droughty, and deep-rooted crops have some difficulty developing the needed root system in the loamy till. The main management need is a cropping system that reduces losses to erosion and runoff. Artificial drainage is needed in some places if waterways and terrace channels are used. Fertility also needs to be maintained.

This soil is used mainly for crops, and it is well suited to corn, small grain, and hay. Some areas are pasture or woodland. Capability unit IIe–1; woodland group 1; community development group 6; outdoor recreation group 5.

Racine silt loam, 6 to 12 percent slopes (RaC).—This soil is on convex side slopes adjacent to glacial upland drainageways or to moderately steep to very steep soils. Slopes range from 100 to 300 feet in length. Areas range from 2 to 15 acres in size.

The main limitation is the moderate hazard of erosion, and it is most serious in areas that lack plant cover, especially during seedbed preparation and early plant growth. Surface runoff is medium. Management is needed that reduces losses to erosion and runoff. Fertility also needs to be maintained.

This soil is used for pasture or crops. It is well suited to small grain, corn, and hay. Capability unit IIIe–1; woodland group 1; community development group 6; outdoor recreation group 6.

Racine silt loam, 6 to 12 percent slopes, eroded (RaC2).—This soil is on convex side slopes in glacial uplands. It is adjacent to natural drainageways or to moderately steep to very steep soils on lower slopes. Slopes range from 100 to 300 feet in length. Areas range from 2 to 25 acres in size, and most are 1 mile to 4 miles from a major river valley. This soil has a profile that is similar to that described as representative of the series, but in cultivated areas it lacks a subsurface layer and has a thinner subsoil. Included in mapping are some areas of severely eroded soils that have a brown loam surface layer that is partly mixed into the lower part of the subsoil.

The main limitation is the moderate hazard of further erosion, and it is most serious in areas that lack plant cover, especially during seedbed preparation and early plant growth. Surface runoff is medium. A cropping system is needed that controls erosion and runoff. Fertility also needs to be maintained.

This soil is used for pasture or crops. It is suited to corn, small grain, and hay. Capability unit IIIe–1; woodland group 1; community development group 6; outdoor recreation group 6.

Racine silt loam, 12 to 18 percent slopes, eroded (RaD2).—This soil is on sides of entrenched drainageways in glacial uplands. Most areas are convex and are on escarpments between gently sloping soils upslope and soils downslope in drainageways. Slopes range from 100 to 300 feet in length. Areas range from 2 to 25 acres in size, and most are 1 mile to 4 miles from a major river valley. This soil has a profile similar to that described as representative of the series, but it lacks a subsurface layer and part of the subsoil has been mixed into the surface layer. Bedrock is at a depth of 6 to 10 feet in some areas very close to river valleys.

Included with this soil in mapping are some areas of Seaton soils on the points of low ridges and near the

base of some side slopes. Also included are some areas of severely eroded soils, areas of soils that have firm loamy till at a depth of 1 foot to 2 feet, and some areas of uneroded soils that are pastured or wooded.

The main limitation is the severe hazard of further erosion. It is most serious in areas that lack crop or plant cover, especially during seedbed preparation and early plant growth. Surface runoff is rapid. A suitable cropping system is needed to control runoff and erosion.

This soil is suited to small grain, corn, and hay. It also can be used for permanent pasture. Capability unit IVe–1; woodland group 1; community development group 8; outdoor recreation group 6.

Racine soils, 18 to 35 percent slopes (RaE).—These soils are on side slopes along entrenched narrow drainageways or along ravines and stream valleys. Slopes range from 100 to 300 feet in length. Areas range from 2 to 20 acres in size. Most of these soils have profiles similar to the one described as representative of the series. Others, on some of the foot slopes or in valleys along the Zumbro and Cannon Rivers, contain more sand and have bedrock within a depth of 6 feet. Still others lack the silty sediment and formed mainly in a firm till. Included in mapping are some areas of severely eroded Racine and Seaton soils.

The hazard of erosion is very severe in areas that lack vegetation or have been overgrazed. Surface runoff is very rapid. The main management need is to control erosion and runoff.

Most areas of these soils are in woodland or pasture, and some areas are used for crops. These soils are well suited to woodland or pasture, but pasture requires some control of grazing. Capability unit VIIe–1; woodland group 1; community development group 8; outdoor recreation group 9.

Radford Series

The Radford series consists of nearly level, somewhat poorly drained soils on first bottoms of flood plains of major streams. These soils formed in alluvium. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is very dark grayish-brown silt loam about 9 inches thick. The next layer is 17 inches thick and is very dark grayish-brown silt loam that has thin strata of grayish brown. Below this is a buried soil that is black silt loam about 34 inches thick. The underlying material is gray silty clay loam.

Permeability is moderate, and available water capacity is very high. The content of organic matter is high. The content of available phosphorus is medium, and that of potassium is low. A water table is at a depth of about 5 to 7 feet.

Most areas are used for crops or pasture. These soils are well suited to corn. The main limitation is the hazard of flooding.

Representative profile of Radford silt loam, in a cultivated area 165 feet south of the northeast corner of the SW¼SW¼ of sec. 5, T. 111 N., R. 14 W.

Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, very fine, granular structure; very friable; neutral; abrupt, wavy boundary.

C1—9 to 22 inches, very dark grayish-brown (10YR 3/2) silt loam; common, thin strata of grayish brown (10YR 5/2); weak, very thin, platy structure; very friable; common, very fine and fine continuous pores; neutral; abrupt, wavy boundary.

C2—22 to 26 inches, very dark grayish-brown (10YR 3/2) silt loam; common, thin strata of grayish brown (10YR 5/2); weak, thin, platy structure; very friable; common, very fine and fine, tubular pores; neutral; abrupt, wavy boundary.

IIA11b—26 to 36 inches, black (10YR 2/1) heavy silt loam; weak, very fine, granular structure; very friable; many, very fine and fine, tubular pores; neutral; clear, wavy boundary.

IIA12b—36 to 46 inches, black (10YR 2/1) silt loam; moderate, fine, granular structure; friable; many, very fine and fine, tubular pores; neutral; gradual, wavy boundary.

IIA13b—46 to 60 inches, black (10YR 2/1) silt loam; moderate, fine, prismatic structure parting to moderate, medium, angular blocky; slightly sticky; mildly alkaline; gradual, wavy boundary.

IIC—60 to 65 inches, gray (5Y 5/1) silty clay loam; massive; slightly sticky; mildly alkaline.

Thickness of the recent sediments over the buried soil ranges from 20 to 40 inches. These sediments are thickest adjacent to stream channels or in the path of side-valley tributaries and are thinner in areas more distant from stream channels. The upper parts of the A and C horizons are very dark grayish brown or dark grayish brown. They have common to many, thin or very thin strata of dark grayish brown or grayish brown. They are silt loam and some have few to common, thin strata of fine sandy loam. Reaction is neutral to mildly alkaline. The IIAb horizon ranges from 10 to 40 inches in thickness. It is black or very dark gray, and it ranges from silt loam to silty clay loam. The IIC horizon is gray or dark-gray silt loam or silty clay loam.

Radford soils are near McPaul and Lawson soils. They do not have free lime in the upper part of the profile, whereas McPaul soils have free lime in all parts. They have a buried soil beginning at a depth of 20 to 40 inches, and Lawson soils do not.

Radford silt loam (0 to 2 percent slopes (Rd).—This soil is on flood plains along major streams in the county. It is on the first level above the stream channel in narrow stream valleys (fig. 12). Areas range from 5 to 100 acres in size. Along the outer edges are more sloping soils on elevated high bottoms, benches, foot slopes, or valley walls. Floods generally are caused by heavy snow melt or heavy rains, when runoff collects in watershed areas. These areas generally are more than 2 square miles and range to as much as 60 square miles in size. Floods range from about 2 hours to 2 days in duration. Stratified sediment accumulates. It is thickest adjacent to stream channels and in the path of side-valley tributaries. The darker color of the layer below the sediment indicates that it was the surface layer of an earlier soil.

Included with this soil in mapping are areas of Alluvial land and Orion soils. The Orion soils are along some of the side-valley tributaries that are seepy.

This soil is used mostly for crops, especially corn, and it is well suited to this use. The hazard of flooding and weeds tend to limit other common crops. The more frequently flooded areas are used for pasture or are idle. The severe hazard of flooding is a concern in any areas planned for recreational, residential, or industrial uses. Capability unit IIw–2; woodland group 8; community development group 1; outdoor recreation group 2.

Salida Series

The Salida series consists of nearly level to very steep, excessively drained soils on benches and bench

Figure 12.—**Radford silt loam on narrow bottoms between valley walls. Brodale and Sogn soils are in background.**

escarpments of major rivers. These soils formed in sandy and gravelly outwash. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is very dark brown gravelly coarse sand about 8 inches thick. The subsoil is very dark grayish-brown, loose gravelly coarse sand about 5 inches thick. The underlying material is pale-brown stratified gravel and coarse sand.

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

Most areas are in pasture, and some areas are used as a source of gravel. The main limitation is the hazard of drought.

Representative profile of Salida gravelly coarse sand, 1 to 12 percent slopes, on the face of a gravel pit 710 feet south and 33 feet east of the center of sec. 7, T. 112 N., R. 17 W.

A1—0 to 8 inches, very dark brown (10YR 2/2) gravelly coarse sand; single grained; very friable; many roots; about 30 percent gravel; mildly alkaline; abrupt, wavy boundary.

B2—8 to 13 inches, very dark grayish-brown (10YR 3/2) gravelly coarse sand; single grained; loose; common roots; about 30 percent gravel; mildly alkaline; clear, irregular boundary.

C1—13 to 38 inches, pale-brown (10YR 6/3) gravelly coarse sand; common, very dark grayish-brown (10YR 3/2) tubular mixings; single grained; about 40 percent gravel; mildly alkaline; slightly effervescent; clear, irregular boundary.

C2—38 to 60 inches, pale-brown (10YR 6/3) stratified gravel and coarse sand; single grained; loose; about 40 percent gravel and about 15 percent cobblestones; mildly alkaline; slightly effervescent.

The solum ranges from 7 to 19 inches in thickness. The content of gravel ranges from 35 to 50 percent. The A horizon ranges from 7 to 10 inches in thickness. It is black, very dark brown, or very dark gray and is gravelly coarse sandy loam, gravelly loamy coarse sand, or gravelly coarse sand. It ranges from medium acid to mildly alkaline. The B horizon ranges to as much as 10 inches in thickness in some places, but it is missing in other places. It is dark-brown or very dark grayish-brown gravelly loamy coarse sand or gravelly coarse sand. It ranges from neutral to mildly alkaline. The C horizon is pale brown, yellowish brown, brown, and light olive brown. It ranges from gravelly coarse sand to stratified sand and gravel. The content of stones, cobblestones, or boulders ranges from 0 to 30 percent in this horizon.

Salida soils are near Estherville soils and are similar

to Lilah soils. They have less silt and clay and more sand and gravel in their solum than those soils.

Salida gravelly coarse sand, 1 to 12 percent slopes (SaB).—This soil is on knolls and escarpments on the major stream benches. Areas range from 1 to 20 acres in size. This soil has the profile described as representative of the series. Included in mapping are some areas of steep Salida soils that are indicated on the detailed soil map by the symbol for escarpments.

Because available water capacity is very low, the main limitation is the severe hazard of drought. Surface runoff is slow, and most of it is absorbed because the rate of infiltration is very high and permeability is very rapid. Natural fertility and the content of organic matter are low.

The best potential use of this soil is to convert it to permanent vegetation. It is very poorly suited to crops because it is very droughty. Some areas are used as a source of sand and gravel. Where the soil is used as a septic tank absorption field and the water table is below a depth of 10 feet, pollution is a hazard because the underlying material is very rapidly permeable. Capability unit IVs–1; woodland group 4, community development group 3; outdoor recreation group 11.

Salida gravelly coarse sand, 12 to 45 percent slopes (SaE).—This soil is on narrow escarpments of stream benches that adjoin lower flood plains or stream benches. Slopes range from 50 to 150 feet in length. Areas range from 2 to 40 acres in size.

Because available water capacity is very low, the main limitation is the severe hazard of drought. Surface runoff is medium, and much of it is absorbed because infiltration is rapid and permeability is very rapid. This soil is subject to severe gullying in areas of surface runoff or those that lack sufficient vegetation. Natural fertility and content of organic matter are low.

Most of the acreage is wooded or is left idle, and the soil is well suited to those uses. Some areas are a source of sand and gravel. This soil is poorly suited to pasture or crops because the hazards of erosion and drought are severe. Where the soil is used as a septic tank absorption field or sanitary landfill, pollution of ground water is a hazard. Capability unit VIIs–1; woodland group 4; community development group 9; outdoor recreation group 13.

Schapville Series

The Schapville series consists of gently sloping to very steep, moderately well drained soils on convex crests and sides of narrow upland ridges. These soils formed in shale and shale residuum. The native vegetation was prairie grasses and deciduous forest.

In a representative profile the surface layer is very dark gray silty clay loam about 8 inches thick. The upper 6 inches of the subsoil is dark-brown, firm silty clay; the lower 7 inches is gray, firm clay. The underlying material is greenish-gray shale that is firm at a depth below 3 feet.

Permeability is slow, and available water capacity is low. The content of organic matter is moderate. The content of available phosphorus and potassium is medium.

Most areas are used for crops and pasture. The main limitations are hazards of drought and seasonal wetness.

Representative profile of Schapville silty clay loam, 2 to 12 percent slopes, 640 feet east and 100 feet north of the southwest corner of NW¼NE¼ sec. 30, T. 112 N., R. 17 W.

Ap—0 to 8 inches, very dark gray (10YR 3/1) silty clay loam; moderate, very fine, granular structure; friable; slightly acid; abrupt, wavy boundary.

B2t—8 to 14 inches, dark-brown (10YR 4/3) silty clay; very dark grayish-brown (10YR 3/2) coatings on faces of peds; moderate, fine, subangular blocky structure; firm; many, very thin clay films; slightly acid; abrupt, wavy boundary.

IIB3—14 to 21 inches, gray (5Y 5/1) clay; many, large, faint mottles of greenish gray (5GY 5/1); moderate, medium, prismatic structure; firm; moderately alkaline; clear, irregular boundary.

IIC—21 to 45 inches, greenish-gray (5GY 5/1) shale; massive; firm; moderately alkaline; slightly effervescent.

The solum ranges from 10 to 25 inches in thickness. The A horizon ranges from very dark brown to very dark gray. It is mainly heavy silt loam or silty clay loam, but in some places it is silty clay. The B2 horizon ranges from dark brown to olive brown and has coatings of very dark grayish brown or dark grayish brown. It is silty clay or heavy silty clay loam. The B3 horizon ranges from gray to bluish gray. The C horizon is gray, greenish-gray, or bluish-gray shale, mainly of the Decorah Formation.

The Schapville soils in Goodhue County have a thinner solum and the loess mantle is missing or is thinner than is defined in the range for the series. This does not alter use or behavior of the soils.

Schapville soils are near Shullsburg soils and are similar to Derinda soils. They have a thinner solum than Shullsburg soils. They formed in a thinner mantle of loess than Derinda soils.

Schapville silty clay loam, 2 to 12 percent slopes (ScC).—This soil is on convex crests of narrow upland ridges and side slopes adjacent to natural drainageways. Areas range from 2 to 20 acres in size. Slopes range from 100 to 200 feet in length. This soil has the profile described as representative of the series. Included in mapping are some areas of soils that are 1 foot to 3 feet deep over limestone bedrock.

Because available water capacity is low, the main limitations are the moderate hazards of erosion and drought. This soil must be moist for most uses, and it is very difficult to work when it is too wet or dry. It erodes easily if the surface layer is well granulated, especially areas that have been fall plowed and left over winter. Surface runoff is medium, and very little is absorbed because natural infiltration is very slow. Minimum tillage and leaving crop residue on the surface are ways to control erosion and runoff. Very little can be done to control droughtiness, however, but limiting plant population and scheduling early fieldwork to best utilize available water in the soil and the more frequent seasonal rains are feasible.

This soil is used for crops, woodland, or pasture. It is well suited to small grain, hay, and some corn. Some areas are near expanding communities and can be developed for housing or other related uses. The limitation for septic tank absorption fields is severe because percolation is slow and the shrink-swell potential is high. Capability unit IIIe–2; woodland group 3; community development group 5; outdoor recreation group 8.

Schapville silty clay loam, 12 to 18 percent slopes (ScD).—This soil is on convex side slopes on the upper part of upland ridges. Slopes range from 100 to 300 feet in length. Areas range from 2 to 20 acres in size. Included in mapping are areas of soils that have limestone at a depth of 1 foot to 3 feet. Also included are some areas of Copaston or Sogn soils.

The main limitation is the severe hazard of erosion. This soil is most susceptible to erosion where the surface layer is well granulated, especially in areas that have been fall plowed and left over winter or worked for seedbed preparation. It also granulates or cracks in dry weather in summer. Surface runoff is rapid, and very little is absorbed because infiltration is very slow. Management is needed to control erosion and runoff, and minimum tillage that leaves a crop residue on the surface is effective. The hazard of drought is moderate because available water capacity is low.

This soil is used for crops, pasture, or woodland. It is well suited to pasture or woodland. It is suited to small grain, some corn, and hay. Capability unit IVe–3; woodland group 3; community development group 5; outdoor recreation group 8.

Schapville-Sogn complex, 18 to 35 percent slopes (SdE).—This complex is on the upper part of convex sides of upland ridges that are mainly south-facing to west-facing. It is about 50 percent Schapville soils and about 40 percent Sogn soils. The profile of the Schapville soil is shallower than that described as representative of the series. Included in mapping in about 10 percent of the areas are areas of Copaston soils or Shullsburg soils.

This complex is mostly pasture or woodland. Although some areas are cropped, the hazard of erosion is too great and runoff is too rapid for this use. Capability unit VIIs–2; woodland group 6; community development group 7; outdoor recreation group 9.

Seaton Series

The Seaton series consists of nearly level to very steep, well-drained soils on broad uplands, on narrow upland ridges, and in some stream valleys. These soils formed in loess that ranges from 6 to 15 feet in thickness. The native vegetation was mixed hardwood forest.

In a representative profile the surface layer is very dark grayish-brown silt loam about 5 inches thick, and the subsurface layer is dark-brown and grayish-brown silt loam about 13 inches thick. The subsoil is yellowish-brown and dark yellowish-brown friable silt loam about 27 inches thick. The underlying material is yellowish-brown and light olive-brown, very friable silt loam (fig. 13).

Permeability is moderate, and available water capacity is very high. The content of organic matter is moderate. The content of available phosphorus is medium, and that of available potassium is low.

Most areas are used for crops, forest, and pasture. The main limitation is the hazard of erosion.

Representative profile of Seaton silt loam, 2 to 6 percent slopes, in a wooded area 20 feet west and 125 feet north of the southeast corner of SW¼NW¼ sec. 35, T. 112 N., R. 17 W.

A1—0 to 5 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, very fine, granular structure; very friable; slightly acid; abrupt, wavy boundary.

A21—5 to 8 inches, dark-brown (10YR 4/3) silt loam; dark grayish-brown (10YR 4/2) coatings on peds; weak to moderate, very thin, platy structure; very friable; many, fine and very fine, tubular pores; medium acid; abrupt, wavy boundary.

A22—8 to 14 inches, grayish-brown (10YR 5/2) silt loam; weak, medium, platy structure; very friable; many very fine, fine, and medium, tubular pores; medium acid; abrupt, wavy boundary.

B&A—14 to 18 inches, dark-brown (10YR 4/3) heavy silt loam; grayish-brown (10YR 5/2) porous silty coatings on faces of peds; weak to moderate, fine, subangular blocky structure; friable; many very fine, fine, and medium, tubular pores; strongly acid; clear, wavy boundary.

B21t—18 to 25 inches, dark yellowish-brown (10YR 4/4)

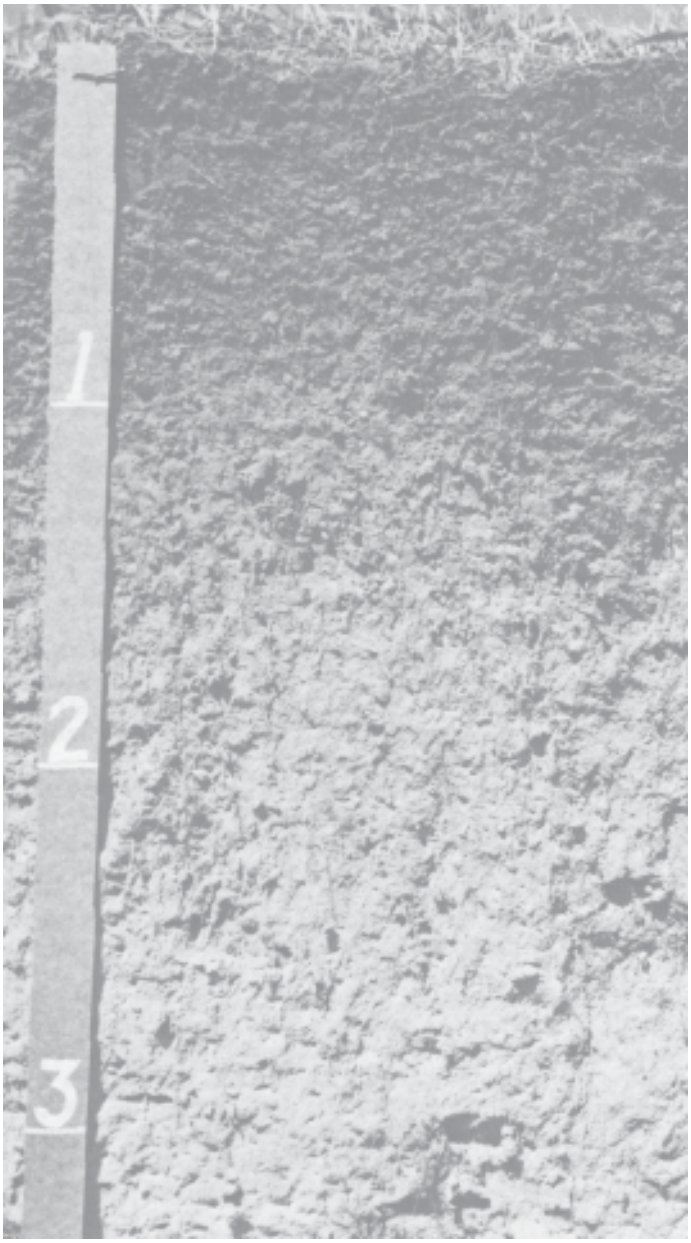

Figure 13.—**Profile of Seaton silt loam under hardwood forest.**

heavy silt loam; thin, discontinuous, clean, dark-brown (10YR 4/3), silty coatings on faces of peds; moderate, fine, subangular blocky structure; friable; common, very fine and fine, tubular pores; strongly acid; clear, wavy boundary.

B22t—25 to 35 inches, yellowish-brown (10YR 5/4) heavy silt loam; dark-brown (10YR 4/3) coatings on faces of peds; moderate, medium, subangular blocky structure; friable; common very fine, fine, and medium, tubular pores; few thin clean silty coatings; common thin clay films on faces of peds; strongly acid; clear, wavy boundary.

B3t—35 to 45 inches, yellowish-brown (10YR 5/4) silt loam; weak, coarse, prismatic structure; friable; few, fine to medium, tubular pores; few thin clay films on faces of peds; medium acid; gradual, wavy boundary.

C1—45 to 55 inches, yellowish-brown (10YR 5/4) silt loam; massive; very friable; slightly acid; few tubular pores; slightly acid; clear, wavy boundary.

C2—55 to 70 inches, light olive-brown (2.5Y 5/4) silt loam; massive; very friable; mildly alkaline.

The solum ranges from 36 to 50 inches in thickness. Depth to free carbonates ranges from 50 to 70 inches. About 50 to 65 percent of the silt-size fraction of the solum is fine silt; however, the content of coarse silt in the lower 6 to 10 inches of the solum and in the C horizon is 50 to 70 percent.

The A1 horizon ranges from 3 to 6 inches in thickness. In cultivated areas the Ap horizon ranges from 6 to 10 inches in thickness. The A1 and Ap horizons range from very dark grayish brown to dark grayish brown. The A2 horizon commonly ranges from 2 to 10 inches in thickness, but it is lacking in some eroded areas. It is dark grayish brown, dark brown, or grayish brown. The B&A horizon is common in wooded areas, but some places have a B1 horizon instead. These horizons range from 2 to 6 inches in thickness. The B2 horizon ranges from 15 to 30 inches in thickness and is dark brown to yellowish brown. It typically is heavy silt loam but ranges to silty clay loam. The B3 and C horizons are silt loam, and the content of coarse silt and very fine sand in these horizons is low to high. The C horizon is yellowish brown or light olive brown.

Seaton soils are near Chaseburg, Dubuque, and Vasa soils, and they are similar to Mt. Carroll soils. They have a B horizon, and the Chaseburg soils do not. They do not have bedrock above a depth of 40 inches, whereas Dubuque soils have bedrock at a depth of 20 to 40 inches. They are better drained than Vasa soils. They have a thicker A2 horizon than Mt. Carroll soils.

Seaton silt loam, 0 to 2 percent slopes (SfA).—This soil is on crests of broad uplands. Areas range from 2 to 20 acres in size. Included in mapping are some areas of Vasa soils.

This soil has no serious limitation to use. Surface runoff is medium. Applications of lime and fertilizer are needed for maximum production. Minimum tillage practices that leave plant residue on the soil are very effective in containing surface runoff.

This soil is used mainly for crops and is well suited to this use. It is well suited to small grain, field corn, sweet corn, and hay. Capability unit I–1; woodland group 1; community development group 6; outdoor recreation group 5.

Seaton silt loam, 2 to 6 percent slopes (SfB).—This soil is on convex crests and on side slopes of broad, loess-covered uplands. Areas range from 2 to 100 acres in size. The profile of this soil is the one described as representative of the series. Included in mapping are areas of eroded soil that do not have a subsurface layer.

The main limitation is the slight to moderate hazard of erosion, especially on the lower part of side slopes. In some places the surface layer is low in organic-matter content and crusts easily after rain. Surface runoff is medium. All areas need contouring, terracing, or minimum tillage that leaves residue on the surface. Fertility also needs to be maintained.

Most areas of this soil are cropped, and some areas are pasture or woodland. This soil is well suited to crops, especially field corn, small grain, hay, and sweet corn. Capability unit IIe–1; woodland group 1; community development group 6; outdoor recreation group 5.

Seaton silt loam, 6 to 12 percent slopes, eroded (SfC2).—This soil is on convex side slopes adjacent to drainageways in the uplands. Slopes are 200 to 400 feet long. Areas range from 2 to 20 acres in size. The profile of this soil is similar to the one described as representative of the series, but it lacks a subsurface layer and has a thinner subsoil that is partly mixed into the surface layer. Included in mapping are some areas of slightly eroded Seaton, Racine, and Timula soils.

The main limitation to farming is the severe hazard of erosion. It is very serious in areas that lack plant cover, especially during seedbed preparation and early plant growth. The hazard of erosion is also severe in areas that are extensively graded or excavated. Surface runoff is medium. Where the surface layer crusts easily, runoff is increased. The main management needs are practices that control erosion and runoff.

This soil is used mainly for crops. It is suited to corn, small grain, and hay. Soybeans are not so well suited, because they increase erosion. Special care is needed to control excessive erosion in all cultivated areas, however. Capability unit IIIe–1; woodland group 1; community development group 6; outdoor recreation group 6.

Seaton silt loam, 12 to 18 percent slopes, eroded (SfD2).—This soil is on convex side slopes in the uplands. It is principally along long, entrenched, natural drainageways and partly along the upper part of narrow ridges adjacent to major stream valleys. Slopes range from 100 to 300 feet in length. Areas range from 2 to 20 acres in size. The profile of this soil is similar to the one described as representative of the series, but it lacks the subsurface layer and upper part of the subsoil, and part of the subsoil has been mixed into the surface layer. Included in mapping are areas of Dubuque and Racine soils and slightly eroded Seaton soils.

The main limitation to farming is the severe hazard of erosion. It is very serious in areas that lack plant cover, especially during seedbed preparation and early plant growth. The hazard of erosion is also severe in areas that are extensively graded or excavated. Surface runoff is rapid. The main management concern is control of erosion and runoff. Tilth is improved by minimum tillage practices.

This soil is used mainly for crops. It is suited to corn, small grain, and hay. Growing soybeans can cause serious erosion. Special care is needed to limit erosion in cultivated areas. Some areas need to be converted to permanent pasture. Capability unit IVe–1; woodland group 1; community development group 6; outdoor recreation group 6.

Seaton silt loam, 18 to 25 percent slopes (SfE).—This soil is on side slopes in the uplands. It is principally along the long, entrenched, natural drainageways, and

some areas are along the upper part of narrow upland ridges adjacent to stream valleys. Slopes range from 100 to 300 feet in length. Areas range from 2 to 20 acres in size. The profile of this soil is similar to the one described as representative of the series, but in cultivated areas the surface layer is thicker and the subsurface layer is thinner or is lacking. Included in mapping are areas of some severely eroded soils and some Dubuque soils.

The main limitation is the severe hazard of erosion. It is very serious in areas that lack plant cover, especially during seedbed preparation and early plant growth. Surface runoff is rapid. The main management concern is to control runoff and erosion during critical periods. Some areas should be converted to permanent vegetation if erosion is too serious. Capability unit VIe–1; woodland group 1; community development group 8; outdoor recreation group 9.

Seaton silt loam, valleys, 6 to 12 percent slopes, eroded (ShC2).—This soil is on smooth foot slopes at the base of valley walls. Slopes are generally 100 to 300 feet long, and are longer where contiguous with other Seaton soils. Areas range from 2 to 20 acres in size. The profile of this soil is similar to the one described as representative of the series, but in cultivated areas the subsurface layer and a small part of the subsoil have been lost through erosion. Rocky residuum from limestone and sandstone underlies this soil at a depth of 6 to 20 feet in most areas. Included in mapping are some areas of Lindstrom soils, Timula soils, and severely eroded Seaton soils.

The main limitation to farming is the moderate hazard of erosion. It is most serious in areas that lack plant cover, especially during seedbed preparation and early plant growth. Surface runoff is medium, and runoff is also received from adjacent soils on foot slopes and valley walls. The main management need is to control erosion and runoff. The hazard of erosion is severe in extensively graded or excavated areas.

This soil is used for crops, pasture, or woodland. It is well suited to corn, small grain, and hay. Capability unit IIIe–1; woodland group 1; community development group 6; outdoor recreation group 6.

Seaton silt loam, valleys, 12 to 18 percent slopes, eroded (ShD2).—This soil is on smooth foot slopes at the base of valley walls. Slopes range from 100 to 300 feet in length and are smooth in most areas. Areas range from 2 to 30 acres in size. The profile of this soil is similar to the one described as representative of the series, but in cultivated areas the subsurface layer and part of the subsoil have been lost through erosion. In most places this soil is underlain at a depth of 6 to 15 feet by rocky residuum weathered from limestone and sandstone. Included in mapping are some areas of Lindstrom and Timula soils.

The main limitation to farming is the severe hazard of erosion, especially in areas that lack plant cover and those in seedbed preparation and early plant growth. The hazard of erosion is also severe in extensively graded or excavated areas. Runoff is rapid in overgrazed areas. This soil also receives runoff from soils upslope on valley walls. The main management need is to control erosion and runoff.

This soil is used as cropland, pasture, or woodland. It is suited to corn, small grain, and hay, although special care is needed to control erosion caused by cultivation. It is well suited to pasture or woodland. Grazing needs to be controlled to reduce runoff. Capability unit IVe–1; woodland group 1; community development group 6; outdoor recreation group 6.

Seaton silt loam, valleys, 18 to 25 percent slopes (ShE).—This soil is on smooth foot slopes at the base of valley walls. Slopes are generally 100 to 300 feet long, and are longer where contiguous with other Seaton soils. Areas range from 2 to 30 acres in size. The profile of this soil is similar to the one described as representative of the series, but the surface layer is thicker and darker because of soil accumulated through downslope creep. Also, the surface layer contains more sand and pieces of rock that have been dislodged from valley walls. In most places this soil is underlain at a depth of 6 to 15 feet by rocky residuum derived from limestone and sandstone. Included in mapping are some areas of Lindstrom, Timula, and severely eroded Seaton soils and Frontenac soils on valley walls.

The main limitation is the very severe hazard of erosion, especially in areas that lack plant cover and those in seedbed preparation and early plant growth. Runoff is rapid because of lack of cover and overgrazing. The main management needs are practices that control erosion and contain runoff.

This soil is used for crops, pasture, or woodland. It is better suited to permanent pasture or woodland than to corn and small grain because of the very severe hazard of erosion. Controlled grazing is essential to reduce runoff. Capability unit VIe–1; woodland group 1; community development group 8; outdoor recreation group 9.

Seaton complex, 6 to 12 percent slopes, eroded (SkC2).—This complex is on circular knolls on broad uplands. It is about 60 percent Seaton silt loam and 40 percent Lilah sandy loam and Kegonsa silt loam. The Lilah and Kegonsa soils that are shallow and moderately deep to gravel are on the crests of the knolls, and the Seaton soil is on the sides of the knolls. Areas range from 2 to 30 acres in size. Slopes are 75 to 200 feet long.

The profile of the Seaton soil is similar to the one described as representative of the series, but because of cultivation and erosion, the subsurface layer is missing. These soils are about 1 foot to 15 feet of loess underlain by weathered gravelly outwash. The loess is very thin or is missing in the Lilah and Kegonsa soils. The weathered outwash is about 5 to 30 feet thick and is underlain by sandstone or loamy glacial till.

The hazard of erosion is moderate. The hazard of drought is moderate to severe in Kegonsa and Lilah soils. Runoff is medium in areas that lack vegetation, are closely grazed, or are in seedbed preparation. The main management need is to control erosion and runoff.

This complex is used for crops, pasture, or hay. It is suited to corn, small grain, and hay. Capability unit IIIe–1; woodland group 1; community development group 6; outdoor recreation group 6.

Seaton complex, 12 to 25 percent slopes, eroded (SkD2).—This complex is on circular knolls on broad uplands. It is about 55 percent Seaton silt loam and 45 percent Lilah sandy loam and Kegonsa silt loam. The Lilah and Kegonsa soils are distinctive gravelly out-

croppings on the crests or points of the knolls. The Seaton soil is on all lower side slopes and saddlelike areas and in drainageways around these crests or points. Loess is thicker in these areas. Slopes range from 75 to 200 feet in length. Areas range from 2 to 15 acres in size.

The profile of the Seaton soil is similar to the one described as representative of the series, but it is eroded and lacks the subsurface layer and part of the subsoil. Included in mapping are some Eleva soils that have sandstone nearer the surface.

The hazard of erosion is very severe. The hazard of drought is moderate to severe on Kegonsa and Lilah soils. Runoff is rapid in areas that lack vegetation, are closely grazed, or are in seedbed preparation. The main management concerns are to control erosion and contain runoff.

This complex is used for crops, pasture, and hay. It is better suited to pasture in areas where grazing is controlled to reduce runoff. Corn, small grain, and hay can be grown if soil conserving practices are used. Capability unit IVe–1; woodland group 1; community development group 6; outdoor recreation group 6.

Seaton, Timula, and Bold silt loams, steep (SlE).—These soils are on the upper parts of valley walls and on the foot slopes below. Some areas are along the long, entrenched drainageways in the uplands. Slopes range from 100 to 200 feet in length. Areas range from 2 to 30 acres in size.

Seaton soils make up about 40 percent of this unit, Timula soils about 30 percent, and Bold soils about 25 percent. These soils do not occur in any pattern, and they occupy similar positions on the landscape. Timula and Bold soils, however, are near less sloping Timula soils, and Seaton soils are near less sloping Seaton soils. Included in mapping are some areas of Dubuque, Frontenac, or Marlean soils. They make up about 5 percent of the acreage.

The hazard of erosion is very severe in areas that lack vegetation, especially those used for crops. It is excessive in cultivated and overgrazed areas. The hazard of erosion is so severe that these soils are generally not farmed, although crops grow well on them. Surface runoff is very rapid.

These soils should be converted to permanent vegetation such as woodland or pasture. Grazing needs to be carefully controlled. Capability unit VIIe–1; woodland group 1; community development group 8; outdoor recreation group 9.

Shullsburg Series

The Shullsburg series consists of gently sloping to sloping somewhat poorly drained soils on concave sides of narrow upland ridges and on walls of river valleys. These soils formed in loess, shale residuum, or shale. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is black silty clay loam about 13 inches thick. The subsoil is 29 inches thick. The upper 6 inches is mottled, dark-gray, firm clay that has some black material from the surface layer. The lower 23 inches is mottled, gray, firm clay. The underlying material is mottled gray, olive, and greenish-gray, firm clay about 8 inches thick. Below this is greenish-gray soft shale.

Permeability is slow, and available water capacity is moderate to high. The content of organic matter is high. The content of available phosphorus and potassium is medium.

Most areas are used for pasture or crops. The main limitation is the hazard of seasonal wetness.

Representative profile of Shullsburg silty clay loam, 2 to 14 percent slopes, in a cultivated area 460 feet south and 320 feet west of the northeast corner of NW¼NE¼ sec. 19, T. 112 N., R. 17 W.

A11—0 to 8 inches, black (10YR 2/1) silty clay loam; moderate, fine, subangular blocky structure; friable; strongly acid; abrupt, wavy boundary.

A12—8 to 13 inches, black (10YR 2/1) heavy silty clay loam; strong, fine, granular structure; firm; about 2 percent gravel; strongly acid; clear, wavy boundary.

IIB21tg—13 to 19 inches, dark-gray (10YR 4/1) clay; common mixings of black (10YR 2/1); many, fine and medium, prominent, yellowish-brown (10YR 5/6) mottles; strong, fine, granular structure; firm; about 3 percent gravel; common thin clay films on faces of peds; strongly acid; clear, irregular boundary.

IIB22tg—19 to 38 inches, gray (5Y 5/1) clay; many, coarse, distinct, olive-brown (2.5Y 4/4) mottles and dark-gray (10YR 4/1) coatings on faces of peds; common, large mixings of black (10YR 2/1) and common, large masses of greenish-gray (5G 6/1) weathered shale; moderate, medium, prismatic structure parting to moderate, fine, subangular blocky; firm; common, very fine and fine tubular pores; about 2 percent gravel; common thin clay films; strongly acid; clear, irregular boundary.

IIB3g—38 to 42 inches, gray (5Y 5/1) clay; many, coarse, distinct, olive (5Y 5/4) mottles and common, large, distinct greenish-gray (5G 6/1) soft shale masses; common, medium, dark-brown (7.5YR 3/2), soft oxide masses; weak, medium, subangular blocky structure; firm; about 8 percent coarse gravel; medium acid; clear, irregular boundary.

IIC—42 to 50 inches, mottled gray (5Y 5/1), olive (5Y 5/4), and greenish-gray (5G 6/1) clay; massive; firm; mildly alkaline.

IIR—50 to 60 inches, greenish-gray (5G 6/1) soft shale.

The solum ranges from 24 to 48 inches in thickness. The loess mantle ranges from 5 to 20 inches in thickness. Depth to free carbonates ranges from 25 to 60 inches. The A horizon ranges from 10 to 20 inches in thickness and from black to very dark brown or very dark gray in color. It is heavy silt loam or silty clay loam. Reaction in this horizon ranges from strongly acid to neutral. The B horizon ranges from dark gray or gray to grayish brown or olive gray. It is heavy silty clay loam, silty clay, or clay and has common to many, olive, olive-brown, or yellowish brown mottles. Masses of material from the A horizon range from 5 to 25 percent of the upper part of the B horizon. Reaction in this horizon ranges from strongly acid to neutral. The R horizon is shale bedrock that ranges from soft to hard and from neutral to mildly alkaline.

The Shullsburg soils in Goodhue County have a grayer B horizon than is defined in the range for the series. This difference does not alter use and management.

Shullsburg soils are near Schapville soils. They are deeper over shale, are wetter, and have a grayer B horizon than Schapville soils.

Shullsburg silty clay loam, 2 to 14 percent slopes (SmC).—This soil is mainly on concave side slopes on the upper part of upland ridges that receive runoff and seepage from higher lying soils. Some areas are near the base of valley walls and are a part of some foot slopes. Slopes range from 100 to 300 feet in length. Areas range from 2 to 20 acres in size. Included in

mapping are some seepy areas that have free-flowing springs that can be developed as a source of water. These areas are as much as 5 acres in size and are indicated on the detailed soil map by the symbol for wet spots.

The main limitation is the slight or moderate hazard of wetness; the surface layer and underlying material are very sticky and difficult to work when wet. This limitation is most significant following spring runoff or slow, saturating rain. Surface runoff is medium, and infiltration is slow or very slow. The main management need is to establish sod in waterways to provide good surface drainage. Some fields that have been fall plowed and are prepared the following spring for grain or row crops are susceptible to erosion.

This soil is used mostly for crops and is well suited to this use. Small grain, corn, soybeans, and hay are the main crops grown. This soil is also well suited to pasture. The seepy areas are mostly limited to pasture. Some areas near expanding communities can be developed for residential or related uses, but the slow percolation is a severe limitation for septic tank absorption fields, and the high shrink-swell potential is a limitation for building sites. Some areas of this soil creep downslope. Capability unit IIIw–2; woodland group 2; community development group 5; outdoor recreation group 4.

Skyberg Series

The Skyberg series consists of nearly level, somewhat poorly drained soils on side slopes and crests of broad uplands. These soils formed in silty sediment and firm loamy glacial till. The native vegetation was dominantly oak forest.

In a representative profile, the surface layer is very dark gray silt loam about 7 inches thick, and the subsurface layer is dark grayish-brown and grayish-brown silt loam about 5 inches thick. The upper 10 inches of the subsoil is grayish-brown, friable silty clay loam that has strong-brown mottles. The lower 38 inches of the subsoil is yellowish-brown, firm loam that has grayish-brown mottles. The underlying material is mottled, yellowish-brown loam.

Permeability is moderately slow, and available water capacity is high. The content of organic matter is moderate. The content of available phosphorus is medium, and that of potassium is low. A seasonal water table is at a depth of 1 foot to 3 feet.

Most areas are used for crops, and some are in pasture. These soils are well suited to corn and soybeans, but soybeans require more lime. The main limitation is the hazard of wetness.

Representative profile of Skyberg silt loam, 1,310 feet north and 500 feet east of the southwest corner of sec. 14, T. 109 N., R. 17 W.

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

A21—7 to 9 inches, dark grayish-brown (10YR 4/2) silt loam; common, fine, faint, brown (10YR 4/3) mottles; moderate, thin, platy structure; friable; common very dark gray (10YR 3/1) coatings on faces of peds; few black (10YR 2/1) worm channels; medium acid; abrupt, smooth boundary.

A22—9 to 12 inches, grayish-brown (2.5Y 5/2) silt loam; common, fine, distinct, brown (10YR 4/3) mottles; moderate, thick, platy structure; friable; strongly acid; clear, wavy boundary.

B21tg—12 to 18 inches, grayish-brown (2.5Y 5/2) silty clay loam; common, fine, distinct, strong-brown (7.5YR 5/6) mottles; moderate, fine, subangular blocky structure; friable; common, thin, dark grayish-brown (2.5Y 4/2) and grayish-brown (2.5Y 5/2) clay films on faces of peds; many, fine, tubular pores; strongly acid; clear, wavy boundary.

B22tg—18 to 22 inches, grayish-brown (2.5Y 5/2) silty clay loam; many, fine, distinct, yellowish-brown (10YR 5/8) mottles; moderate, fine, subangular blocky structure; friable; few, thin, dark grayish-brown (2.5Y 4/2) and grayish-brown (2.5Y 5/2) clay films on faces of peds; strongly acid; abrupt, wavy boundary.

IIB23t—22 to 26 inches, yellowish-brown (10YR 5/6) loam; many, fine, distinct, grayish-brown (2.5Y 5/2) mottles; moderate, medium and coarse, prismatic structure; firm; thick, porous, sandy, grayish-brown (2.5Y 5/2) coatings on faces of peds; few thin clay films in pores; thin stone line in upper part of horizon, about 4 percent coarse fragments in lower part; strongly acid; abrupt, wavy boundary.

IIB24t—26 to 36 inches, yellowish-brown (10YR 5/6) loam; many, fine and medium, distinct, grayish-brown (2.5Y 5/2) mottles; strong, coarse, prismatic structure; very firm; thick, porous, sandy, grayish-brown (2.5Y 5/2) coatings on faces of peds; few thin clay films in pores; few fine black concretions; about 4 percent coarse fragments; medium acid; abrupt, wavy boundary.

IIB3—36 to 60 inches, yellowish-brown (10YR 5/6) loam; many, fine, distinct, grayish-brown (2.5Y 5/2) mottles; weak, coarse, subangular blocky structure; firm; few, thin, sandy, grayish-brown (2.5Y 5/2) coatings on vertical faces of peds in upper part of horizon; about 4 percent coarse fragments; slightly acid in upper part, grading to neutral in lower part; clear, wavy boundary.

IIC—60 to 66 inches, yellowish-brown (10YR 5/6) loam; many, fine, distinct, light olive-brown (2.5Y 5/4) and grayish-brown (2.5Y 5/2) mottles; massive; firm; few, light-gray (10YR 7/2) limy segregations; about 4 percent coarse fragments; mildly alkaline; slightly effervescent.

Thickness of the solum, or depth to free carbonates, ranges from 42 to 70 inches. The loess mantle ranges from 16 to 24 inches in thickness. The IIB and IIC horizons formed in glacial till and range from 2 to 8 percent gravel or cobblestones. A stone line, pebble band, or partly sorted layer as much as 10 inches thick commonly separates the two sediments.

The A horizon is silt loam or silty clay loam. The Ap or A1 horizon ranges from 6 to 10 inches in thickness and from black to very dark grayish brown in color. The B horizon in the loess is heavy silt loam or silty clay loam. The IIB horizon is loam or clay loam and ranges from 20 to 40 inches in thickness.

Skyberg soils are near Kasson and Maxfield soils. They have a grayer profile than Kasson soils. They differ from Maxfield soils by having an A2 horizon and a thinner A1 horizon.

Skyberg silt loam (0 to 2 percent slopes) (Sn).—This soil is at the heads and flanks of natural drainageways. It is between Kasson soils on high summits and Maxfield soils along drainageways and in swales. Areas range from 5 to 30 acres in size (fig. 14).

The main limitation is the hazard of wetness, which restricts the depth of roots. This soil is very difficult to manage during wet periods. Surface runoff is slow, and runoff collects from soils upslope. The surface layer easily becomes hard and cloddy if worked when

Figure 14.—Typical landscape of Skyberg silt loam. The contrasting darker colored areas in the background are Maxfield soils.

too wet. The main management needs for farming are artificial drainage and fall plowing. Under this type of management, the growing season is lengthened because of earlier access to fields for seedbed preparation and faster warming of the soil in spring. Some waterways are also needed to contain and carry off surface runoff.

Most of the acreage is used for crops or pasture. This soil is well suited to crops, and adequately drained areas are especially well suited to corn and soybeans. Capability unit IIIw–2; woodland group 2; community development group 2; outdoor recreation group 4.

Sogn Series

The Sogn series consists of moderately steep to very steep, somewhat excessively drained soils on convex upper parts of southwest-facing valley walls and hillsides. These soils formed in thin loamy sediment underlain by limestone bedrock. The native vegetation was dryland prairie grasses.

In a representative profile the surface layer is very dark grayish-brown flaggy loam about 6 inches thick. The subsoil is dark grayish-brown, friable flaggy loam about 10 inches thick. It is underlain by limestone bedrock.

Permeability is moderate, and available water capacity is very low. The content of organic matter is moderate. The content of available phosphorus and potassium is low.

Most areas are idle or are in pasture. The main limitations are hazards of drought and erosion.

Representative profile of Sogn flaggy loam in an area of Sogn and Copaston soils, 12 to 25 percent slopes, 620 feet west and 165 feet south of the northeast corner of sec. 13, T. 110 N., R. 17 W.

A1—0 to 6 inches, very dark grayish-brown (10YR 3/2) flaggy loam; weak, very fine, granular structure; friable; many roots; about 20 percent rock fragments, mostly flagstones and channers; moderately alkaline; slightly effervescent; abrupt, wavy boundary.

B2—6 to 16 inches, dark grayish-brown (10YR 4/2) flaggy loam; weak, fine, subangular blocky structure; friable; common tubular mixings of very dark

grayish brown (10YR 3/2); common coatings of lime as much as 2 millimeters thick on underside of fragments; about 35 percent rock fragments, mostly flagstones, channers, and stones; moderately alkaline; strongly effervescent; abrupt, wavy boundary.

IIR—16 inches, limestone bedrock.

The solum ranges from 8 to 20 inches in thickness. The A1 horizon ranges from 4 to 8 inches in thickness. It is black, very dark grayish-brown, or very dark brown flaggy loam or loam. The B horizon ranges from 4 to 12 inches in thickness. It is dark grayish brown or dark brown and ranges from flaggy silt loam of flaggy loam to flaggy clay loam. The A and B horizons range from 20 to 35 percent coarse fragments that are flagstones, channers, and stones. The IIR horizon is dolomite or limestone bedrock of Galena, Platteville, Shakopee, and Oneota Formations.

Sogn soils are near Bellechester, Brodale, and Copaston soils. They are loamy and have bedrock at a shallow depth, whereas Bellechester soils are sandy and have bedrock at a greater depth. They have bedrock at a shallower depth than Brodale soils. They have free carbonates throughout the solum, but Copaston soils do not have free carbonates in most of the solum.

Sogn and Copaston soils, 12 to 25 percent slopes (SoD).—These soils are on sides of narrow upland ridges. Sogn soils have mostly south-facing and west-facing slopes, and Copaston soils principally are on north-facing and east-facing slopes. Areas range from 2 to 15 acres in size.

Sogn soils make up about 60 percent of this unit, and Copaston soils about 40 percent. The profile of the Sogn soil is that described as representative of the Sogn series; the profile of the Copaston soil is similar to that described as representative of the Copaston series, but it contains more coarse fragments. Included in mapping are some areas of Copaston loam, moderately deep.

The main limitations are the severe hazards of drought and erosion. Surface runoff is rapid. The main management need is to control erosion and runoff, and permanent vegetation is effective. The hazard of drought is too severe for any crops.

This unit is used mostly for pasture. Some areas are woodland, and very few are used for crops. This unit is well suited to woodland because it controls runoff. Areas used for pasture require very close control of grazing because of excessive runoff and erosion. Soils should not be used for septic tank absorption fields because pollution is a hazard. Capability unit VIIs–2; woodland group 6; community development group 7; outdoor recreation group 9.

Sparta Series

The Sparta series consists of nearly level, excessively drained soils on benches of major streams. These soils formed in sandy outwash. The native vegetation was grasses.

In a representative profile the surface layer is very dark brown loamy sand about 8 inches thick, and the subsurface layer is very dark brown and dark-brown loamy coarse sand about 11 inches thick. The subsoil is dark-brown, loose coarse sand about 21 inches thick. The underlying material is yellowish-brown coarse sand.

Permeability is very rapid, and available water capacity is low. The content of organic matter is moderately low. The content of available phosphorus and potassium is low.

Most areas are used for crops or pasture. The main limitation is the hazard of drought.

Representative profile of Sparta loamy sand, 0 to 3 percent slopes, in a cultivated field 400 feet east and 200 feet north of the southwest corner of SE¼SE¼ sec. 31, T. 114 N., R. 15 W.

Ap—0 to 8 inches, very dark brown (10YR 2/2) loamy sand; weak, fine, granular structure; loose; about 5 percent very fine gravel; strongly acid; abrupt, smooth boundary.

A12—8 to 11 inches, very dark brown (10YR 2/2) loamy sand, high in content of coarse sand; weak, fine, granular structure; loose; about 5 percent very fine gravel; strongly acid; clear, wavy boundary.

A3—11 to 19 inches, dark-brown (10YR 3/3) loamy coarse sand; single grained; loose; about 10 percent very fine gravel; strongly acid; clear, wavy boundary.

B2—19 to 40 inches, dark-brown (10YR 4/3) coarse sand; single grained; loose; about 10 percent very fine gravel; medium acid; abrupt, wavy boundary.

C—40 to 60 inches, yellowish-brown (10YR 5/4) coarse sand; single grained; loose; medium acid; about 15 percent very fine gravel; medium acid.

The solum ranges from 30 to 50 inches in thickness. The solum and upper part of the underlying material are typically free of carbonates. Very fine gravel is as much as 10 percent of the solum in some places. The solum ranges from slightly acid to strongly acid. The A horizon ranges from 10 to 20 inches in thickness. The Ap or A1 horizon is mostly very dark brown but is very dark grayish brown in a few places. It is typically loamy sand, but ranges to loamy coarse sand. The B horizon is dark-brown or brown sand or coarse sand. The C horizon is typically coarse sand that is as much as 15 percent very fine gravel.

Sparta soils are near Estherville and Plainfield soils. They contain less silt and clay and more sand in the solum than Estherville soils. They have a thicker dark-colored A horizon than Plainfield soils.

Sparta loamy sand, 0 to 3 percent slopes (SpA).—This soil is on stream benches. Areas are wide and can make up a large part of the benches. They range from 5 to 200 acres in size. Slopes are smooth and decline in the direction of the escarpments adjacent to the flood plain.

The hazard of drought is severe because available water capacity is low. Irrigation is feasible in some areas, but applications need to be more frequent because available water capacity is especially low in the upper part of the soil. Surface runoff is very slight. The hazard of erosion or soil blowing is severe in open areas that lack plant or crop cover. The sediment from this soil collects as drifts on field or woodlot borders and along road ditches and other legal rights of way. The drifting sand is abrasive and damages property and vegetation. Some deep gullies occur along escarpments where surface runoff spills over.

This soil is used for crops, woodland, or pasture, or it is idle. It is suited to some crops. Early maturing crops that can be planted early should be selected to best utilize the early and more frequent rain showers. Where the soil is used as a septic tank absorption field and the water table is below a depth of 10 to 15 feet, pollution is a hazard because the underlying material is rapidly permeable. Capability unit IVs–1; woodland group 4; community development group 3; outdoor recreation group 11.

Terril Series

The Terril series consists of gently sloping to steep, well-drained soils on concave foot slopes at the base of valley walls. These soils formed in loamy sediment. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is very dark grayish-brown sandy loam and loam about 28 inches thick. The upper 6 inches of the subsoil is dark yellowish-brown, friable clay loam; the lower 8 inches is yellowish-brown, friable sandy loam. The underlying material is yellowish-brown heavy sandy loam. Light yellowish-brown, loose sand is at a depth of 68 inches.

Permeability is moderate, and available water capacity is high. The content of organic matter is moderate. The content of available phosphorus is medium, and that of potassium is low.

Most areas are used for crops or pasture. The main limitation is the hazard of erosion.

Representative profile of Terril sandy loam, 12 to 25 percent slopes, 330 feet east and 100 feet north of the center of sec. 5, T. 111 N., R. 18 W.

A1—0 to 10 inches, very dark grayish-brown (10YR 3/2) sandy loam; weak, very fine, granular structure; very friable; slightly acid; clear, wavy boundary.

A3—10 to 28 inches, very dark grayish-brown (10YR 3/2) loam; weak, fine, subangular blocky structure; friable; many, very fine and fine, tubular pores; slightly acid; abrupt, wavy boundary.

B2—28 to 34 inches, dark yellowish-brown (10YR 4/4) clay loam; dark-brown (10YR 4/3) coatings on faces of peds; weak to moderate, medium, subangular blocky structure; friable; many, very fine, fine, and medium, tubular pores; medium acid; abrupt, wavy boundary.

B3—34 to 42 inches, dark yellowish-brown (10YR 4/4) sandy loam; dark-brown (10YR 4/3) coatings on faces of peds; weak, medium, subangular blocky structure; friable; common, very fine and fine, tubular pores; medium acid; abrupt, wavy boundary.

C1—42 to 68 inches, yellowish-brown (10YR 5/4) heavy sandy loam; common thin strata of very fine sandy loam and sand; massive; very friable; medium acid; abrupt, wavy boundary.

IIC2—68 to 70 inches, light yellowish-brown (10YR 6/4) sand; single grained; loose; medium acid.

The solum ranges from 40 to 65 inches in thickness. Free carbonates are absent in most places, but are at a depth of 65 inches or more in some places. Depth to sand ranges from 50 to 70 inches. Sandstone bedrock typically begins at a depth ranging from 60 to 80 inches, but it is lacking in some places. The A horizon ranges from 24 to 35 inches in thickness. The A1 horizon ranges from black to very dark grayish brown and is loam or sandy loam. The A3 horizon ranges from very dark brown to dark brown. It is typically loam but is sandy loam in some places. The B horizon ranges from 12 to 40 inches in thickness. Some subhorizons of the B horizon are silt loam or silty clay loam. The C1 horizon is loam or sandy loam.

Terril soils in Goodhue County are slightly coarser textured in the upper part of the solum and in the C horizon than is defined as the range for the series. This difference does not alter use or behavior.

Terril soils are near Dickinson, Lindstrom, and Bellechester soils. They have a thicker A horizon and contain less sand than Dickinson soils. They contain more sand and less silt than Lindstrom soils. They contain more silt and clay and less sand than Bellechester soils.

Terril sandy loam, 2 to 6 percent slopes (TeB).—This soil is on the lower part of foot slopes near the base of valley walls. Most areas are just above level Dickinson soils on stream benches. Areas are concave or saucer shaped and collect runoff from soils upslope. They range from 2 to 30 acres in size. Slopes range from 100 to 300 feet in length. This soil has a profile similar to that described as representative of the series, but the sand is at a depth of about 55 inches. Included in mapping are some Dickinson soils.

The main limitation is the hazard of erosion, because runoff collects on this soil. Surface runoff is medium. The main management need is to control runoff by terraces and dams upslope. Permanent vegetation, preferably woodland on valley walls, is also needed.

Most of the acreage is used for crops or pasture. This soil is well suited to corn, soybeans, small grain, and hay. Capability unit IIe–1; woodland group 1; community development group 6; outdoor recreation group 5.

Terril sandy loam, 6 to 12 percent slopes (TeC).—This soil is on foot slopes near the base of valley walls. Most areas are just above or surround less sloping Terril or Dickinson soils. They are concave or saucer shaped and are contiguous with other Terril soils. They range from 2 to 30 acres in size. Slopes range from 100 to 300 feet in length. Included in mapping are some areas of Dickinson soils.

The main limitations are hazards of erosion from runoff that collects on this soil and siltation in cultivated fields. Surface runoff is medium. The main management need is to control surface runoff by terraces and dams upslope. Soil conserving practices and maintenance of fertility are important. Permanent vegetation, preferably woodland, is needed on valley walls.

Most of the acreage is used for pasture or crops. This soil is well suited to corn, small grain, and hay crops. Capability unit IIIe–1; woodland group 1; community development group 6; outdoor recreation group 6.

Terril sandy loam, 12 to 25 percent slopes (TeD).—This soil is on the upper parts of foot slopes near the base of valley walls. Areas are smooth to concave and are above and contiguous with less sloping Terril or Lindstrom soils. They range from 2 to 30 acres in size. Slopes range from 100 to 300 feet in length. Included in mapping are some areas of soils that are loamy sand in the upper 12 to 24 inches.

The main limitations are severe hazards of erosion from runoff that collects on this soil and of siltation in cultivated fields. Surface runoff is rapid. The main management need is to control surface runoff and downwaste materials by terraces or dams upslope and to plant permanent vegetation, preferably trees, on valley walls. Soil conserving practices and maintenance of fertility are needed in cultivated areas.

This soil is used for crops or pasture. It is well suited to permanent pasture. Under good management it is well suited to corn and small grain. Capability unit IVe–1; woodland group 1; community development group 8; outdoor recreation group 6.

Timula Series

The Timula series consists of gently sloping to very steep, well-drained soils on convex, circular knolls or pahas on narrow and broad upland ridges (fig. 15). These soils formed in loess. The native vegetation was deciduous forest.

In a representative profile the surface layer is very

Figure 15.—**Timula silt loam on a paha, or low hill of loess.**

dark grayish-brown silt loam about 6 inches thick. The subsoil is yellowish-brown, very friable silt loam about 20 inches thick. The underlying material is light olive-brown, very friable silt loam.

Permeability is moderate, and available water capacity is very high. The content of organic matter is moderately low. The content of available nitrogen, phosphorus, and potassium is low.

Most areas are used for crops or pasture. The main limitation is the hazard of erosion.

Representative profile of Timula silt loam, 2 to 6 percent slopes, 300 feet west and 100 feet south of the center of SW¼ sec. 24, T. 112 N., R. 17 W.

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, medium, subangular blocky structure; very friable; neutral; abrupt, wavy boundary.

B2—6 to 12 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; common, fine, tubular pores; some clean or washed faces of peds are neutral; clear, wavy boundary.

B3—12 to 26 inches, yellowish-brown (10YR 5/4) silt loam high in content of very fine sand; weak, coarse, subangular blocky structure; very friable; common, fine, tubular pores; neutral; abrupt, wavy boundary.

C1—26 to 60 inches, light olive-brown (2.5Y 5/4) silt loam high in content of fine sand; weak, coarse, subangular blocky structure; very friable, soft; common, fine, tubular pores; mildly alkaline; strongly effervescent; gradual, irregular boundary.

C2—60 to 103 inches, light olive-brown (2.5Y 5/4) silt loam; common, yellowish-brown (10YR 5/6), soft, partly indurated iron oxide masses; massive; very friable; mildly alkaline; strongly effervescent.

The solum ranges from 18 to 36 inches in thickness. Depth to free carbonate ranges from 15 to 30 inches. The A horizon is very dark grayish brown or dark grayish brown. It is typically silt loam, but in some places it is loam that has a high content of coarse silt and very fine sand or very fine sandy loam. The B horizon is yellowish brown or dark yellowish brown. It typically ranges from silt loam to very fine sandy loam, but in some places it is loam that has a high content of very fine and fine sand and coarse silt. The B horizon ranges to heavy silt loam in some places where the solum is thick. The C horizon is typically light olive-brown or brown silt loam that has a high content of coarse silt and very fine sand or very fine sandy loam.

Timula soils are near Bold and Seaton soils. They have a B horizon that commonly lacks free lime, whereas Bold soils do not have a B horizon and have free lime throughout the profile. They do not have much translocated clay

in the B horizon, whereas Seaton soils have appreciable amounts.

Timula silt loam, 2 to 6 percent slopes (TmB).—This soil is on crests and side slopes of broad uplands and narrow upland ridges. Areas range from 2 to 50 acres in size. Slopes range from 75 to 300 feet in length. Included in mapping are areas of soils similar to Mt. Carroll soils, but that have a thinner combined surface layer and subsoil. Also included are small areas of Seaton soils.

The main limitation is the moderate hazard of erosion, and it is most severe on side slopes. Surface runoff is medium. The main management need is to control erosion and runoff. Fertility also needs to be maintained.

Most of the acreage is used for crops, and some areas are pasture or woodland. The soil is well suited to crops, especially corn, small grain, and alfalfa-brome hay. Capability unit IIe–1; woodland group 1; community development group 6; outdoor recreation group 5.

Timula silt loam, 6 to 12 percent slopes (TmC).—This soil is on side slopes adjacent to drainageways and knolls on broad uplands and narrow upland ridges. Slopes range from 100 to 200 feet in length. Areas range from 2 to 15 acres in size. Included in mapping are some areas of Bold soils.

The main limitation is the moderate to severe hazard of erosion. Surface runoff is medium, and infiltration is moderate to moderately rapid. Erosion is most severe and runoff is most rapid in areas that lack plant cover, especially during seedbed preparation and early plant growth. The main management need is to control erosion and runoff. Fertility needs to be maintained also.

Most of the acreage is used for crops, pasture, or woodland, and the soil is well suited to all these uses. Favored crops are corn, small grain, and alfalfa-brome hay. Capability unit IIIe–1; woodland group 1; community development group 6; outdoor recreation group 6.

Timula-Bold silt loams, 12 to 25 percent slopes (ToD).—These soils are on side slopes, principally along long, entrenched, narrow drainageways and some knolls on uplands. They also are on foot slopes at the base of valley walls. Slopes range from 100 to 300 feet in length.

Timula silt loam makes up about 60 percent of this unit, and Bold silt loam about 40 percent. Both soils have the profile described as representative of their respective series. The Bold soils are on the points or spurs in the landscape, and the Timula soils are on side slopes.

The main limitation to farming is the very severe hazard of erosion and rapid runoff. This hazard is most severe in areas that lack plant cover, especially during seedbed preparation and early plant growth. The main management need is permanent vegetation or a cropping system that controls runoff and erosion. The hazard of erosion is also very severe in extensively graded or excavated areas.

These soils are used for crops, pasture, or woodland. They are well suited to woodland for control of erosion and runoff and suited to pasture for control of erosion. Controlled grazing is needed, however. If erosion and runoff can be controlled, small grain and alfalfa-brome hay are suited. Capability unit VIe–1; woodland group 1; community development group 8; outdoor recreation group 6.

Vasa Series

The Vasa series consists of nearly level and gently sloping, moderately well drained soils on flat crests and side slopes above or adjoining drainageways on broad uplands. These soils formed in loess. The native vegetation was deciduous forest.

In a representative profile the surface layer is very dark grayish-brown silt loam about 9 inches thick. The upper 17 inches of the subsoil is yellowish-brown, friable silt loam that has grayish-brown mottles; the lower 34 inches is grayish-brown to light-gray, friable silt loam and loam. The underlying material is brownish-yellow loam.

Permeability is moderate, and available water capacity is very high. The content of organic matter is moderate. The content of available phosphorus is medium, and that of potassium is low.

Most areas are used for crops or pasture. These soils are well suited to corn. The hazard of wetness is slight, and these soils have no major limitations.

Representative profile of Vasa silt loam, 0 to 3 percent slopes, in a cultivated field 500 feet north and 150 feet west of the southeast corner of SW¼SW¼ sec. 23, T. 111 N., R. 16 W.

Ap—0 to 9 inches, very dark grayish-brown (10YR 3/2) silt loam, grayish brown (10YR 5/2) dry; weak, very fine, granular structure; friable; neutral; abrupt, wavy boundary.

B1—9 to 13 inches, yellowish-brown (10YR 5/4) silt loam; dark yellowish-brown (10YR 4/4) coatings on faces of peds; tubular mixings of very dark grayish brown (10YR 3/2); moderate, very fine, subangular blocky structure; friable; thin porous coatings on faces of peds; neutral; clear, wavy boundary.

B21t—13 to 19 inches, yellowish-brown (10YR 5/4) heavy silt loam; dark-brown (10YR 4/3) coatings on faces of peds; tubular mixings of very dark grayish brown (10YR 3/2); strong, very fine, subangular blocky structure; friable; many, very fine and fine, tubular pores; thin silt-sized porous coatings; neutral; clear, wavy boundary.

B22t—19 to 26 inches, yellowish-brown (10YR 5/4) heavy silt loam; common and many, fine, faint, grayish-brown (10YR 5/2) mottles; strong, fine, subangular blocky structure; friable; common thin clay films lining pores; many, very fine and fine, tubular pores; many grayish-brown (10YR 5/2) silty coatings on faces of peds; slightly acid; clear, wavy boundary.

B23t—26 to 32 inches, grayish-brown (10YR 5/2) silt loam; many, coarse, distinct, dark yellowish-brown (10YR 4/4) mottles; moderate, fine, subangular blocky structure; friable; many, very fine and fine, tubular pores; common, thin clay films lining fine pores; many, gray (10YR 5/1), silty coatings on faces of peds; slightly acid; clear, wavy boundary.

B24t—32 to 42 inches, gray (10YR 5/1) silt loam; many, coarse, distinct, yellowish-brown (10YR 5/6) mottles; moderate, medium, subangular blocky structure; friable; many, very fine and fine, tubular pores; many, gray (10YR 5/1), silty coatings on faces of peds; common thin clay films lining tubular pores; few, fine, dark-colored masses; slightly acid; clear, wavy boundary.

B3t—42 to 60 inches, light-gray (10YR 6/1) loam; many, coarse, prominent, yellowish-brown (10YR 5/6) mottles; moderate, medium, subangular blocky

structure; friable; many, very fine and fine, tubular pores; many thick threads of clay films in fine pores; neutral; abrupt, wavy boundary.

IIC—60 to 65 inches, brownish-yellow (10YR 6/6) loam; massive; firm; few to common thin threads of clay films lining fine pores; about 4 percent coarse fragments; neutral.

The solum ranges from 40 to 70 inches in thickness. The loess ranges from 60 to 80 inches or more in thickness over glacial till. Depth to free carbonates is more than 50 inches. The Ap or A1 horizon ranges from 6 to 9 inches in thickness. It ranges from very dark brown to very dark grayish brown. An A2 horizon as much as 6 inches thick is in some places. It is dark grayish brown or grayish brown. The B horizon ranges from 30 to 55 inches in thickness. It is typically silt loam that is 20 to 26 percent clay, but the lower part ranges to light silty clay loam in some places. The B1 and upper part of the B2 horizons are brown or yellowish brown. They have few to common, faint-gray or grayish-brown mottles, but most mottles are in the lower part of the B horizon. A B3 horizon and a C horizon are in the loess in some places. They range from gray or light gray to pale brown. They are silt loam that is high in content of coarse silt and very fine sand.

Vasa soils are near Garwin and Seaton soils and are similar to Joy soils. They are not wet or gray in the upper part of the B horizon as are Garwin soils. They have grayish-brown or gray mottles in the B horizon, whereas Seaton soils do not. They do not have the thick, dark-colored A horizon that Joy soils have.

Vasa silt loam, 0 to 3 percent slopes (VaA).—This soil is in the upper reaches of wet drainageways on broad uplands. Areas are smooth to slightly concave and collect runoff from adjoining soils upslope. Areas range from 2 to 60 acres in size.

Included in mapping are some areas of somewhat poorly drained soils that are in natural drainageways. These soils formed in similar material, but are grayish brown throughout the subsoil. Also included are areas of somewhat poorly drained soils that have a surface layer of dark-gray silty clay loam about 9 inches thick. The subsoil is dark yellowish-brown silty clay loam and silty clay. It is about 50 inches thick and has gray and grayish-brown mottles. The underlying material is yellowish-brown, stratified silt loam and silty clay loam or silty clay.

The hazard of wetness is slight. Surface runoff is slow to medium. Some natural drainageways need artificial drainage devices and waterways to reduce wetness. Fertility also needs to be maintained.

Most of the acreage is used for crops, and corn is well suited. Capability unit I–2; woodland group 2; community development group 5; outdoor recreation group 4.

Waukegan Series

The Waukegan series consists of nearly level to gently sloping, well-drained soils on broad benches along streams. These soils formed in silty material underlain by sandy or gravelly outwash. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is very dark brown and very dark grayish-brown silt loam about 13 inches thick. The subsoil is dark yellowish-brown and yellowish-brown, friable silt loam about 20 inches thick. The underlying material is gravelly coarse sand.

Permeability is moderate in the surface layer and subsoil and is rapid in the underlying material. Available water capacity is moderate and high. The content of organic matter is high. The content of available phosphorus is medium, and that of potassium is low.

Most areas are used for crops. The main limitation to use is the slight or moderate hazard of drought.

Representative profile of Waukegan silt loam, 0 to 3 percent slopes, 20 feet west and 10 feet south of the northeast corner of SE¼SW¼ sec. 29, T. 112 N., R. 18 W.

Ap—0 to 8 inches, very dark brown (10YR 2/2) silt loam; moderate, very fine, granular structure; very friable; slightly acid; abrupt, wavy boundary.

A3—8 to 13 inches, very dark grayish-brown (10YR 3/2) silt loam, common mixings of very dark brown (10YR 2/2); weak, very fine, granular structure; very friable; slightly acid; clear, wavy boundary.

B21—13 to 22 inches, dark yellowish-brown (10YR 4/4) silt loam, coatings of dark brown (10YR 4/3) on faces of peds; moderate, fine, subangular blocky structure; friable; common, very fine and fine, continuous, tubular pores; slightly acid; clear, wavy boundary.

B22—22 to 30 inches, yellowish-brown (10YR 5/4) silt loam; moderate, medium, subangular blocky structure; friable; common, very fine and fine, tubular pores; slightly acid; abrupt, wavy boundary.

B31—30 to 33 inches, yellowish-brown (10YR 5/4) loam; weak, medium, subangular blocky structure; friable; common, fine and medium, continuous, tubular pores; about 2 percent gravel; slightly acid; abrupt, wavy boundary.

IIB32—33 to 36 inches, grayish-brown (10YR 5/2) gravelly coarse sand; single grained; loose; neutral; clear, wavy boundary.

IIC—36 to 50 inches, grayish-brown (10YR 5/2) gravelly coarse sand; single grained; loose; mildly alkaline; slightly effervescent.

Thickness of the solum, or depth to free carbonates, ranges from 36 to 60 inches. The silty mantle ranges from 30 to 38 inches in thickness. The A horizon ranges from 12 to 20 inches in thickness. The Ap or A1 horizon is black or very dark brown. The A3 horizon is very dark brown or very dark grayish-brown silt loam that is 18 to 23 percent clay. The B horizon ranges from dark brown to yellowish-brown. It is mainly silt loam that is 18 to 24 percent clay. In some places thin B3 subhorizons in the lower part of the profile are loam or sandy loam. The IIC horizon is sand, coarse sand, gravelly coarse sand, or stratified sand and gravel.

Waukegan soils are near Fairhaven and Estherville soils. They have less sand and more silt in the solum than those soils.

Waukegan silt loam, 0 to 3 percent slopes (WaA).—This soil is on broad benches of major streams. Areas range from 5 to 200 acres in size.

Because available water capacity is moderate in some areas, the main limitation is the slight or moderate hazard of drought. The main management need is to schedule fieldwork to best utilize available water in this soil and most of the seasonal rainfall. Surface runoff is slow, and much of it is absorbed in the soil because infiltration is moderate and permeability is moderately rapid.

This soil is used mostly for crops, but some areas are pasture or are used as a source of sand and gravel. It is well suited to row crops, especially corn and soybeans. Irrigation can be added where feasible. Where the soil is used as a septic tank absorption field and the water table is below a depth of 10 feet, pollution of ground water is a hazard because the underlying material is rapidly permeable. Capability until IIs–1;

woodland group 3; community development group 3; outdoor recreation group 10.

Whalan Series

The Whalan series consists of gently sloping to very steep, well-drained soils on crests and sides of narrow upland ridges and on sides of entrenched, long and narrow drainageways. These soils formed in a silty and loamy mantle underlain by limestone residuum. The native vegetation was deciduous hardwood forest.

In a representative profile the surface layer is dark grayish-brown silt loam about 9 inches thick. The upper 13 inches of the subsoil is dark-brown and dark yellowish-brown, friable silt loam; the middle 13 inches is dark yellowish-brown, firm loam; and the lower 3 inches is dark yellowish-brown, firm clay loam. Below this is limestone bedrock.

Permeability is moderate, and available water capacity is low to moderate. The content of organic matter is moderate or low. The content of available phosphorus and potassium is low.

Whalan soils are used for crops or pasture, or they are idle or woodland. The main limitations are hazards of erosion and drought.

Representative profile of Whalan silt loam, 1 to 6 percent slopes, 50 feet east and 600 feet north of the southwest corner of NW½ sec. 30, T. 111 N., R. 17 W.

Ap—0 to 7 inches, dark grayish-brown (10YR 4/2) silt loam, light brownish gray (10YR 6/2) dry; weak, very fine, granular structure; slightly acid; abrupt, wavy boundary.

A2—7 to 9 inches, dark grayish-brown (10YR 4/2) silt loam; moderate, thin, platy structure; very friable; bleached, thick, silty coatings on faces of peds; medium acid; clear, wavy boundary.

B1—9 to 14 inches, dark-brown (10YR 4/3) heavy silt loam; moderate, very fine, subangular blocky structure; friable; many, very fine and fine, continuous pores; thick, continuous, bleached silt coatings on faces of peds; strongly acid; abrupt, wavy boundary.

B21—14 to 22 inches, dark yellowish-brown (10YR 4/4) heavy silt loam; dark-brown (7.5YR 4/2) coatings on faces of peds; strong, fine, angular blocky structure; friable; common, fine and very fine, continuous, tubular pores; common thin clay films on faces of peds and inside some pores; few, thin, bleached silt coatings on faces of peds; strongly acid; clear, wavy boundary.

IIB22—22 to 27 inches, dark yellowish-brown (10YR 4/4) loam; moderate, fine, subangular blocky structure; firm; moderate, very fine and fine, tubular pores; common thin clay films on faces of peds; about 4 percent pebbles; strongly acid; clear, wavy boundary.

IIB23—27 to 35 inches, dark yellowish-brown (10YR 4/4) loam; moderate, medium, subangular blocky structure; firm; common, moderately thick clay films on faces of peds; about 4 percent coarse fragments; strongly acid; clear, wavy boundary.

IIB24—35 to 38 inches, dark yellowish-brown (10YR 4/4) heavy clay loam; dark-brown (7.5YR 4/2) coatings on faces of peds; moderate, medium, subangular blocky structure; firm; about 6 percent coarse fragments; many thick clay films on faces of peds; strongly acid; abrupt, wavy boundary.

IIIR—38 inches, limestone bedrock.

Thickness of the solum, or depth to limestone, ranges from 20 to 40 inches. The A horizon is medium acid to neutral. The A1 horizon, where present, is 3 to 6 inches thick and is dark grayish brown or very dark grayish brown. The A2 horizon typically ranges from 2 to 8 inches in thickness. It is dark grayish brown or grayish brown, but it is lacking in some places. The B horizon is slightly acid to strongly acid. In some places an A&B or B&A horizon occurs instead of a B1 horizon. The B21 horizon is heavy silt loam or light silty clay loam. The IIB2 horizon is mainly loam or clay loam, but a 3- to 8-inch subhorizon in the lower part of some IIB2 horizons is sandy clay, silty clay, or heavy clay loam. Clay films range from thick to thin and few to many in the B2 and IIB2 horizons.

Whalan soils are near Marlean and Racine soils and are similar to Dubuque soils. They are 20 to 40 inches deep over bedrock, whereas Marlean and Racine soils are deeper over bedrock. They have more sand and less silt in the solum than Dubuque soils.

Whalan silt loam, 1 to 6 percent slopes (WhB).—This soil is on crests of narrow upland ridges and some sides of large upland areas that are adjacent to stream valleys. Areas range from 2 to 20 acres in size. The profile of this soil is the one described as representative of the series. Bedrock is generally at a depth of 24 to 40 inches, but some included soils are shallower over bedrock.

Because available water capacity is moderate, the main limitation is the moderate hazard of drought. The main management need is to schedule fieldwork to best utilize available water in the soil and from seasonal rainfall. Surface runoff is medium.

Most of the acreage is used for crops or pasture. This soil is well suited to small grain, corn, and hay crops. Where septic tank absorption fields are planned, pollution is a hazard because the underlying fractured limestone is rapidly permeable. Capability unit IIe–2; woodland group 3; community development group 4; outdoor recreation group 7.

Whalan silt loam, 6 to 12 percent slopes, eroded (WhC2).—This soil is on side slopes of narrow upland ridges and of uplands adjacent to stream valleys. Slopes range from 50 to 200 feet in length. Areas range from 2 to 15 acres in size. The profile of this soil is similar to that described as representative of the series, but the subsurface layer and part of the subsoil have been lost through erosion. Included in mapping are some areas of soils where the depth to bedrock is less than 20 inches.

Because available water capacity is moderate, the main limitations are moderate hazards of drought and further erosion. Surface runoff is medium. Erosion is most severe in areas that lack plant cover, especially during seedbed preparation and early plant growth. The main management need is to control erosion and runoff. Fertility needs to be maintained also.

Most of the acreage is used for crops, pasture, or woodland. This soil is well suited to all of these uses. Suited crops are corn, small grain, and alfalfa-brome hay. Where septic tank absorption fields are planned, pollution is a hazard because the underlying fractured limestone is rapidly permeable. Capability unit IIIe–2; woodland group 3; community development group 4; outdoor recreation group 8.

Whalan silt loam, moderately shallow, 1 to 6 percent slopes (WsB).—This soil is on crests of narrow upland ridges. Areas range from 2 to 20 acres in size. The profile of this soil is similar to that described as representative of the series, but the average depth to bedrock is 20 to 24 inches. Included in mapping are some areas where depth to bedrock is less than 20 inches.

Because available water capacity is low, the main

limitation is the severe hazard of drought. The hazard of erosion is moderate. Surface runoff is medium. The main management need is to control erosion and runoff by conservation practices or permanent vegetation.

This soil is used for crops, woodland, or pasture. It is suited to small grain, corn, and hay. Crops should be selected that can be planted early and mature early, because they best utilize the available water in the soil and the more frequent rainfall early in summer. Where septic tank absorption fields are planned, pollution is a hazard because the soil is moderately shallow over bedrock. Capability unit IIIe–3; woodland group 3; community development group 4; outdoor recreation group 7.

Whalan silt loam, moderately shallow, 6 to 12 percent slopes, eroded (WsC2).—This soil is on sides of narrow upland ridges that are adjacent to stream valleys. Areas range from 2 to 15 acres in size. The profile of this soil is similar to that described as representative of the series, but it is thinner because of erosion, and the depth to bedrock ranges from 20 to 24 inches. Included in mapping are areas where the depth to limestone bedrock is less than 20 inches.

The hazard of drought and further erosion is severe. Surface runoff is medium. The main management need is to control erosion and runoff by permanent vegetation and conserving practices.

This soil is used for pasture, woodland, and crops. It is well suited to pasture or woodland. If this soil is used for pasture, grazing needs to be very closely controlled because runoff and erosion are excessive. To some extent, small grain and hay can be grown. Where septic tank absorption fields are planned, pollution is a hazard because the soil is moderately shallow over bedrock. Capability unit IVe–3; woodland group 3; community development group 4; outdoor recreation group 8.

Whalan silt loam, moderately shallow, 12 to 18 percent slopes, eroded (WsD2).—This soil is on sides of narrow upland ridges adjacent to stream valleys. Areas range from 2 to 15 acres in size. The profile of this soil is similar to that described as representative of the series, but it is thinner because of erosion, and the average depth to bedrock ranges from 20 to 24 inches. Included in mapping are some areas of bedrock outcrops.

The main limitations are severe hazards of drought and further erosion. Surface runoff is rapid. The main management need is to control erosion and contain surface runoff by permanent vegetation.

This soil is used mostly for pasture or woodland because the hazard of drought is too severe for crops. It is well suited to pasture and woodland. If it is used for pasture, grazing needs to be very closely controlled because of excessive runoff and erosion. Where septic tank absorption fields are planned, pollution is a hazard because the soil is moderately shallow over bedrock. Capability unit IVe–3; woodland group 3; community development group 4; outdoor recreation group 8.

Whalan silt loam, moderately shallow, 18 to 35 percent slopes (WsE).—This soil is on side slopes of entrenched, narrow drainageways or deep ravines and on the upper part of valley walls adjacent to river valleys. Slopes range from 50 to 200 feet in length. The profile of this soil is similar to that described as representative of the series, but the depth to bedrock mostly ranges from 20 to 24 inches. Included in mapping are some areas where depth to bedrock is less than 20 inches and some areas of eroded soils. Also included are areas of Marlean soils at the base of some side slopes.

The main limitation is the severe hazard of erosion. It is most severe in areas that lack crops or other vegetation. Because available water capacity is moderate, the hazard of drought is moderate. Surface runoff is medium to rapid.

Because the hazard of erosion is so severe, this soil should not be used for crops. It should be converted to pasture, if grazing is closely controlled, or to woodland. Where septic tank absorption fields are planned, pollution is a hazard because the soil is moderately shallow over limestone. Capability unit VIIe–2; woodland group 5; community development group 7; outdoor recreation group 9.

Zumbro Series

The Zumbro series consists of nearly level, moderately well drained soils on high flood plains along major streams. These soils formed in sandy alluvium. The native vegetation was grasses.

In a representative profile the surface layer is very dark brown and very dark grayish-brown loamy sand about 40 inches thick. The subsoil is dark-brown, loose loamy sand about 10 inches thick. The underlying material is grayish-brown, loose sand.

Permeability is rapid, and available water capacity is low. The content of organic matter is moderate. The content of available nitrogen, phosphorus, and potassium is low. A water table is at a depth of 5 to 10 feet.

Most areas are used for crops and pasture. These soils are suited to hardwoods such as walnuts. The main limitation is the hazard of flooding.

Representative profile of Zumbro loamy sand, in a cultivated field 1,320 feet east and 1,320 feet north of the southwest corner of sec. 32, T. 113 N., R. 16 W.

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

A12—8 to 18 inches, very dark brown (10YR 2/2) loamy sand; weak, very fine, subangular blocky structure; very friable; few bleached sand grains on faces of peds; mildly alkaline; gradual, wavy boundary.

A13—18 to 27 inches, very dark brown (10YR 2/2) loamy sand; weak, fine, subangular blocky structure; very friable; mildly alkaline; gradual, wavy boundary.

A3—27 to 40 inches, very dark grayish-brown (10YR 3/2) loamy sand; massive; loose; mildly alkaline; very slightly effervescent; gradual, wavy boundary.

B2—40 to 50 inches, dark-brown (10YR 4/3) loamy sand; massive; loose; about 10 percent fine gravel; mildly alkaline; very slightly effervescent; clear, wavy boundary.

C—50 to 65 inches, grayish-brown (10YR 5/2) sand; single grained; loose; about 15 percent gravel; mildly alkaline; slightly effervescent.

The solum ranges from 30 to 60 inches in thickness. Depth to free carbonates typically is 20 to 50 inches. The solum and C horizon range from 0 to 20 percent gravel, and the upper part of the solum commonly does not have gravel. The A horizon ranges from 24 to 50 inches in thickness. It is mostly loamy fine sand or loamy sand, but it is sandy loam in the upper part of some profiles in some

places. The A horizon is very dark brown or very dark grayish brown. The B horizon is dark-brown or dark yellowish-brown loamy sand, fine sand, or sand. The C horizon is commonly grayish-brown, brown, or yellowish-brown sand or fine sand but ranges to coarse sand.

Zumbro soils are near Ankeny and Sparta soils. They contain more sand than Ankeny soils. They have a thicker A horizon than Sparta soils.

Zumbro loamy sand (0 to 3 percent slopes) (Zu).—This soil is on high bottoms along flood plains of streams (fig. 16). It is braided with slightly convex rises and swales. Areas range from 2 to 100 acres in size. Included in mapping are some areas of Alluvial land, frequently flooded.

Because available water capacity is low, the hazard of drought is moderate. This soil is subject to soil blowing. Surface runoff is slow, and most of it is absorbed because rate of infiltration is high and permeability is rapid. It is subject to flooding, but the flooding is infrequent and occurs as the result of very heavy rain showers or snowmelt.

This soil is suited to crops; but crops such as small grain and, to some extent, corn should be selected because they mature early and best utilize the early and more frequent rain showers and available water in the soil. In irrigated areas, crops selected should have lower peak water needs because available water capacity is low. Capability unit IIIs–1; woodland group 7; community development group 1; outdoor recreation group 2.

Use and Management of the Soils

This section gives interpretations of the soils for use in the production of crops and yield predictions for the principal crops grown in the county. It also describes the management of field and farmstead windbreaks, the suitability of the soils for wildlife habitat, and various engineering uses of the soils.

Use of the Soils for Crops

This section describes the capability classification of soils that is used by the Soil Conservation Service and the capability units to which the soils are assigned. It also gives predictions of the yields to be expected when the different soils are used for crops and for pasture.

Most of the farm acreage in the county is used for corn, oats, flax, soybeans, and alfalfa. These crops are sold or they are fed to livestock.

The sloping soils are subject to water erosion if they are cultivated and not protected. Terracing, contour farming, stripcropping, and mulch tillage management of crop residues help to control erosion and to increase the amount of water that enters the soil and is then available for crops.

Soil blowing occurs most readily on the sandy soils. It can be reduced by keeping vegetation on the soil or by leaving the plowed surface rough until time to prepare a seedbed.

Drainage is needed for intensive farming of the wet, level or depressed soils. Open ditches are commonly used to remove surface water from low areas and closed depressions and to provide outlets for tile drainage systems.

Crops on most of the soils in the county respond to applications of fertilizer. In the descriptions of each soil, the general fertility levels refer to subsoil phosphorus and potassium. The soils are, in general, medium to high in phosphorus content and low to medium in potassium content. 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

***Figure 16.*—Zumbro loamy sand on a flood plain. The main part of the bottom is about 8 to 12 feet above river level.**

the information that is needed to choose the best kinds and amounts of fertilizer.

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 forest trees or for engineering uses.

In the capability system, the kinds of soil are grouped at three levels: the capability class, the subclass, and the unit. These levels are described in the following paragraphs.

CAPABILITY CLASSES, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use, defined as follows:

- Class I soils have few limitations that restrict their use.
- Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.
- Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.
- Class IV soils have very severe limitations that reduce the choice of plants, require very careful management, or both.
- Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture or range, woodland, or wildlife. (None in Goodhue County.)
- Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife.
- Class VII soils have very severe limitations that make them unsuited to cultivation and restrict their use largely to pasture or range, woodland, or wildlife.
- Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, 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 or 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 or range, woodland, wildlife, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–2 or IIIe–4. 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.

In the following pages the capability units in Goodhue County are described and suggestions for the use and management of the soils are given.

CAPABILITY UNIT I–1

This unit consists of deep, well-drained, nearly level and very gently sloping soils of the Mt. Carroll, Port Byron, and Seaton series. These soils are mainly on crests or side slopes on broad uplands. Some are on benches along streams. All are medium textured. Permeability is moderate, and runoff is slow. Natural fertility is medium. Available water capacity is very high. The root zone is deep, and it allows air and water to move into and through the profile.

These soils are among the most productive in the county. They are used intensively for field corn and soybeans and are well suited to those crops. They are also well suited to small grain and hay. Some of these soils are used for and well suited to such canning crops as sweet corn and peas.

Good tilth needs to be maintained wherever crops are grown. If soils are in good tilth, plant nutrients are used more efficiently and soils are easier to work. Good management promotes movement of air and water through the soil and makes use of a large amount of crop residue. Corn can be grown year after year, but some meadow is needed in the cropping system. Tillage should be kept to a minimum and done when moisture content of the soil is favorable. Fieldwork needs to be limited to preparing seedbeds and controlling weeds.

The soils of this capability unit are suited to permanent pasture. A mixture of alfalfa-brome and some orchardgrass is preferred for pasture, but other mixtures can also be used. Kentucky bluegrass tends to crowd out these plants where pastures are overgrazed. Proper grazing management, fertilization, and timely

reestablishment of the more productive species are essential to good forage production.

CAPABILITY UNIT I–2

This unit consists of deep, moderately well drained and somewhat poorly drained, nearly level and very gently sloping soils of the Joy, Vasa, and Klinger series. These soils are on side slopes and summits above drainageways on broad uplands. They are medium textured or moderately fine textured. Permeability is moderate or moderately slow. Runoff is slow. Natural fertility is medium. Available water capacity is high or very high. The root zone is deep.

These soils are among the more productive in the county. They are used intensively for field corn and soybeans and are well suited to such use. They are also used for and are suited to small grain, hay crops, sweet corn, and peas.

These soils are seasonally wet and require drainage. They warm more slowly in the spring than other class I soils and are mostly fall plowed to offset this problem and also to allow better scheduling of spring fieldwork. Fields should be left rough in winter to reduce soil loss to runoff and erosion. The slopes of Klinger soils are longer than others in the unit and require close control of runoff to avoid gullying. They are best farmed on the contour as much as possible. Corn can be grown year after year if the optimum number of plants are seeded and a sufficient amount of fertilizer is applied. To maintain tilth, tillage should be minimized and done when moisture content is favorable. Necessary fieldwork should be limited to preparing seedbed and controlling weeds.

Permanent pastures are of good quality. They generally are a mixture of alfalfa bromegrass and some orchardgrass, but other mixtures can be used also. Kentucky bluegrass tends to take over or crowd out these plants if the soils are overgrazed year after year. Proper grazing management, fertilization, and reestablishment as needed of more productive species are essential to good forage production.

CAPABILITY UNIT IIe–1

This unit consists of deep, well-drained, gently sloping, medium textured and moderately coarse textured soils of the Lindstrom, Mt. Carroll, Ostrander, Port Byron, Racine, Timula, and Terril series. These soils occupy all parts of broad uplands and some foot slopes at the base of valley walls. Permeability is moderate, and available water capacity is high to very high. The hazard of erosion is slight or moderate. In some areas these soils are eroded. Runoff is medium. Soils on foot slopes receive runoff from valley walls, and sometimes special management practices are required to contain this runoff.

These soils are productive if management can reduce erosion, contain runoff, and maintain fertility, tilth, and available water in the soil. They are suited to all crops commonly grown in the county, some of which are field corn, soybeans, small grain, alfalfa, sweet corn, and peas.

All tillage should be across the slope and on the contour as much as possible. In areas where slopes are fairly uniform and more than 300 feet long, terracing or stripcropping and crop rotation effectively reduce erosion and contain some of the runoff. Wetness occurs, at times, in terrace channels of Ostrander and Racine soils. Where row crops are grown year after year, minimum tillage on the contour is essential to reduce soil loss. It is much better than straight-row minimum tillage, because it increases the amount of available moisture in the soil. Wheel track planting is also very effective on soils that have a moderately high infiltration rate in the surface layer, such as Terril and Timula soils, because they more readily absorb rainfall. This practice is effective on the other soils, also. Some of the eroded Seaton soils have a low level of organic matter and tend to slake or crust following rain showers.

Permanent pastures are of good quality, but returns are more profitable if areas are used for rotation pasture or for cultivated crops. Many pastures produce poor forage because they are partly wooded, are brushy, or are overgrazed. If pastures of tall grass are well managed and well fertilized, they produce more forage than pastures in native bluegrass. A suitable mixture for seeding pasture consists chiefly of alfalfa and bromegrass, but a small amount of orchardgrass is seeded in some areas.

CAPABILITY UNIT IIe–2

This unit consists of gently sloping, well-drained soils of the Copaston, Dodgeville, Dubuque, and Whalan series. These soils are on crests of narrow upland ridges. They are underlain by limestone at a depth of 20 to 40 inches, and they are mostly medium textured to this depth. Available water capacity and permeability are moderate. The soils warm early in spring and generally are easy to till. Because available water capacity is only moderate, they are slightly droughty. They are subject to erosion, and some are moderately eroded. Runoff is medium.

If the supply of moisture is adequate and the soils are well managed, production of most crops grown in the county is good. Small grain, hay, and pasture are well suited.

Because erosion is a hazard, these soils should be farmed on the contour or across the slope. Some of the crests can be used more intensively for row crops. Contour stripcropping with hay, row crops, and grain helps control erosion. Terraces can be used, but the depth to bedrock should be checked for sufficient grading. Mulch planting and contouring can be effective in control of erosion. Sod waterways can be developed in all of the natural draws to collect runoff from these soils. Dubuque and Whalan soils are lower than other soils in the unit in content of organic matter in the surface layer and tend to crust more easily when tilled. More plant residue should be returned to Dubuque and Whalan soils to maintain and improve tilth.

Pastures are of fairly good quality, but supplemental pasture generally is needed during prolonged dry periods. More forage can be produced on well-managed and well-fertilized pasture of tall grasses and legumes, such as those that consist of alfalfa and bromegrass and include a small amount of orchardgrass. Most permanent pastures are of poor quality because they are partly wooded or are brushy and the dominant grass is bluegrass, which lies dormant in the middle of the summer.

Cover for wildlife can be established in some of the irregularly shaped areas that have limited access for farming.

CAPABILITY UNIT IIw–1

This unit consists of deep, nearly level, poorly drained soils of the Biscay, Canisteo, Garwin, and Maxfield series. These soils are in the upper reaches of wet drainageways and on some adjoining higher lying side slopes. They have a permanently or seasonally high water table at a depth of 1 foot to 3 feet. These soils are dominantly moderately fine textured. The underlying material is coarse textured in the Biscay soils and is medium textured in the Garwin and Maxfield soils. Permeability is moderately slow in the Garwin and Maxfield soils and moderate in the Biscay and Canisteo soils.

Drained areas of these soils are well suited to row crops year after year. Undrained areas are limited mainly to permanent pasture, although some crops can be grown during drier years. Drained areas are well suited to corn and soybeans. Tile and open ditches are commonly used for drainage. Tiles are generally spaced 80 to 100 feet apart in the Garwin and Maxfield soils and somewhat farther apart in the Biscay soils.

Most drained and undrained areas are fall plowed, mainly for convenience in scheduling fieldwork. Fall plowing also adds to the growing season, because soils that are plowed in fall are easier to work and warm faster in spring. If plowed in fall, these soils should be left rough and some plant residue left on the surface. Tilling at a minimum in spring when moisture content is favorable helps maintain tilth. If worked when wet, the soils become cloddy and seedbeds are difficult to prepare.

Most permanent pastures are of poor quality because they are hummocky and contain low-quality grasses, such as bluegrass and sedge mixtures, or because they are overgrazed or grazed when they are very wet and the surface is soft. Renovated pastures of bluegrass, bromegrass, red clover, and alsike mixtures are preferred for improved forage; water-tolerant grasses are better suited to very wet areas. Grazing should be controlled and delayed until soils have a firm surface.

Soils of this unit are suitable for pit-type ponds that can be used as a source of water for livestock, for recreation, and especially, for waterfowl habitat.

CAPABILITY UNIT IIw–2

This unit consists of deep, somewhat poorly drained, nearly level soils of the Lawson and Radford series. These soils are on flood plains in broad stream valleys. They are medium textured throughout. Permeability is moderate, and available water capacity is very high. The hazard of flooding is moderate. Flooding is mostly infrequent, but in some areas it is frequent. It occurs mostly during spring runoff or following heavy seasonal rain.

Most areas of these soils are well suited to and are used for row crops, such crops as corn and soybeans, year after year. These soils are also well suited to small grain and hay.

Very little tillage is needed to maintain these soils. Some fields are subject to scouring during flooding, and debris, soil, fertilizer, and pesticides can be carried in the downstream floodwaters. Possible pollution by these materials should be considered.

Some of these soils are in pasture and are used as a permanent pasture of bluegrass. Forage yield from bluegrass is low. Yields can be improved by seeding a mixture of alfalfa, bromegrass, and small amounts of orchardgrass.

CAPABILITY UNIT IIw–3

This unit consists of deep, well drained and moderately well drained, nearly level to gently sloping soils of the Chaseburg and McPaul series. These soils are on the upper and lower parts of flood plains of small or large watersheds. These soils formed in medium-textured alluvium. The hazard of flooding is severe, and it limits most crops. Sediment is continually accumulating from runoff and also is picked up again and carried farther downstream during the recutting of stream channels and scouring of flood plains.

Flooding is too damaging in the few areas used for crops. Where row crops are grown, the application of pesticides and fertilizers should be controlled so they will not be picked up in floodwaters. In some areas, large retardance structures effectively reduce flooding, and these areas are well suited to crops.

Most areas of these soils are used for pasture and are well suited to this use. The amount of forage can be increased if the soils are renovated and reseeded with mixtures, such as alfalfa, bromegrass, and some orchardgrass.

CAPABILITY UNIT IIs–1

This unit consists of well-drained, nearly level to very gently sloping soils of the Alvin, Ankeny, Dakota, Gale, Fairhaven, Kegonsa, and Waukegan series. These soils are underlain by sand and gravel at a depth of 24 to 60 inches, and they are medium textured to moderately coarse textured to this depth. Most of these soils are on benches along streams, but Ankeny soils are on a high bottom of a flood plain. Permeability is moderate or moderately rapid. Natural fertility is medium. Available water capacity is moderate in some soils, and those soils tend to be droughty.

If the supply of moisture is adequate, these soils are well suited to small grain, hay, corn, soybeans, and such canning crops as peas and sweet corn.

Maintaining tilth generally is not a problem, but all crop residue should be returned to the soil to improve available water capacity and fertility. Most row crops can be grown year after year or can be planted in rotation with other crops. These soils are also suited to irrigated crops.

A mixture of alfalfa and bromegrass and, at times, a small percentage of orchardgrass is suitable for permanent pasture. Good pasture management is needed to maintain stands of quality grasses.

CAPABILITY UNIT IIs–2

Moderately well drained Kasson silt loam, 1 to 3 percent slopes, is the only soil in this unit. It is on crests of glacial uplands. This soil is medium textured. The lower part of the subsoil and the underlying material are firm. Permeability is moderately slow. Available water capacity is high. The upper 1 foot to 3 feet is seasonally wet.

In most areas this soil is used for crops, and it is well suited to corn, small grain, hay, and soybeans.

The depth of the root zone is the major limitation because this soil is seasonally wet. The crop roots spread and remain shallow, resulting in slight droughtiness, uneven stands, and crops of poorer quality. In some places, artificial drainage can correct part of the problem, but the restricting layer that causes the wetness is generally too high in the profile for adequate tile placement. Some drainage, however, of the associated, somewhat poorly drained or poorly drained soils is needed. Kasson silt loam, 1 to 3 percent slopes, is normally fall plowed, mainly for convenience in scheduling fieldwork. Fall plowing also adds to the growing season, because this soil is more easily worked and warms faster in spring. Fall plowing helps control erosion by leaving the surface rough and covered with some plant residue. Tilling at a minimum in spring when the moisture content is favorable helps maintain tilth. If worked when wet, this soil becomes cloddy and difficult to work.

Permanent pasture is of good quality. Renovated pastures of mixtures of bromegrass, red clover, and alsike are preferred for improved forage. Pasture that is unimproved is of low quality.

CAPABILITY UNIT IIIe–1

This unit consists of deep, well-drained, sloping soils of the Lindstrom, Mt. Carroll, Ostrander, Port Byron, Racine, Seaton, Terril, and Timula series. Permeability is moderate. Available water capacity is high or very high. These soils are mainly medium textured. They have low to high content of organic matter and require periodic applications of lime. Fertility is low to medium. Fertilizer should be applied according to soil tests. In most cultivated areas, these soils have lost 50 percent or more of their original surface layer through erosion. The hazard of further erosion is severe. Runoff is medium.

If well managed, these soils are productive. Alfalfa and other hay or pasture crops are well suited. Row crops, including soybeans, should not be grown unless erosion is controlled and fertility is maintained. Cropping systems that provide frequent use of legumes and grasses or mulch tillage are generally needed. All crop residue should be returned to the soil, adequate fertilizer applied, and large amounts of manure added.

Contour stripcropping, with alternate strips in meadow, and terraces can be used in many places to control erosion. A year before terraces are built, waterways should be constructed and protected by seeding. If properly designed and kept in grass, waterways remove water safely and prevent erosion. Some cropping systems that use terraces are continuous row crop and mulch planting or a rotation that is one-third or one-half hay. Wheel track planting of plowed fields is effective on all soils in this unit; it is particularly effective on Port Byron and Timula soils because their rate of infiltration is higher. Better weed control is obtained with this practice. Some Seaton soils tend to slake or crust readily because the content of organic matter is low. For these soils the return of more plant residue is needed to build and maintain tilth. Also more cultivation is needed to slow runoff.

Pastures are of fairly good quality, but supplemental pasture generally is needed during prolonged dry periods. More forage can be produced on pasture of tall grass and legumes, chiefly alfalfa and bromegrass and a small percentage of orchardgrass, than on permanent pasture of bluegrass.

CAPABILITY UNIT IIIe–2

This unit consists of sloping, well drained and moderately well drained soils of the Derinda, Dodgeville, Dubuque, Fairhaven, Kegonsa, Schapville, Whalan series and the Copaston, moderately deep variant, series. Most of these soils are underlain by limestone or shale bedrock at a depth of 20 to 40 inches, but Fairhaven and Kegonsa soils are underlain by coarse-textured material. Most of these soils are medium textured to this depth, but Schapville soils are finer textured. All are easy to till, but they are steep and the hazard of further erosion is severe. Fertility is medium. Permeability is moderate or moderately rapid in most of these soils, but is slow in Derinda and Schapville soils. All are droughty because available water capacity is moderate or low. Because they are eroded, the content of organic matter is low in many areas.

If well managed, these soils are suited to most crops commonly grown in the county. Soybeans should not be grown because the hazard of erosion is too great. Plant growth for most crops is limited because available water capacity is low.

These soils should be farmed on the contour. Contour stripcropping, with alternate strips in grass-legume meadow, helps control erosion and slows runoff. Mulch planting and a combination of minimum tillage and contouring are also effective. Terraces generally are not feasible because the soils are shallow over bedrock. Waterways should be constructed in all natural drainageways to contain and carry off runoff. Derinda, Dubuque, and Whalan soils tend to crust or slake easily because the content of organic matter is low. More cultivation is needed to break the crust. Returning plant residue helps to maintain and improve tilth.

Permanent pasture is of good quality early in the season, but droughtiness generally limits needed forage in the middle of the summer. More forage is produced in tall-grass pastures of alfalfa and bromegrass than in permanent bluegrass pasture, which tends to lie dormant during midseason.

CAPABILITY UNIT IIIe–3

This unit consists of shallow, well-drained, nearly level and gently sloping medium-textured soils of the Copaston and Whalan series. These soils are on crests and upper side slopes extending down from these crests on narrow upland ridges. The depth to bedrock ranges from 10 to 24 inches. Permeability is moderate, and available water capacity is low. These soils are very droughty. Some are eroded. The hazard of erosion is moderate. Runoff is medium.

These soils are productive if erosion is controlled, runoff is contained, and fertility, tilth, and available water capacity are maintained. They are suited to small grain and hay crops. Such row crops as corn and soybeans, which require more moisture than these soils generally have available, tend to dry out before they reach maturity. Some corn crops that mature quickly and are grown in limited populations can be planted

early to best utilize periods before soil moisture is depleted and when seasonal rain is more frequent. Canning crops, such as sweet corn and peas, can also be used in this way.

The main management required is control of runoff and erosion, which can also greatly replenish water taken up in crop growth. Where feasible, these soils should be farmed on the contour or across the slope. Contour stripcropping and alternate strips of hay can effectively reduce soil and runoff losses. Mulch planting is also effective where row crops are grown year after year. Row crops should be planted on the contour.

Some soils in this unit are too shallow over rock and too droughty for cultivated crops. These are idle or are in pasture. Areas that can be managed and tilled should be seeded to a suitable mixture of alfalfa and bromegrass and a small percentage of orchardgrass. Forage yields are higher in such areas than in pasture of bluegrass.

CAPABILITY UNIT IIIe–4

This unit consists of well-drained and somewhat excessively drained, sloping sandy loams of the Billett, Dickinson, and Eleva series. These soils are on uplands, small knolls, and escarpments. They are mostly moderately coarse textured. Sand, gravel, or sandstone bedrock is at a depth of 20 to 40 inches. Permeability is moderately rapid. These soils are droughty because available water capacity is low to moderate. Some are eroded; the hazard of erosion is moderate. Runoff is medium or slow. Some is absorbed because the infiltration rate is moderately high.

The soils of this unit are productive if erosion is reduced, runoff is contained, and fertility and tilth are maintained. They are well suited to hay and small grain. Most row crops, such as corn and soybeans, are less suited because the soils are droughty; these crops require a longer growing season and tend to dry out before they reach maturity. Some row crops can be grown if they mature quickly and are planted early to best utilize available water in the soil and periods early in summer when seasonal rain is more frequent. Sweet corn and peas are examples.

The main management required is control of erosion and runoff, which is needed to resupply the water continually used in plant growth. These soils should be farmed on the contour or across the slope. Contour stripcropping, with alternate strips in hay, helps control erosion and runoff. Mulch planting and wheel track planting are also very effective where row crops are planted year after year.

Permanent pasture is of fair quality because in most areas the surface layer is sandy loam. Available water capacity is lower in sandy loams than in soils that have a surface layer of loam or silt loam. Deep-rooted grasses and legumes, such as a mixture of alfalfa-brome and a small part of orchardgrass, can utilize the moisture deeper in the soils.

CAPABILITY UNIT IIIw–1

This unit consists of deep, very poorly drained, nearly level soils of the Garwin and Maxfield series. These soils are in the upper reaches of wet drainageways. They have a seasonal high water table at a depth of 1 foot to 3 feet. They are moderately fine textured. Permeability is moderately slow. Frequent flooding is a hazard.

Most undrained areas are idle or used as pasture. Other areas are used as outlets for drainage systems in adjoining wet fields. These systems consist of open ditches, waterways, or large tile mains. In order to install such a system, the area should be as much as 50 percent or more one mapping unit. Some areas are cropped up to the drainage outlets, but they are subject to flooding.

These soils are suited to corn and soybeans. Drained areas are generally fall plowed, mainly for convenience in scheduling fieldwork. Fall plowing also adds to the growing season, because soils that are plowed in fall are easier to work and warm faster in spring. Soils that are fall plowed should be left rough and some plant residue left on the surface. Tilling at a minimum in spring when moisture content is favorable helps maintain tilth. If worked when wet, these soils become cloddy and seedbeds are difficult to prepare. Waterways should be constructed in areas of excessive overflow because they control erosion from scouring or gullying. Careful use of pesticides is needed because they are easily picked up in runoff water.

These soils are poorly suited to pasture because they are wet, have a soft surface layer, and tend to develop hummocks. Pasture is generally of a poorer quality than improved stands of other permanent pastures; it contains a mixture of reeds, sedges, and reed canarygrass, which can be cut for wild hay. Pasture areas are difficult to improve because of wetness.

Idle areas of these soils are of limited quality for wildlife, but they can be improved if ponds are developed. Where future drainage systems are planned, ponds for wildlife should be considered.

CAPABILITY UNIT IIIw–2

This unit consists of deep, somewhat poorly drained, nearly level to sloping soils of the Shullsburg and Skyberg series. These soils are on glacial uplands in areas of shale bedrock. Shullsburg soils are moderately fine textured or fine textured, and Skyberg soils are medium textured. Permeability is slow or moderately slow. Available water capacity is moderate to high.

These soils are chiefly used for crops, and they are well suited to corn, small grain, hay, and soybeans. The depth of the root zone is the major limitation. Water perched seasonally in the upper 1 foot to 3 feet limits the depth of the root zone and causes some droughtiness and uneven crop stands. Artificial drainage is feasible for Skyberg soils.

Skyberg and Shullsburg soils are generally fall plowed, mainly for convenience in scheduling fieldwork. Fall plowing also adds to the growing season because soils that are plowed in fall are easier to work and warm faster in spring. If plowed in fall, these soils should be left rough and some plant residue left on the surface. Tilling at a minimum in spring when the moisture content is favorable helps maintain tilth. If worked when wet, these soils become cloddy and seedbeds are difficult to prepare. Shullsburg soils, the more sloping, require erosion control.

Pasture is of good to fair quality. The surface layer generally is firm enough so that hummocks are not a

concern. Renovated pastures in mixtures of bromegrass, red clover, and alsike are preferred for improved forage. Grazing should be controlled and delayed until the surface layer is firm.

CAPABILITY UNIT IIIw-3

This unit consists of deep, poorly drained and very poorly drained, nearly level soils of the Bremer, Colo, and Orion series. Most of these soils are on narrow flood plains in small watershed areas, but Bremer and some Colo soils are on the larger flood plains. These soils formed in medium-textured or moderately fine textured alluvium. Springs and heads of small streams are common, and most areas are cut by small streams. Permeability is moderately slow or moderate. Available water capacity is very high. These soils are subject to flooding and in most areas are very wet. Sediment generally accumulates in most areas and also is scoured off and carried farther downstream.

Most areas of these soils are used for pasture, but some are used for crops and others are used as outlets for drainage systems either as a natural channel or a constructed ditch. Areas of improved drainage along the channel are well suited to corn and soybeans. Caution is needed in flooded areas of fields to prevent flood scouring that can incorporate debris, fertilizers, pesticides, and soil in the downstream floodwaters. A buffer zone or drainageway should be grassed where overflow is likely and frequent.

These soils are well suited to poorly suited to pasture and hay. Permanent grasses in most pastures are mixtures of bluegrass, reed canarygrass, and sedges. Pastures can be improved by seeding mixtures of bromegrass, red clover, and alsike. Other areas can be improved by grasses, such as reed canarygrass. Some areas are very wet, and the surface layer is likely to be soft. These areas easily become hummocky when pastured. Grazing should be controlled and delayed until the surface layer is firm.

Soils of this unit are suitable for pit-type ponds, which can be used as a source of water for livestock, for recreation, and especially for wildlife habitat. Control of sediment and floodwaters is needed.

CAPABILITY UNIT IIIs-1

This unit consists of nearly level to gently sloping, somewhat excessively drained to moderately well drained soils of the Burkhardt, Dickinson, Estherville, and Zumbro series. These soils are on benches and flood plains along major rivers. They are medium textured to coarse textured. The depth to sand or gravel generally ranges from 15 to 30 inches, but is more than 30 inches in Dickinson soils. Most of these soils are very droughty because available water capacity is low and the root zone is shallow; available water capacity is moderate and the root zone is deeper in the Dickinson soils. Permeability is moderately rapid or rapid. Natural fertility is low. These soils are subject to soil blowing.

If adequate moisture is available throughout the growing season, these soils are suited to small grain, some hay, and irrigated field crops. Some row crops, such as corn or soybeans, can be grown, but growth is somewhat limited. Limiting plant population and planting crops that can mature during periods of more frequent rain insure the best utilization of moisture.

Permanent pasture grows well in spring and early in summer, but it dries up or is dormant in summer. More forage is produced on pasture of bromegrass and alfalfa than on permanent bluegrass pasture.

CAPABILITY UNIT IVe-1

This unit consists of deep, well-drained, moderately steep to steep soils of the Lindstrom, Racine, Seaton, and Terril series. Most of these soils are medium textured. Most of the slightly eroded or noneroded soils are in pasture or woodland. Permeability is moderate, and available water capacity is high or very high. Runoff is rapid. These soils erode easily if ground cover is lacking, especially during seedbed preparation. The eroded soils generally are in poor tilth. The hazard of further erosion is severe, and some severely eroded soils have been included in mapping.

Soils of this unit are suited to small grain, corn, and hay if they are well managed and stripcropped on the contour, with alternate strips in hay. If more row crops, especially corn, are needed, mulch planting on the contour and wheel track planting are desirable. Soybeans should not be planted because they tend to loosen soil and increase the hazard of further erosion. Some terraces or diversions are effective in containing runoff, especially in areas where slopes are very long.

Soils in this unit are fairly well suited to pasture. Most unmanaged pastures, however, are dominated by Kentucky bluegrass, which tends to go dormant during the summer. The sandy loam surface layer in Terril soils has less available water than other soils and tends to dry out faster. More forage is produced on pasture of tall grass and legumes, for example, alfalfa and bromegrass and some orchardgrass.

CAPABILITY UNIT IVe-2

This unit consists of well drained and moderately well drained, moderately steep to steep soils of the Derinda and Dubuque series. These soils are on the upper sides of ridges and entrenched drainageways on uplands. They are underlain by bedrock at a depth of 20 to 40 inches. They are medium textured. Most of these soils are cultivated and eroded. Some are severely eroded. Most of the slightly eroded or noneroded soils are in pasture or woodland. Permeability is slow in Derinda soils and moderate in Dubuque soils. Available water capacity is moderate. Runoff is rapid. These soils erode easily if ground cover is lacking. They lack tilth and tend to slake or crust because the content of organic matter is low. The hazard of further erosion is severe.

These soils are suited to small grain, corn, and hay if they are well managed and stripcropped on the contour, with alternate strips in hay. If more row crops, especially corn, are needed, mulch planting and contour and wheel track planting are desirable. Soybeans should not be planted because the soils erode very easily. Terraces are effective, but installation is difficult because the soils are shallow over bedrock. Wetness is possible in Derinda soils.

Soils in this unit are fairly well suited to pasture, but supplemental pasture is needed during prolonged dry periods. More forage is produced on pasture of tall grass and legumes, such as alfalfa and bromegrass and

a small percentage of orchardgrass, than on permanent bluegrass pasture. Bluegrass pasture is dormant during periods of high temperatures. Many pastures are of poor quality because they are covered with brush.

CAPABILITY UNIT IVe-3

This unit consists of sloping to moderately steep, well drained and moderately well drained soils of the Copaston, Schapville, and Whalan series. These soils are on the upper sides of narrow upland ridges. Schapville soils are fine textured. The rest are medium textured. Limestone or shale bedrock is at a depth of 12 to 24 inches. Runoff is medium. Permeability is slow in Schapville soils and moderate in the rest. Available water capacity is low. The hazard of erosion is severe. These soils are droughty.

The soils of this unit are fairly productive. They are suited to small grain, hay, or rotation pasture. Management is needed to reduce erosion and contain runoff which, in turn, maintains fertility, tilth, and available water capacity. Row crops that benefit from frequent seasonal rains and mature early can be grown. Some areas have numerous rock outcrops and are difficult to cultivate. Mulch planting, wheel track planting, and contour stripcropping, with alternate strips in hay, can reduce the loss of soil through erosion. Some steeper, escarpmentlike areas should be converted to permanent woodland.

Schapville soils are difficult to manage because the content of clay is high. If worked when wet, these soils are very sticky and become hard and cloddy when dry. If worked at the proper moisture content, they are very friable and require a minimum tillage. In some areas fall plowing is needed to keep the soil friable. Management that conserves the soil is needed.

Permanent pasture is of good quality early in the season. The forage needed, however, is not produced in the middle of the summer because the soil is droughty. Yields of forage are highest on tall-grass pastures, such as mixtures of alfalfa, bromegrass, and some orchardgrass, all of which have deep roots. Some permanent pastures are of poor quality because they are wooded or brushy.

CAPABILITY UNIT IVe-4

This unit consists of well-drained or somewhat excessively drained, sloping to moderately steep soils of the Billett, Dickinson, Eleva, and Estherville series. These soils are in upland areas and on escarpments of benches. They are mostly moderately coarse textured. Depth to sand, gravel, or sandstone bedrock is 20 to 40 inches. Permeability is moderately rapid and rapid. Available water capacity is low and moderate. Natural fertility is low or medium. The hazards of erosion and drought are severe. Soil lost through erosion is carried downslope to a lower bench or flood plain. Runoff is medium. Much of it is absorbed because infiltration is moderate.

These soils are productive if erosion is reduced and runoff is contained. Controlling runoff and erosion maintains fertility, tilth, and available water in the soil. The soils are well suited to small grain and hay. Most row crops require a longer growing season and are not so well suited because they tend to dry out before they reach maturity. They can be grown if the plants selected mature quickly and are planted early to best utilize the available water in the soil and the more frequent seasonal rains early in summer. Mulch planting, wheel track planting, and contour stripcropping, with alternate strips in hay, can reduce soil loss where crops are grown.

Some of the steeper, narrow escarpments should be converted to permanent woodland because the hazard of erosion is very severe.

Most permanent pasture is only fair quality because the soil is droughty. Shallow-rooted grasses, especially Kentucky bluegrass, are dormant early in summer. More of the deeper rooted grasses and legumes, for example, mixtures of alfalfa and bromegrass and some orchardgrass, should be grown to utilize the moisture deeper in the soil.

CAPABILITY UNIT IVs-1

This unit consists of nearly level and gently sloping, excessively drained and somewhat excessively drained soils of the Gotham, Lilah, Plainfield, Salida, and Sparta series. These soils are on benches or foot slopes below walls of major stream valleys. They are mostly coarse textured. Permeability is rapid and very rapid. Natural fertility is low. The hazard of drought is severe. Available water capacity is low or very low. The hazard of soil blowing is severe.

These soils are generally too droughty for most cultivated crops grown in the county. They are suited to special crops, such as Christmas trees or tree nurseries. Vegetable or fruit crops that are suited to sandy soils also can be grown. The potential for irrigated crops, such as corn, is limited because frequent applications of water are needed.

These soils are poorly suited to permanent pasture. Many pastures are woody or brushy. Forage normally is dormant early in the season because the soils are dry. More forage can be produced on pasture of alfalfa and bromegrass than on pasture of native bluegrass. Improved pasture is very limited by the drought.

CAPABILITY UNIT VIe-1

This unit consists of well-drained, moderately steep or steep soils of the Bold, Seaton, and Timula series. These soils are on side slopes along entrenched drainageways on uplands and on some foot slopes below valley walls. They are medium textured. The content of organic matter is medium to low. Available water capacity is very high. Some soils in this unit are eroded, and some are severely eroded. Wooded areas and pasture are not eroded or are slightly eroded. Runoff is rapid.

These soils generally are not suited to row crops, because the hazard of erosion is severe. They are suited to hay, pasture, woodland, or wildlife. They are well suited to alfalfa and bromegrass because free lime carbonates are at a depth of 40 inches in some of the soils and are slightly deeper in others. Hayland is better suited to grazing than permanent bluegrass pasture. Grazing of any of these soils should be controlled because excessive runoff is a concern.

CAPABILITY UNIT VIw-1

This unit consists of very poorly drained, organic soils of the Houghton series. Areas are seepy and depressional and remain wet throughout the year.

These soils are not used for crops because they generally are wet and seepy and are impractical to drain. Most areas are used for wild hay and pasture. Some areas can be improved for forage if reed canarygrass and Garrison creeping foxtail are established. Those grasses form a tough, dense sod that supports light haying equipment or grazing cattle even when the soils are somewhat wet. Reed canarygrass is of better quality and is more palatable than hay from marsh grass. Satisfactory stands of Garrison creeping foxtail require adequate nitrogen fertilizer.

Most soils in this unit provide cover for wildlife. Many areas can be improved by constructing shallow pits that provide open water for ducks and other waterfowl. The areas should be protected from fire. These soils are too wet to be used as woodland.

CAPABILITY UNIT VIw–2

This unit consists only of deep, well-drained to poorly drained Alluvial land, frequently flooded. This land is on flood plains that are flooded very frequently or inundated for long periods. The alluvium is mostly silty or sandy sediment.

Alluvial land, frequently flooded, has very limited use. Some of the acreage is used as pasture or woodland, but most of it is idle. Improving it for pasture or crops is not feasible because the hazard of flooding is too severe.

CAPABILITY UNIT VIw–3

This unit consists of deep, well-drained, coarse-textured Alluvial land, sloping. This land is on narrow flood plains and alluvial fans that are near soils of the valley wall. Flooding is very frequent, is very high in velocity, and occurs after most rains. Some of the acreage is used as pasture or woodland, but most is idle. Most pastures are unimproved because access is limited or the soil is of poor quality.

CAPABILITY UNIT VIIe–1

This unit consists of deep, steep and very steep, well-drained silty and loamy soils of the Bold, Racine, Seaton and Timula series. These soils are on upper parts of lower foot slopes of valley walls and on some sides of entrenched drainageways on uplands. Permeability is moderate. Available moisture capacity is high and very high. Runoff is rapid. The hazard of erosion is severe in cultivated areas or areas that lack vegetation.

These soils are not suited to cultivated crops, and areas now in crops should be in permanent vegetation. If these soils are used for pasture or hay, a good cover of plants should be maintained to control erosion. Also, grazing must be limited to avoid excessive runoff that causes gullies along lower slopes. These soils are better suited to woodland and to recreational uses. Wooded areas should not be pastured.

CAPABILITY UNIT VIIe–2

This unit consists of steep and very steep, well drained and moderately well drained soils of the Dubuque, Frontenac, and Whalan series. These soils are on parts of valley walls and on side slopes of entrenched drainageways. They are medium textured. They are 20 to 40 inches deep over bedrock or residuum. The hazard of erosion is very severe.

Control of erosion and runoff is essential because gullies are forming on lower foot slopes and in drainageways. This control is best obtained through permanent vegetation, such as prairie or woodland. If some areas are grazed, close control is needed to keep the vegetative cover thick.

CAPABILITY UNIT VIIs–1

This unit consists of sloping to very steep, excessively drained and somewhat excessively drained soils of the Bellechester, Gotham, Lilah, Plainfield, and Salida series. These soils are mostly coarse textured. They are underlain by sand and gravel at a depth of 12 inches. Available water capacity is low or very low. The hazards of drought and erosion are severe and limit use.

These soils are too droughty to be used for crops, and a good cover of pasture or hay is difficult to maintain. In many areas, plants are spindly and sparse. The soils should not be pastured because the hazard of gullying is severe. Most areas are better suited to woodland or wildlife cover than to most other uses. All wooded areas must be protected from grazing and fire.

Gullies should be shaped and seeded to grass for use as waterways. Some gullies require structures, such as diversions or dams, that stabilize the soil enough to allow grass or trees to grow.

CAPABILITY UNIT VIIs–2

This unit consists of very steep, excessively drained, well drained, and moderately well drained soils of the Brodale, Copaston, Marlean, Schapville, and Sogn series. These soils occupy all areas on valley walls. Silty or loamy material, 10 to 20 inches thick, overlies limestone, limestone residuum, or shale. These soils are subject to very rapid runoff, especially in areas that lack thick vegetative cover.

These areas should be in permanent vegetation of woodland or prairie. Under a dense plant cover, these soils can absorb more runoff and the hazard of gullying is reduced along lower foot slopes and drainageways. Woodland can be harvested for timber. On south-facing and west-facing slopes, which generally are in native grass, some grazing could be permitted to help establish some warm-season grasses, such as switchgrass, side-oats grama, and the bluestems. A few weeks of early summer grazing can suppress cool-season grasses, such as bluegrass, and allow more of the warm-season grasses to take over. If these warm-season grasses become established, they can support limited grazing. These soils are very easily overgrazed, however, and erosion ond runoff can be severe. Natural stands of warm-season grasses can be lost.

CAPABILITY UNIT VIIIw–1

Only Marsh is in this capability unit. It consists of ponded areas and land bridgings of Bremer, Houghton, McPaul, and Orion soils and Alluvial land, frequently flooded. The water level fluctuates, depending on the season and the ground water table.

Vegetation consists of cattails, rushes, sedges, willows, and other water-tolerant plants. Marsh is too wet

for crops, pasture, or trees. In some places it can be cut for wild hay.

Areas of Marsh provide food, cover, and nesting places for waterfowl, muskrat, mink, and beaver. Areas can be improved for wildlife by providing level ditches to control the water level.

CAPABILITY UNIT VIIIs–1

This unit consists of very steep, excessively drained or well drained soils of the Brodale and Sogn series. Most of these soils are on south-facing and west-facing sides of valley walls. These soils are flaggy loams or sandy loams 10 to 40 inches deep over bedrock. They are subject to very rapid runoff.

These soils should be left in permanent vegetation and not grazed. If possible, they should be planted to trees to slow or contain runoff. Pasturing or excessive traffic increases runoff.

Predicted yields

Table 2 shows predicted average yields per acre of the principal crops grown on the soils in the county. Yields are predicted for two levels of management. Those in columns A are obtained under an average level of management, and those in columns B are obtained under a high level. No yields are shown for Marsh.

The average level of management is the management followed by most farmers in the county. At this level, oats, hay, pasture, and soybean crops are seldom fertilized. Starter fertilizer or manure is used for corn. Crops in the rotation are corn and small grain, but the acreage of legume-grass hay on the farm is too small to permit effective rotation of crops. A green-manure crop is sometimes seeded with the small grain. Contouring and contour stripcropping are used to control erosion. Tile drainage is generally provided on wet soils. The stands of corn range from 15,000 to 24,000 plants per acre, and the number is not generally adjusted to the type of soil or the amount of soil moisture. The seedbed is prepared and cultivated in the common manner. Rotation grazing is not practiced.

The high level of management, for which yields are predicted in columns B, is followed by many farmers. At this level, fertilizer is applied according to soil tests. Manure is generally available. An optimum stand of corn is planted; the number of plants in the stand is adjusted to the type of soil and the supply of moisture. The rotation includes a legume-grass mixture or a green-manure crop. Erosion is controlled where needed. The wet soils are drained by adequate surface drainage and tile, but not necessarily by a complete drainage system. Large amounts of crop residue are returned to the soil, and the amount of tillage is minimized. Weeds, plant diseases, and insects are controlled. Pastures are seeded to a suitable mixture of grasses and legumes, and grazing is rotated or regulated. The immediate response of crops to this level of management depends on past management of the soil.

The predictions of yields are based on information received from several sources. Yields were measured on experimental plots on some soils in the county. Records of yields and of soil management practices were reported by farmers for crops on some of the soils. Information was obtained from a study of the productivity of specific soils conducted jointly by the Soil Conservation Service, the Agricultural Extension Service, and the Department of Soils, University of Minnesota. Crops were observed and farmers were interviewed during the course of the soil survey. The predictions were judged in relation to soil properties that are known to affect growth of crops, compared with predictions made for similar soils in other counties, and checked against average yields reported in the Agricultural Census.

The yields shown in table 2 are those obtainable by using present farming practices and varieties of crops. As agricultural technology advances, increased yields per acre might be obtained. It is also possible that plant diseases and pests might cause average yields to be less than those predicted here.

Use of the soils for pasture and hay

Most well-drained soils, such as those in capability unit IIe–1, that are well suited to crops are also well suited to pasture or hay. Under proper fertilization, rotation grazing, timely harvesting, and weed control, these soils have the potential for high-level production of hay or pasture. A hay crop is alfalfa or an alfalfa-grass mixture. Pasture is mainly grass, such as brome or timothy, or a mixture of grasses and legumes.

For wet soils, such as those in capability unit IIw–1 or IIw–2, which are subject to flooding or are too wet for normal cropping, hay or pasture is an alternative land use. Under proper fertilization, timely harvesting, rotation grazing, and proper stocking, high levels of production are attainable. On these soils it is essential to seed grasses and legumes that tolerate wetness.

For droughty soils, for example, those in capability unit IIIs–1, and for soils on which the hazard of erosion is severe, such as those in capability unit VIe–1, hay or pasture is an alternative land use. On droughty soils moisture is the limiting factor and careful management is essential. Fertilization must be related to the productive potential of the site. Grazing is limited to the active growth period of the grasses and legumes in use, and weeds are controlled to obtain maximum production of forage for hay or grazing.

Also in the county are numerous areas of native grassland soils, such as those in capability unit VIIs–2. Most of these soils are steep and are suited only to grazing or recreational use. Some areas of this grassland are in excellent condition. Some are heavily overgrazed. Many areas are dominated by Kentucky bluegrass and a residual composition of native prairie grasses. Other areas are warm-season grasses, dominantly big bluestem, indiangrass, side-oats grama, and little bluestem. The bluegrass can be managed for maximum production through fertilization and proper grazing use. The key management principles essential in improving the native warm-season species are early grazing, which utilizes the cool-season grasses, and then deferment from grazing during the growth period of warm-season grasses; or repeated deferment from grazing until the vigor of warm-season grass is restored. Following improvement, the grassland is managed to control grazing, taking half and leaving half of the current year's production. Under this system, it provides good quality forage during July and August,

TABLE 2.—*Predicted average yields per acre of principal crops under two levels of management*

[Absence of a figure indicates the crop is not commonly grown on the soil or is not suited to the soil]

Mapping unit	Corn for grain		Corn for silage		Soybeans		Oats		Alfalfa-brome hay		Rotation pasture		Permanent pasture	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu	*Bu*	*Tons*	*Tons*	*Bu*	*Bu*	*Bu*	*Bu*	*Tons*	*Tons*	*AUM*[1]	*AUM*[1]	*AUM*[1]	*AUM*[1]
Alluvial land, frequently flooded[2]													3.0	
Alluvial land, sloping													1.5	
Alvin fine sandy loam, 0 to 3 percent slopes	60	80	10	12	18	26	45	60	2.4	3.5	3.7	5.2	2.5	4.3
Ankeny sandy loam, 0 to 3 percent slopes	60	80	10	12	20	28	45	60	2.4	3.5	3.7	5.2	2.5	4.3
Bellechester sand, 25 to 45 percent slopes[2]													1.0	1.0
Billett sandy loam, 2 to 6 percent slopes	55	70	7	10	20	22	41	53	2.5	3.0	3.8	4.5	2.0	3.8
Billett sandy loam, 6 to 12 percent slopes	50	65	6	9	16	20	40	49	2.0	2.5	3.0	3.7	2.0	3.0
Biscay loam	75	95	12	14	27	35	57	70	3.0	4.0	4.5	6.0	3.0	4.8
Bremer silty clay loam, wet[3]		115		16		40		85		4.5		6.7	3.0	5.4
Brodale-Sogn flaggy loams, steep[2]													1.0	1.0
Brodale-Sogn flaggy loams, very steep[2]													1.0	1.0
Burkhardt loam, 0 to 3 percent slopes	45	55	4	5	15	20	35	41	2.2	2.2	3.7	3.7	1.5	3.0
Canisteo silty clay loam	70	95	10	14	21	35	49	65	4.0	4.5	6.0	6.7	3.0	5.4
Chaseburg silt loam, 0 to 3 percent slopes[3]		110		16		35		80		5.0		7.5	2.5	5.4
Colo silty clay loam[3]		110		16		40		65		4.5		6.7	3.5	5.5
Copaston loam, 1 to 6 percent slopes[4]		55		6		16		41		2.2		3.5	1.5	3.3
Copaston loam, 6 to 12 percent slopes, eroded[4]		45		5		14		37		2.0		3.7	1.5	3.0
Copaston loam, moderately deep, 0 to 6 percent slopes	65	90	8	13	20	27	49	67	2.6	3.6	3.8	5.2	2.0	4.3
Copaston loam, moderately deep, 6 to 12 percent slopes, eroded	60	80	7	11	18	24	45	60	2.4	3.2	3.6	4.5	2.0	3.8
Dakota loam, 0 to 3 percent slopes	65	90	9	13	20	27	49	67	2.6	3.6	3.8	5.2	2.0	4.3
Derinda silt loam, 5 to 12 percent slopes, eroded	65	80	9	12	20	24	49	60	2.6	3.6	3.3	5.2	2.5	4.3
Derinda silt loam, 12 to 25 percent slopes, eroded[5]		55		8				41		3.0		4.5	2.0	3.8
Dickinson sandy loam, 0 to 2 percent slopes	70	80	10	12	21	24	53	60	2.6	3.2	3.8	4.5	1.5	3.8
Dickinson sandy loam, 2 to 6 percent slopes	65	70	9	10	20	21	49	53	2.0	2.8	3.0	3.7	1.5	4.3
Dickinson sandy loam, 6 to 12 percent slopes	50	60		7	15	18	39	45	2.0	2.4	3.0	3.6	1.5	3.8
Dodgeville silt loam, 1 to 6 percent slopes	65	75	9	11	20	22	49	57	2.6	3.0	3.8	4.5	2.5	3.8
Dodgeville silt loam, 6 to 12 percent slopes, eroded	60	70	7	10	18	21	45	53	2.4	2.8	3.6	4.0	2.5	3.6
Dubuque silt loam, 2 to 6 percent slopes, eroded	65	75	9	11	20	22	49	57	2.6	3.0	3.8	4.5	2.5	3.8
Dubuque silt loam, 6 to 12 percent slopes, eroded	60	70	7	10			45	53	2.4	2.8	3.6	4.0	2.5	3.8
Dubuque silt loam, 12 to 18 percent slopes, eroded	55	65	6	7			45	49	2.2	2.6	3.2	3.8	2.0	3.2
Dubuque silt loam, 18 to 35 percent slopes[5]								49	2.2	2.6	3.1	3.8	1.5	3.0
Eleva sandy loam, 2 to 6 percent slopes	55	70	7	10	16	21	41	53	2.2	2.8	3.1	4.0	1.5	3.5
Eleva sandy loam, 6 to 18 percent slopes	50	65	6	9	16	21	40	49	2.0	2.5	2.5	3.0	1.5	2.4
Estherville silt loam, 0 to 6 percent slopes	50	65	6	8	16	21	40	49	2.0	2.5	2.5	3.0	1.5	3.0
Estherville soils, 6 to 18 percent slopes[4]		54		6		15	39	39	2.0	2.0	2.5	2.5	1.0	2.0
Fairhaven silt loam, 0 to 3 percent slopes	75	95	11	14	22	28	57	71	3.0	3.8	4.5	5.8	2.5	4.5
Frontenac soils, steep[2]													1.0	
Frontenac soils, very steep[2]													1.0	
Gale silt loam, 0 to 3 percent slopes	75	80	11	12	22	25	57	70	3.0	4.0	4.5	6.0	2.5	4.8
Garwin silty clay loam	60	125	7	17	18	38	45	94	3.0	4.0	4.5	6.0	3.0	4.8
Garwin silty clay loam, swales[3]		110		16		33		32		4.0		6.0	3.0	5.5
Gotham fine sand, 2 to 12 percent slopes		50		6		15		30		2.0		3.0	1.0	2.4
Gotham fine sand, 12 to 35 percent slopes										2.0		3.0	1.0	2.4
Houghton muck													3.5	5.5
Houghton muck, seepy													3.5	5.5
Joy silt loam, 0 to 3 percent slopes	90	125	13	17	30	35	65	80	3.5	5.0	5.2	7.5	2.5	6.0
Kasson silt loam, 1 to 3 percent slopes	75	95	11	14	20	25	65	70	3.5	4.0	5.2	6.0	2.5	6.0
Kegonsa silt loam, 0 to 3 percent slopes	70	80	10	12	21	24	53	60	2.8	3.2	4.0	4.3	2.5	3.6
Kegonsa and Fairhaven silt loams, 6 to 18 percent slopes[2]													2.0	
Klinger silty clay loam, 1 to 3 percent slopes	85	115	12	16	30	35	65	80	3.5	5.0	5.2	7.5	3.0	6.0
Lawson silt loam	90	125	13	17	30	35	65	80	3.5	5.0	5.2	7.5	3.0	6.0
Lilah sandy loam, 0 to 6 percent slopes[4]		50		6		15		30		2.0		3.0	1.0	2.4
Lilah sandy loam, 6 to 35 percent slopes[2]													1.0	
Lindstrom silt loam, 2 to 6 percent slopes	85	120	12	16	30	35	65	80	3.5	5.0	5.2	7.5	2.5	6.0
Lindstrom silt loam, 6 to 12 percent slopes	75	105	11	15	25	30	60	70	3.5	4.5	5.2	6.7	2.5	5.4
Lindstrom silt loam, 12 to 25 percent slopes	10	100	10	15			55	65	3.0	4.5	4.5	6.7	2.5	5.4
Marlean soils, steep[2]													1.0	
Marlean soils, very steep[2]													1.0	
Maxfield silty clay loam	60	115	7	16		35		80	3.5	4.5	5.2	6.7	3.0	5.5
Maxfield silty clay loam, swales		105		15		35		75		4.0		5.5	3.0	5.5
McPaul silt loam[3]		110		16		35		80		5.0		7.5	2.5	6.0
Mt. Carroll silt loam, 0 to 2 percent slopes	85	120	13	16	25	30	65	80	3.0	5.0	4.5	7.5	2.5	6.0
Mt. Carroll silt loam, 2 to 6 percent slopes	80	120	12	16	25	30	65	80	3.0	5.0	4.5	7.5	2.5	6.0
Mt. Carroll silt loam, 6 to 12 percent slopes, eroded	75	110	11	15	22	28	60	75	3.0	4.5	4.5	6.7	2.5	5.4
Mt. Carroll silt loam, benches, 0 to 3 percent slopes	85	120	12	16	25	30	65	80	3.0	5.0	4.5	7.5	2.5	6.0
Orion silt loam, wet[3]		110		15		35		80		5.0		7.5	3.0	6.0
Ostrander silt loam, 1 to 6 percent slopes	80	110	12	15	25	30	55	80	3.0	4.5	4.5	6.7	2.5	5.4
Ostrander silt loam, 6 to 12 percent slopes, eroded	75	100	11	15	20	25	55	75	3.0	4.5	4.5	6.7	2.0	5.4

See footnotes at end of table.

TABLE 2.—*Predicted average yields per acre of principal crops under two levels of management*—Continued

Mapping unit	Corn for grain		Corn for silage		Soybeans		Oats		Alfalfa-brome hay		Rotation pasture		Permanent pasture	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu	*Bu*	*Tons*	*Tons*	*Bu*	*Bu*	*Bu*	*Bu*	*Tons*	*Tons*	*AUM*[1]	*AUM*[1]	*AUM*[1]	*AUM*[1]
Plainfield loamy sand, 0 to 6 percent slopes[4]	-----	45	-----	7.5	-----	-----	-----	35	-----	2.5	-----	2.5	1.0	2.5
Plainfield loamy sand, 6 to 25 percent slopes[2]	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	.5	-----
Port Byron silt loam, 0 to 2 percent slopes	90	130	13	20	28	35	60	80	3.0	5.0	4.5	7.5	2.5	6.0
Port Byron silt loam, 2 to 6 percent slopes	90	125	13	17	25	35	60	80	3.0	5.0	4.5	7.5	2.5	6.0
Port Byron silt loam, 6 to 12 percent slopes, eroded	75	110	11	16	22	28	60	75	3.0	4.5	4.5	6.7	2.5	5.4
Port Byron silt loam, benches, 0 to 3 percent slopes	90	130	13	20	28	35	60	80	3.0	5.0	4.5	7.5	2.5	6.0
Racine silt loam, 1 to 6 percent slopes	80	105	12	15	25	30	55	80	3.0	4.5	4.5	6.7	2.5	5.4
Racine silt loam, 6 to 12 percent slopes	75	95	11	14	20	25	50	75	3.0	4.5	4.5	6.7	2.5	5.4
Racine silt loam, 6 to 12 percent slopes, eroded	75	95	11	14	20	25	50	75	3.0	4.5	4.5	6.7	2.5	5.4
Racine silt loam, 12 to 18 percent slopes, eroded	65	85	8	11	-----	-----	50	70	3.0	4.0	4.5	6.0	2.5	4.8
Racine soils, 18 to 35 percent slopes	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	2.0	4.3
Radford silt loam	100	120	15	16	35	40	60	85	4.0	5.0	6.0	7.5	2.5	6.0
Salida gravelly coarse sand, 1 to 12 percent slopes[4]	-----	35	-----	-----	-----	14	-----	35	-----	2.0	-----	2.4	1.0	2.0
Salida gravelly coarse sand, 12 to 45 percent slopes[2]	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.5	-----
Schapville silty clay loam, 2 to 12 percent slopes	55	65	6	7	17	23	55	60	2.5	3.0	3.7	4.5	1.5	3.8
Schapville silty clay loam, 12 to 18 percent slopes[2]	-----	55	-----	6	-----	-----	-----	55	-----	3.0	-----	4.5	1.5	3.8
Schapville-Sogn complex, 18 to 35 percent slopes	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.6	2.5
Seaton silt loam, 0 to 2 percent slopes	85	120	13	16	27	30	65	80	3.5	5.0	5.2	7.5	2.5	610
Seaton silt loam, 2 to 6 percent slopes	85	115	13	15	27	30	65	80	3.5	5.0	5.2	7.5	2.5	6.0
Seaton silt loam, 6 to 12 percent slopes, eroded	75	110	11	14	22	28	60	75	3.0	4.5	4.5	6.7	2.5	5.4
Seaton silt loam, 12 to 18 percent slopes, eroded	70	90	10	13	-----	-----	50	70	3.0	4.0	4.5	6.0	2.5	4.8
Seaton silt loam, 18 to 25 percent slopes[5]	-----	75	-----	11	-----	-----	-----	65	3.0	4.0	4.5	6.0	2.0	4.8
Seaton silt loam, valleys, 6 to 12 percent slopes, eroded	75	110	11	14	22	28	60	75	3.0	4.5	4.5	6.7	2.5	5.4
Seaton silt loam, valleys, 12 to 18 percent slopes, eroded	70	90	10	13	-----	-----	50	70	3.0	4.0	4.5	6.0	2.5	4.8
Seaton silt loam, valleys, 18 to 25 percent slopes[5]	-----	75	-----	11	-----	-----	-----	65	3.0	4.0	4.5	6.0	2.0	4.8
Seaton complex, 6 to 12 percent slopes, eroded	70	85	10	12	20	25	60	70	3.0	4.0	4.5	6.0	2.5	4.8
Seaton complex, 12 to 25 percent slopes, eroded[5]	-----	75	-----	11	-----	-----	-----	65	3.0	4.0	4.5	6.0	2.5	4.8
Seaton, Timula, and Bold silt loams, steep[2]	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.5	-----
Shullsburg silty clay loam, 2 to 14 percent slopes	55	90	6	13	20	28	55	70	3.0	4.5	4.5	6.7	2.5	4.8
Skyberg silt loam	75	90	11	13	22	27	57	67	3.0	3.6	4.5	5.2	3.0	4.8
Sogn and Copaston soils, 12 to 25 percent slopes[2]	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	-----	1.0	-----
Sparta loamy sand, 0 to 3 percent slopes[4]	-----	55	-----	5	-----	16	-----	41	-----	2.2	-----	2.1	1.5	2.5
Terril sandy loam, 2 to 6 percent slopes	85	115	12	15	26	35	64	86	3.4	4.6	5.1	6.8	2.5	5.5
Terril sandy loam, 6 to 12 percent slopes	75	100	11	15	22	30	57	75	3.0	4.0	4.5	6.0	2.0	4.8
Terril sandy loam, 12 to 25 percent slopes	70	90	10	13	21	27	53	67	2.8	3.6	4.0	5.3	2.0	4.4
Timula silt loam, 2 to 6 percent slopes	75	105	11	15	22	31	57	78	3.0	4.2	4.5	6.2	2.0	5.0
Timula silt loam, 6 to 12 percent slopes	70	95	10	14	21	28	53	71	2.8	3.8	4.2	5.8	2.0	4.3
Timula-Bold silt loams, 12 to 25 percent slopes	65	80	9	12	-----	21	49	60	2.6	3.2	3.8	4.7	1.5	4.2
Vasa silt loam, 0 to 3 percent slopes	75	115	12	15	22	35	57	86	3.0	4.6	4.5	6.8	2.5	5.3
Waukegan silt loam, 0 to 3 percent slopes	70	100	11	14	21	35	53	75	2.8	4.0	4.0	6.0	2.5	4.6
Whalan silt loam, 1 to 6 percent slopes	70	80	10	12	21	24	53	60	2.8	3.2	4.0	4.3	2.0	3.6
Whalan silt loam, 6 to 12 percent slopes, eroded	60	70	7	10	18	21	49	53	2.4	2.8	3.6	4.0	2.0	3.5
Whalan silt loam, moderately shallow, 1 to 6 percent slopes[4]	-----	65	-----	9	-----	20	-----	49	-----	2.6	-----	3.8	2.0	3.1
Whalan silt loam, moderately shallow, 6 to 12 percent slopes, eroded[4]	-----	60	-----	7	-----	18	-----	45	-----	2.4	-----	3.6	2.0	2.9
Whalan silt loam, moderately shallow, 12 to 18 percent slopes, eroded[4]	-----	50	-----	7	-----	-----	-----	39	-----	2.0	-----	3.0	2.0	2.4
Whalan silt loam, moderately shallow, 18 to 35 percent slopes[2]	-----	-----	-----	-----	-----	-----	-----	-----	-----	2.0	-----	3.0	1.5	-----
Zumbro loamy sand[4]	-----	55	-----	7	-----	16	-----	41	-----	2.2	-----	3.2	1.5	4.0

[1] AUM. Animal-unit-months is a term used to express the carrying capacity of pasture. It is the number of animal units, or 1,000 pound of live weight, that can be grazed on an acre of pasture for a period of 30 days.

[2] These are very steep or flooded soils that have some potential for permanent pasture. They are mostly inaccessible to farm equipment. Special consideration has to be given to control erosion and runoff.

[3] Yields are generally obtainable only after major limitations have been corrected. Very little of this was practical at the time this survey was prepared because the expense involved is considerable.

[4] Supply of moisture is generally too limited for crops during most years, and very few areas are currently cropped. Highest average yields are attainable where favorable moisture supply is available.

[5] Generally these are very steep soils that are subject to erosion. Some cropping could be permitted during reestablishment of permanent vegetation. Estimated yields are given for some of these crops that could be used.

a period when bluegrass and other introduced species tend to go dormant.

Woodland, Windbreaks, and Shelterbelts [2]

This section gives general facts about the woodland in the county. It describes the principal forest cover types, the soil properties that affect the production of trees, and the pests and diseases that affect woodland. It also gives facts about windbreaks and shelterbelts and discusses the woodland groups.

Goodhue County is near the north end of the new Minnesota Memorial Hardwood State Forest, which extends from Hastings in Dakota County to Houston County in the southeastern corner of the State. The forest takes in all of the bluffs along the Mississippi River and extends back from the Mississippi River along the Zumbro and Cannon Rivers and other major tributaries of the Mississippi.

Forest cover types.—Hardwoods make up a large part of the present forest cover in this county, but there are some brushy species. Most of the harvestable timber is red oak, but other valuable hardwoods of high quality that should be managed are black walnut, hard maple, and basswood. According to data by the Office of Iron Range Resources and Rehabilitation, about 64,000 acres of six forest cover types are in this county. About 5,500 acres is northern hardwoods, about 37,700 acres is oaks; about 10,000 acres is bottom-land hardwoods; about 3,400 acres is aspen-birch; about 2,000 acres is grass-upland brush; and about 5,400 acres is lowland brush.

The northern hardwoods cover type is mainly a mixture of red oak, white oak, basswood, hard maple, and American elm and a few black walnut, butternut, and black cherry trees.

The oak cover type is mainly red oak. Secondary species are white oak and bur oak.

The bottom-land hardwood cover type consists mainly of eastern cottonwood, soft maple, and American elm. White willow, basswood, and black ash are minor species.

The aspen-birch cover type is made up of quaking aspen and paper birch.

The upland brush cover type is made up of partly cleared uplands, taken over by sumac, prickly ash, gooseberry, and buckthorn. The areas were formerly covered by oaks or northern hardwoods.

The lowland brush cover type is made up mainly of willows that grow on bottom lands along rivers. The areas were formerly cropland or pasture.

Soil properties that affect the production of trees.—The combinations of species or forest types that grow on a particular area are determined largely by the kinds of soil and by the position of the soils on the landscape. The soils of this county differ greatly in their suitability for trees.

Among the most important factors that affect the capacity of soils for growing trees are optimum soil moisture and soil features that permit the development of an adequate root system. Other significant characteristics are the thickness of the surface layer, the natural supply of plant nutrients, the texture and consistence of the soil material, the aeration, the drainage, and the depth to the water table.

In this county, drainage is an important factor that affects the suitability of a site for trees. The soils have been classified as excessively drained, well drained, moderately well drained, somewhat poorly drained, poorly drained, and very poorly drained. On excessively drained soils, pines are more suitable than hardwoods. On the somewhat poorly drained, poorly drained, and very poorly drained soils, many species of trees do not thrive.

In the steeper areas trees grow better on slopes that face north and east than on slopes that face south and west, because the north- and east-facing slopes are cooler and more moist. The coves are even more desirable for trees.

Woodland pests and diseases.—All wooded areas are subject to insect disease and animal damage. The insects are the defoliators, the leaf miners, and the sucking, twig, and stem borers. Animal pests include mice, moles, gophers, rabbits, and deer. The most serious diseases are Dutch elm disease, oak wilt, and white pine blister rust.

Little relationship can be established between the kinds of soil and the prevalence of insects and diseases. The relationship between the topography and the severity of white pine blister rust is somewhat more evident. Trees at the high elevations, such as trees on upland ridges, appear to be less susceptible to white pine blister rust than soils on valley slopes. Damage caused by pocket gophers is more severe on sandy soils, such as Plainfield and Sparta soils, and on silty soils, such as the Seaton, Mt. Carroll, and Port Byron soils.

Woodland grouping

Management of woodland can be planned more easily if the soils are grouped according to those characteristics that affect the growth of trees and the management of the stand. The soils of the county have been assigned to nine major woodland suitability groups and to subgroups according to slope and aspect.

Each woodland group is made up of soils that have similar suitability for trees and shrubs and are subject to similar hazards and limitations.

The woodland groups in the county are shown in table 3. The table shows, by woodland group, the degree of hazard to management for wood crops, the preferred species for planting, and the site index, or productivity, of the major trees that grow on the soils of each group. More specific and detailed information than can be shown in the table is given in the descriptions of the individual groups of soils. To learn the woodland group to which a particular soil has been assigned, refer to the Guide to Mapping Units.

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 loss is between 25 and 50 percent, *severe* if more than 50 percent.

Plant competition refers to the encroachment of competing vegetation. Competition is *slight* if competing vegetation does not restrict the growth of seedlings. It is *moderate* if plant invaders delay, but do not

[2] Prepared by JOHN HULTGREN, forester, Soil Conservation Service.

TABLE 3.—*Site productivity ratings by woodland suitability group*

Woodland suitability group and aspect	Hazard to management					Preferred species for planting	Productivity	
	Seedling mortality	Plant competition	Erosion hazard	Equipment limitations	Windthrow hazard		Important species	Estimated site index
Group 1:								
0 to 12 percent slopes.	Slight	Severe	Slight	Slight	Slight	Black walnut, red oak, white oak, silver maple, sugar maple, white pine, spruce, Scotch pine.	Black walnut Basswood Red oak Sugar maple Cottonwood Spruce and pine	55–65 65–75 65–75 55–65 85–95 60–70
12 to 35 percent slopes, north- and east-facing.	Slight	Severe	Moderate	Moderate	Slight	Sugar maple, red oak, white pine.	Black walnut Sugar maple Red oak White oak Basswood	50–65 50–65 60–75 60–75 60–75
12 to 35 percent slopes, south- and west-facing.	Slight to moderate.	Severe	Moderate to severe.	Moderate	Slight	Scotch, red Austrian pine, ponderosa pine.	Red oak Bur oak White birch	45–55 45–55 30–40
Group 2	Slight	Severe	Slight	Slight or moderate (seasonal wetness).	Slight	Sugar maple, silver maple, cottonwood, white pine, spruce, red oak.	Ash Basswood Cottonwood Red oak Silver maple Sugar maple	55–65 65–70 80–90 65–70 65–70 55–65
Group 3:								
0 to 12 percent slopes.	Slight to moderate.	Severe	Slight to moderate.	Slight	Slight	Oaks, silver maple, black walnut, red pine, white pine.	Black walnut Basswood Red oak White oak Sugar maple	55–60 55–60 55–70 55–70 50–60
12 to 35 percent slopes, north- and east-facing.	Slight	Severe	Moderate to severe.	Moderate	Slight	Red oak, red pine, white pine, white spruce.	Red oak Aspens Paper birch White oak Walnut Pine	50–70 55–65 45–55 50–70 40–50 50–65
12 to 35 percent slopes, south- and west-facing.	Moderate to severe.	Moderate	Severe	Moderate	Slight	Austrian pine, Scotch pine, ponderosa pine, red pine.	Eastern redcedar Paper birch Bur oak	20–35 35 35
Group 4	Moderate	Slight to moderate.	Slight	Slight	Slight	Jack pine, red pine, ponderosa pine, bur oak.	Eastern redcedar Bur oak Pine	10–30 35–45 45–55
Group 5	Moderate	Slight to moderate.	Moderate or severe.	Moderate	Slight to severe.	Red oak, basswood, white spruce, white pine.	Northern red oak Aspen Birch White oak White pine	45–60 50–60 40–50 45–60 50–60
Group 6	Severe	Slight	Severe	Severe	Slight to severe.	Ponderosa pine, red pine, Austrian pine, jack pine.	Eastern redcedar Red pine Paper birch Bur oak	10–30 40–50 10–35 25–40
Group 7	Slight	Severe	Slight	Slight or moderate.	Moderate	Black walnut, river birch, green ash, silver maple, hackberry, white oak, black spruce, balsam fir.	American elm Green ash Silver maple Cottonwood	55–75 55–60 60–70 80–100
Group 8	Slight	Severe	Slight	Slight	Slight	Black walnut, green ash, white oak, silver maple, balsam fir.	American elm Green ash Silver maple Cottonwood Black walnut White oak	55–65 55–65 65–75 80–100 55–75 55–75

TABLE 3.—*Site productivity ratings by woodland suitability group*—Continued

Woodland suitability group and aspect	Hazard to management					Preferred species for planting	Productivity	
	Seedling mortality	Plant competition	Erosion hazard	Equipment limitations	Windthrow hazard		Important species	Estimated site index
Group 9	Slight	Severe	Slight	Severe	Moderate or severe.	Cottonwood, black spruce, black ash, tamarack, northern white cedar.	Willow Black ash Red maple Cottonwood	20–60 20–60 30–60 60–80

prevent, the establishment of a normal, fully stocked stand of desirable species. Competition is *severe* if grass, brush, or undesired trees prevent adequate regeneration and intensive site preparation and maintenance are needed until desired species are well established.

The hazard of erosion is the degree of soil loss caused by kind or water action. The plant cover, the slope, and soil properties are important factors. The hazard is *slight* if erosion is no problem. It is *moderate* if normal conservation measures are needed to control soil loss. It is *severe* where special measures or restrictions are needed to control soil loss and maintain the level of fertility.

Equipment limitation is *slight* where restrictions are few on the type of equipment or on the time of the year that the equipment can be used. The limitation is *moderate* if the use of equipment is restricted by steep slopes or wetness for more than 3 months or if indiscriminant use of equipment could create soil erosion or damage tree roots. The limitation is *severe* if the use of equipment is restricted or limited more than 6 months per year.

Windthrow hazard refers to soil characteristics that enable trees to resist being blown down by the wind. The hazard is *slight* if most trees withstand the wind; it is *moderate* if some trees are expected to blow down because of high winds and excessive wetness; it is *severe* if many trees are expected to blow down during periods when the soil is wet and winds are moderate or high.

Site index is the height attained in 50 years by the average dominant and codominant trees growing in a relatively even-aged stand. A dominant tree is one that is among the tallest, with its crown well up in the top of the canopy. A codominant tree may not be the tallest, but it has the top of its crown in the upper canopy for sunlight, has some side competition in the upper canopy, and is not suppressed or held back in its height growth. Site index is a term used to reflect the combined effect of different environmental factors and is commonly used by foresters as a measure of stand productivity. Table 4 gives estimated yields of various species by site index for well-stocked, unmanaged, even-aged stands in about a 50-year rotation.

WOODLAND GROUP 1

This group consists of the Bold, Lindstrom, Mt. Carroll, Ostrander, Port Byron, Racine, Seaton, Terril, and Timula soils. These soils are well drained, and they range from medium to moderately coarse in texture. Natural fertility is low to medium. The content of organic matter ranges from low to high. Available water capacity is high or very high, and permeability is moderate.

The soils in this group are on a variety of landscapes over a large percentage of the county, and for this reasons site conditions vary somewhat. The south- or west-facing aspects of the moderately steep to very steep soils have more exposure to the sun than the others. This, in turn, causes more evaporation and keeps the site warmer and drier. The site index is also lower in these areas. The soils in deep coves or ravines have the most nearly ideal growing conditions for hardwoods.

TABLE 4.—*Annual yields per acre for stated kinds of trees by site index*

[Adapted from unpublished data by S. P. Gevorkiantz, North Central Forest Experiment Station. The symbol > means more than; the symbol < means less than]

Annual yield in cords per acre[1]	Site index for—		
	Red pine and white spruce	White pine, upland oaks, ash, elm	Jack pine, northern hardwoods, poplars, and white birch
>0.7	>60	>65	>70
0.6 to 0.7	55	60	65
0.5 to 0.6	50	55	60
<0.5	<45	<50	<55

[1] Trees greater than 6 inches in diameter at breast height.

WOODLAND GROUP 2

This group consists of Joy, Kasson, Klinger, Shullsburg, Skyberg, and Vasa soils. These soils are moderately well drained and somewhat poorly drained. They are medium textured and moderately fine textured. All are wet or have a seasonal water table in the upper 1 foot to 3 feet. Joy, Kasson, and Vasa soils are seasonally wet. Slopes are dominantly 0 to 4 percent, but are as much as 14 percent in the Shullsburg soils. Natural fertility is medium. The content of organic matter is moderate or high. Permeability is moderate to slow.

The soils in this group are well suited to hardwood trees. Most of the acreage, however, is used for cultivated crops.

WOODLAND GROUP 3

This group consists of Alvin, Billett, Copaston, Dakota, Derinda, Dickinson, Dodgeville, Dubuque, Eleva, Fairhaven, Gale, Kegonsa, Schapville, Waukegan, and Whalan soils. These soils are on stream benches and upland ridges. They are dominantly well drained. They are medium textured and moderately coarse textured and are mostly underlain by sand, sand and gravel, or bedrock. Derinda and Schapville soils are underlain by shale. Available water capacity is dominantly moderate, but is low in Eleva soils and ranges to high in Waukegan soils. Permeability is dominantly moderate to moderately rapid, but is slow in Derinda and Schapville soils. The content of organic matter in the surface layer ranges from low to high.

The soils in this group are on a variety of landscapes, and for this reason growing conditions vary. The steeper soils and south- or west-facing aspects in the uplands are poorer sites for trees because their greater exposure to the sun causes them to be drier than other soils. Soils in the deep, narrow ravines in the uplands are good sites for hardwoods because they are protected from wind. Soils on stream benches generally are suitable for trees if they are protected from wind, but sites vary.

WOODLAND GROUP 4

This group consists of somewhat excessively drained and excessively drained, nearly level to moderately steep soils of the Burkhardt, Estherville, Gotham, Lilah, Plainfield, Salida, and Sparta series. These soils are mainly on benches along streams. They are dominantly coarse textured. The upper part of Burkhardt and Estherville soils is medium textured or moderately coarse textured. Available water capacity is low and very low. The content of organic matter is low to moderate. Natural fertility is low.

Most sites are fairly uniform. The best sites are protected from wind. Most areas of the Gotham soils are on foot slopes along north- and east-facing hillsides. These soils have a cooler and moister climate than the other soils in this group. These soils are suitable for hardwoods, such as red oak, hard maple, and basswood.

WOODLAND GROUP 5

This group consists of well-drained, moderately steep to very steep soils of the Dubuque, Frontenac, Marlean, and Whalan series. These soils are on walls of stream valleys or deep upland ravines. They are medium textured. They are shallow or moderately deep over bedrock or its residuum. Natural fertility is medium. The content of organic matter ranges from low to high. Available water capacity is low to moderate.

For the most part, these soils are excellent for hardwoods and have a high site index, especially in narrow ravines or along foot slopes in stream valleys, mainly because they are protected from wind. Most areas are north-facing to east-facing, but some of the ravines face south to west. A large percentage of the native hardwoods growing in this county are on these soils.

WOODLAND GROUP 6

This group consists of well drained, moderately well drained, and excessively drained, moderately steep to very steep soils of the Bellechester, Brodale, Copaston, Schapville, and Sogn series. Brodale, Copaston, and Sogn soils are shallow over bedrock or its residuum and are coarse textured. Schapville soils are fine textured. All are on walls of stream valleys. Most areas face south to west. Slopes are very long and have an elevation difference of 75 to 400 feet. The soils are very warm, dry, and sunny. The content of free lime is mainly high. Natural fertility is low. Available water capacity is low to very low.

WOODLAND GROUP 7

This group consists of the well drained or moderately well drained Chaseburg, McPaul, and Zumbro soils and the well drained to poorly drained Alluvial land, frequently flooded, and Alluvial land, sloping. All but the Zumbro soils are flooded very frequently. All range from medium textured to coarse textured. Available water capacity is low to very high. Fertility is low to medium. The content of organic matter is low to moderate. If a water table occurs, it is typically at a depth of more than 5 feet, except in Alluvial land, frequently flooded.

Uprooting is a hazard because the soil around tree trunks is undermined by channel cutting. This is typical of Alluvial land.

WOODLAND GROUP 8

This group consists of Ankeny, Lawson, and Radford soils. These soils are on flood plains along major streams. They are medium textured and are dominantly moderately well drained or somewhat poorly drained. A water table is generally at a depth of 5 to 7 feet. Available water capacity is very high in the Lawson and Radford soils and is moderate in the Ankeny soils. Fertility is low to medium. Content of organic matter is moderate to high.

WOODLAND GROUP 9

This group consists of Biscay, Bremer, Colo, Canisteo, Garwin, Houghton, Maxfield, and Orion soils and areas of Marsh. These soils are poorly drained and very poorly drained. A seasonal water table is at a depth of 1 foot to 3 feet. Available water capacity is mostly high or very high. The content of organic matter is moderate to very high.

Windbreaks for fields and farmsteads

Farmsteads need protection from wind, especially in winter.

Farmstead windbreaks retard wind velocity and trap

much of the snow before it reaches the farmstead. Many benefits are derived from windbreaks. Fuel savings are substantial, feed consumption by protected livestock is reduced, and living conditions are more pleasant.

Field windbreaks or shelterbelts are needed on some of the soils in the county to control soil blowing and drifting snow. They also conserve moisture and protect crops, livestock, and wildlife. Some of the soils in woodland groups 4 and 5 need this kind of protection. All windbreaks or shelterbelts should be designed to fit the site.

Wildlife[3]

The soils of Goodhue County have the potential to provide habitat for various kinds of species of wildlife. Different soils have different suitabilities for producing various types of habitat components. A distinct interrelationship exists between different types of plants on different soils and the animals associated with these plants. For example, the Seaton soil association has good potential for habitat elements favorable to the deer. The associated soils in this association produce heavy timber stands that deer utilize for browse and escape cover. They also produce high-quality food plants and woody cover needed by deer.

Pheasant populations are fair in the southwestern part of the county on the Maxfield-Klinger, Klinger-Maxfield-Kasson, and Racine-Ostrander-Maxfield associations. Better cover conditions are needed to improve these areas, however.

Waterfowl populations are concentrated along the Mississippi River on the eastern boundary of Goodhue County where an extensive network of marshes, wetlands, and streams occur. Waterfowl mainly inhabit the Marsh-McPaul-Radford association on the Cannon and Mississippi River bottoms.

Numerous upland game and songbirds are distributed throughout the county. For more specific information related to the soil suitabilities for various types of habitat, see table 5.

[3] Prepared by JOHN W. BEDISH, biologist, Soil Conservation Service.

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 steepness of 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 6, 7, and 8, which show, respectively, estimates of soil properties significant in engineering;

[4] THEODORE O. THORSON, engineer, Soil Conservation Service, helped prepare this section.

TABLE 5.—*Suitability of the soil associations for wildlife habitat*

Soil association[1]	Upland game (pheasant and Hungarian partridge)	Waterfowl and furbearers (ducks, mink, beaver, and muskrat)	Small game (squirrels, rabbits)	Big game (deer)	Songbirds (bluebird, field sparrow)
Maxfield-Klinger association	Fair	Fair to poor[2]	Fair	Fair	Good.
Klinger-Maxfield-Kasson association	Fair	Fair to poor[2]	Fair	Fair	Good.
Racine-Ostrander-Maxfield association	Fair to poor	Fair to poor[2]	Fair	Fair	Good.
Seaton association	Good	Poor	Good	Good	Good.
Mt. Carroll-Garwin-Port Byron association	Fair to good	Fair to poor[2]	Fair to good	Fair to good	Good.
Seaton-Racine-Marlean association	Fair	Poor	Fair	Fair	Fair.
Timula-Frontenac association	Fair	Poor	Fair	Fair	Fair.
Seaton-Frontenac-Chaseburg association	Fair	Poor	Fair	Fair	Fair.
Estherville-Waukegan-Alluvial land association	Fair	Fair	Good	Good	Good.
Marsh-McPaul-Radford association	Fair	Good	Fair	Fair	Good.

[1] See general soil map for location.
[2] Poorly and very poorly drained soils have a good potential for wetland development.

TABLE 6.— *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 that may have different
column. The symbol > means

Soil series and map symbols	Depth to—		Depth from surface	USDA texture	Classification	
	Bedrock	Seasonal high water table			Unified	AASHO
	Feet	*Feet*	*Inches*			
Alluvial land:						
Af	>10	1–4				
Few reliable estimates can be made. Material too variable.						
An	>10	>10				
Few reliable estimates can be made. Material too variable.						
Alvin: AvA	>10	>10	0–13	Fine sandy loam	SM	A–4
			13–60	Fine sandy loam	SM or SC	A–4
			60–65	Gravelly coarse loam	SW or SP	A–1
Ankeny: AxA	>10	5–7	0–27	Sandy loam	SM	A–2 or A–4
			27–36	Loam	ML or CL	A–4
			36–60	Loamy sand	SM	A–2–4
			60–70	Coarse sand	SW or SM	A–1–b
Bellechester: BaF	3–6	(3)	0–23	Sand	SP	A–3
			23–42	Sand	SP	A–3
			42	Sandstone bedrock.		
Billett: BbB, BbC	5–10	>10	0–20	Sandy loam	SM or SC	A–2–4
			20–34	Loamy sand	SM	A–2–4
			34–60	Sand	SP or SM	A–3
Biscay: Bc	>10	1–3	0–12	Loam	ML or CL	A–7
			12–30	Clay loam	CL	A–7
			30–60	Gravelly coarse sand	SW or SP	A–1–b
Bold	>10	>10	0–6	Silt loam	ML	A–4
Mapped only with Seaton and Timula soils.			6–60	Silt loam	ML	A–4
Bremer: Bm	>10	1–4	0–15	Silty clay loam	MH	A–7
			15–35	Silty clay loam	CH or CL	A–7
			35–41	Silty clay	MH or CH	A–7
			41–60	Silt loam	CL or ML	A–7
*Brodale: BoE, BoF	4–6½	(3)	0–10	Flaggy loam	SM or SC	A–2 or A–4
For Sogn part, see Sogn series.			10–50	Flaggy sandy loam	SM	A–2
			50	Limestone bedrock.		
Burkhardt: BrA	>10	>10	0–16	Loam	SM or ML	A–4
			16–35	Gravelly coarse sand	SM or SC	A–1
			35–70	Stratified coarse sand and fine gravel.	SP or GW	A–1
Canisteo: Ca	>10	2–4	0–18	Silty clay loam	ML or MH	A–7
			18–29	Silt loam	ML	A–7
			29–50	Sandy loam	SM or SC	A–4 or A–6
			50–60	Loam	CL	A–6
Chaseburg: ChA	>10	>10	0–74	Silt loam	ML	A–4
Colo: Co	>10	1–3	0–30	Silty clay loam	ML, MH, OH, or OL	A–7
			30–60	Silty clay loam	CL or MH	A–7
Copaston:						
CvB, CvC2	1–1½	(3)	0–6	Loam	ML, SC or SM	A–4
			6–16	Loam	SM–SC	A–4
			16	Bedrock.		
CwB, CwC2	2–3	(3)	0–13	Loam	ML	A–4
			13–25	Loam	ML	A–4
			25–32	Sandy clay loam	SC	A–7
			32	Bedrock.		

See footnotes at end of table.

significant in engineering

properties and limitations. For this reason it is necessary to follow carefully the instructions for referring to other series that appear in the first more than; < means less than]

Coarse fraction greater than 3 inches in diameter	Percentage of material less than 3 inches in diameter 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 (042 mm.)	No. 200 (0.074 mm)						
Percent					*Percent*		*Inches per hour*	*Inches per inch of soil*	*pH*	
									6.6–7.8	Low.
									6.6–7.8	Low.
0	95–100	95–100	70–85	40–50	20–30	2–8	2.0–6.0	0.16–0.18	5.6–6.0	Low.
0	95–100	95–100	70–85	40–50	25–35	5–10	0.6–2.0	0.15–0.17	5.6–6.0	Low.
(1)	90–95	70–80	35–50	2–5	(2) NP	NP	6.0–20.0	0.02–0.04	7.4–7.8	Low.
0	98–100	95–100	60–80	25–45	NP	NP	2.0–6.0	0.13–0.15	6.6–7.3	Low.
0	98–100	95–100	90–98	70–80	20–25	2–8	2.0–6.0	0.17–0.19	6.1–6.5	Low.
0	98–100	95–100	60–75	15–30	NP	NP	2.0–6.0	0.08–0.10	6.1–6.5	Low.
0	95–100	95–100	35–50	5–10	NP	NP	6.0–20.0	0.02–0.04	7.4–7.8	Low.
0–6	80–100	80–90	50–70	2–5	NP	NP	6.0–20.0	0.06–0.09	7.4–7.8	Low.
0–10	80–100	80–90	50–70	2–5	NP	NP	6.0–20.0	0.04–0.08	7.4–8.4	Low.
0	95–100	95–100	60–70	25–35	20–30	2–8	2.0–6.0	0.13–0.15	6.1–7.3	Low.
0	90–95	90–95	60–70	15–20	NP	NP	2.0–6.0	0.09–0.11	6.6–7.3	Low.
(1)	85–95	80–90	50–70	5–10	NP	NP	6.0–20.0	0.05–0.07	6.6–7.3	Low.
0	95–100	95–100	70–90	50–60	40–50	10–20	0.6–2.0	0.20–0.22	6.6–7.8	Moderate.
0	98–100	95–100	90–100	70–80	40–50	25–30	0.6–2.0	0.15–0.19	6.6–7.8	Moderate.
(1)	65–90	60–80	20–45	2–5	NP	NP	6.0–20.0	0.02–0.04	7.4–7.8	Low.
0	----------	100	96–100	88–98	25–30	0–4	0.6–2.0	0.20–0.22	7.4–8.4	Low.
0	----------	100	96–100	88–89	20–30	0–3	0.6–2.0	0.20–0.22	7.4–8.4	Low.
0	100	98–100	95–100	85–95	60–65	20–25	0.2–0.6	0.18–0.22	6.1–7.3	High.
0	100	98–100	95–100	85–95	45–55	20–25	0.2–0.6	0.16–0.19	6.1–6.5	High.
0	----------	100	98–100	95–98	50–65	25–35	0.2–0.6	0.11–0.15	6.1–6.5	High.
0	----------	100	98–100	95–98	40–50	18–25	0.2–0.6	0.16–0.18	6.6–7.3	High.
45–70	65–85	60–80	55–75	30–45	10–40	0–15	0.6–2.0	0.06–0.12	7.4–8.4	Low.
40–70	65–85	60–80	55–75	20–35	10–30	0–10	0.6–2.0	0.04–0.09	7.9–8.4	Low.
0	85–100	75–100	50–60	35–55	20–30	5–10	2.0–6.0	0.13–0.20	6.6–7.3	Low.
0	50–80	40–75	20–50	5–15	NP	NP	6.0–20.0	0.03–0.05	6.6–7.3	Low.
0	35–70	30–60	15–30	0–5	NP	NP	6.0–20.0	0.02–0.04	7.4–7.8	Low.
0	98–100	95–100	85–98	70–80	45–55	15–20	0.6–2.0	0.18–0.22	7.4–7.8	Moderate.
0	98–100	95–100	90–100	70–90	40–50	12–18	0.6–2.0	0.20–0.22	7.4–7.8	Moderate.
(1)	90–100	75–95	60–70	35–45	25–30	5–15	2.0–6.0	0.11–0.14	7.4–7.8	Moderate.
(1)	95–100	90–98	80–95	60–75	35–40	12–20	0.6–2.0	0.12–0.19	7.4–7.8	Moderate.
0	----------	100	98–100	95–100	NP	NP	0.6–2.0	0.20–0.24	6.6–7.3	Low.
0	----------	100	98–100	95–100	40–60	15–20	0.2–0.6	0.16–0.22	6.6–7.3	High.
0	----------	100	95–100	90–100	45–60	20–30	0.2–0.6	0.16–0.19	6.6–7.3	High.
0–5	90–100	90–100	60–75	45–55	25–40	4–10	0.6–2.0	0.20–0.22	5.6–6.0	Low.
0–5	90–100	90–100	50–70	35–50	20–30	2–8	0.6–2.0	0.17–0.19	6.1–7.3	Low.
0	95–100	90–100	75–85	50–60	25–30	2–4	0.6–2.0	0.20–0.22	6.6–7.3	Moderate.
0–5	95–100	90–100	75–85	50–60	25–30	3–6	0.6–2.0	0.17–0.19	6.1–6.5	Moderate.
0–5	95–100	95–100	80–90	40–45	40–50	18–25	0.6–2.0	0.16–0.18	6.1–6.5	Moderate.

TABLE 6.— *Estimated soil properties*

Soil series and map symbols	Depth to—		Depth from surface	USDA texture	Classification	
	Bedrock	Seasonal high water table			Unified	AASHO
	Feet	*Feet*	*Inches*			
Dakota: DaA	>10	>10	0–27	Loam	CL or ML	A–6 or A–4
			27–35	Sandy loam	SM or SC	A–4
			35–45	Sand, with loamy sand bands.	SM	A–2–4
			45–60	Gravelly coarse sand	SP	A–1
Derinda: DeC2, DeD2	2–3	(3)	0–7	Silt loam	ML	A–4
			7–19	Silt loam	CL or MH	A–6 or A–7
			19–24	Silty clay loam	CH	A–7
			24–45	Clay (shale)	CH or MH	A–7
Dickinson DkA, DkB, DkC	>10	>10	0–18	Fine sandy loam	SM	A–2–4 or A–4
			18–32	Fine sandy loam	SM	A–2–4
			32–60	Sand	SM or SP	A–2–4 or A–3
Dodgeville: DoB, DoC2	2–3	(3)	0–9	Silt loam	ML	A–4
			9–24	Silt loam	CL	A–6
			24–29	Clay	CL or CH	A–7
			29	Bedrock.		
Dubuque: DuB2, DuC2, DuD2, DuF.	2–3	(3)	0–14	Silt loam	ML	A–4
			14–28	Silt loam	CL	A–6
			28–32	Sandy clay	CH	A–7
			32	Bedrock.		
Eleva: EeB, EeD	3	(3)	0–9	Sandy loam	SM	A–2–4 or A–4
			9–27	Sandy loam	SM–SC	A–2–4 or A–4
			27–37	Fine sand	SM	A–2–4
			37	Sandstone bedrock.		
Estherville: EsA, EsC	>10	>10	0–8	Loam	SM	A–4
			8–22	Sandy loam	SM	A–2–4
			22–45	Gravelly coarse sand	SP or SM	A–1
			45–80	Gravelly sand	GW, SW, or SP	A–1
Fairhaven: FaA	>10	>10	0–22	Silt loam	ML	A–4
			22–33	Loam	ML	A–4
			33–60	Gravelly coarse sand	SW or SP	A–1
Frontenac: FrE, FrF	5–15	(3)	0–12	Silt loam	ML	A–4
			12–30	Silt loam	ML	A–4
			30–120	Channery or cobbly flaggy loam.	SC or SM	A–4
Gale: GaA	2–3	(3)	0–11	Silt loam	ML	A–4
			11–38	Silt loam	ML	A–4 or A–6
			38–60	Fine sand and sandstone	SP	A–3
Garwin: Gm, Gr	>10	1–3	0–14	Silty clay loam	MH	A–7
			14–20	Silty clay loam	CL	A–7
			20–86	Silt loam	ML	A–4
Gotham: GtB, GtD	5–10	>10	0–36	Fine sand	SM	A–2–4
			36–43	Loamy fine sand	SM or SC	A–4
			43–60	Sand	SP or SM	A–2–4
Houghton: Ho, Hs	>10	1–3	0–72	Muck (sapric material)	Pt	A–8
Joy: JoA	>10	>10	0–11	Silt loam	ML	A–4
			11–33	Silt loam	CL	A–7 or A–6
			33–63	Silt loam	ML	A–4
			63–70	Loam	CL	A–6
Kasson: KaA	>10	>10	0–9	Silt loam	ML	A–4
			9–20	Silty clay loam	CL	A–6 or A–7
			20–70	Loam	CL	A–6

See footnotes at end of table.

significant in engineering—Continued

Coarse fraction greater than 3 inches in diameter	Percentage of material less than 3 inches in diameter 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)						
Percent					*Percent*		*Inches per hour*	*Inches per inch of soil*	*pH*	
0	98–100	95–100	85–95	50–65	25–35	8–12	2.0–6.0	0.19–0.22	5.6–6.0	Moderate.
0	95–100	90–95	85–95	40–50	20–30	2–8	2.0–6.0	0.14–0.16	5.1–5.5	Low.
0	90–95	85–90	60–75	25–35	15–30	2–6	2.0–6.0	0.05–0.07	1.6–6.0	Low.
(1)	80–95	60–90	30–50	2–5	NP	NP	6.0–20.0	0.02–0.04	7.9–8.4	Low.
0	----------	----------	100	98–100	33–40	7–10	0.6–2.0	0.22–0.24	5.6–6.0	Moderate.
0	----------	----------	100	98–100	35–42	12–20	0.6–2.0	0.20–0.22	5.6–6.0	Moderate.
0	100	100	98–100	95–100	50–55	25–30	0.2–0.6	0.13–0.16	5.6–6.0	High.
(1)	100	90–100	85–90	80–90	65–70	35–40	0.06–0.2	0.10–0.14	5.6–6.0	High.
0	98–100	95–100	75–85	20–45	NP	NP	2.0–6.0	0.16–0.18	5.6–6.0	Low.
0	98–100	95–100	75–85	20–35	NP	NP	2.0–6.0	0.15–0.17	5.6–6.0	Low.
0	98–100	90–100	70–80	5–15	NP	NP	6.0–20.0	0.05–0.07	5.6–6.0	Low.
0	----------	100	98–100	90–100	25–35	3–6	0.6–2.0	0.20–0.22	6.1–6.5	Moderate.
0	----------	100	98–100	90–100	30–40	12–20	0.6–2.0	0.20–0.22	6.1–6.5	Moderate.
0–10	90–100	90–100	90–100	75–90	40–55	20–30	0.2–0.6	0.10–0.14	7.4–7.8	High.
0	----------	100	98–100	95–100	30–35	6–10	0.6–2.0	0.22–0.24	5.6–6.0	Moderate.
0	----------	100	98–100	95–100	35–40	12–18	0.6–2.0	0.20–0.22	5.1–5.5	Moderate.
0–10	90–100	80–90	85–90	50–60	50–60	30–35	0.2–0.6	0.16–0.19	5.6–6.0	High.
0	95–100	95–100	85–95	30–45	NP	NP	2.0–6.0	0.16–0.18	5.6–6.0	Low.
0	95–100	95–100	85–95	30–45	20–30	2–8	2.0–6.0	0.15–0.17	5.6–6.0	Low.
0	95–100	95–100	80–90	20–35	NP	NP	2.0–6.0	0.06–0.08	5.1–5.5	Low.
0	90–100	80–90	50–70	35–45	25–40	5–10	2.0–6.0	0.20–0.22	5.6–6.0	Low.
0	85–95	80–90	45–65	25–35	20–25	2–6	6.0–20.0	0.12–0.14	5.6–6.0	Low.
(1)	70–80	65–75	30–40	5–15	NP	NP	5.0–20.0	0.03–0.05	6.6–7.8	Low.
5–25	35–80	30–70	20–30	2–5	NP	NP	6.0–20.0	0.02–0.04	7.4–7.8	Low.
0	98–100	98–100	90–100	70–90	25–35	4–8	2.0–6.0	0.22–0.24	5.6–7.3	Moderate.
(1)	90–95	85–95	70–80	50–60	25–40	4–10	2.0–6.0	0.17–0.19	5.1–5.5	Moderate.
7–30	60–75	50–70	15–30	2–5	NP	NP	6.0–20.0	0.02–0.04	5.6–6.0	Low.
0	98–100	90–100	70–100	60–90	30–40	5–10	0.6–2.0	0.20–0.24	6.1–7.3	Low.
0	98–100	90–100	70–100	60–90	30–40	5–10	0.6–2.0	0.17–0.22	6.1–6.5	Low.
40–70	65–85	60–80	55–75	35–50	30–40	5–10	2.0–6.0	0.04–0.10	7.4–7.8	Low.
0	----------	100	98–100	90–98	NP	NP	0.6–2.0	0.22–0.24	6.1–7.3	Low.
0	----------	100	98–100	90–98	30–40	6–12	0.6–2.0	0.20–0.22	5.1–5.5	Moderate.
(1)	95–100	95–100	80–90	1–5	NP	NP	2.0–6.0	0.05–0.07	5.6–6.0	Low.
0	----------	----------	100	95–100	55–65	20–25	0.2–0.6	0.18–0.22	6.6–7.8	High.
0	----------	----------	100	95–100	40–50	20–25	0.2–0.6	0.16–0.19	6.6–7.3	High.
0	----------	----------	98–100	95–100	25–30	2–6	0.6–2.0	0.20–0.22	6.6–7.8	Moderate.
0	100	98–100	55–65	20–30	NP	NP	6.0–20.0	0.07–0.09	5.1–5.5	Low.
0	100	98–100	60–70	40–50	15–25	4–7	6.0–20.0	0.09–0.11	5.1–5.5	Low.
0	100	98–100	50–60	5–15	NP	NP	6.0–20.0	0.05–0.07	5.6–6.0	Low.
0	----------	----------	----------	----------	----------	----------	2.0–6.0	0.35–0.48	7.4–7.8	Low.
0	----------	----------	98–100	98–100	30–40	5–10	0.6–2.0	0.22–0.24	6.1–7.3	Moderate.
0	100	98–100	95–100	90–95	35–45	15–20	0.6–2.0	0.20–0.22	6.6–7.3	Moderate.
0	100	98–100	95–100	85–95	25–30	2–6	0.6–2.0	0.20–0.22	7.4–7.8	Moderate.
(1)	95–100	90–95	70–80	55–65	28–36	12–17	0.2–0.6	0.17–0.19	7.4–7.8	Moderate.
0	----------	100	95–100	80–95	35–40	5–10	0.6–2.0	0.22–0.24	6.1–6.5	Moderate.
0	100	98–100	92–98	80–95	35–45	15–25	0.6–2.0	0.16–0.19	5.1–6.0	Moderate.
(1)	95–100	90–100	85–95	65–80	25–35	10–15	0.2–0.6	0.17–0.19	5.1–7.8	Moderate.

TABLE 6.— *Estimated soil properties*

Soil series and map symbols	Depth to—		Depth from surface	USDA texture	Classification	
	Bedrock	Seasonal high water table			Unified	AASHO
	Feet	*Feet*	*Inches*			
*Kegonsa: KeA, KfD For Fairhaven part of KfD, see Fairhaven series.	>10	>10	0–21 21–29 29–41 41–65	Silt loam Silty clay loam Sandy loam Gravelly coarse sand	ML CL or ML SC SW or SM	A–4 A–6 A–2 A–1
Klinger: KnA	>10	1–3	0–10 10–25 25–60	Silty clay loam Silty clay loam Loam	ML or CL ML or CL CL	A–7 A–7 A–6
Lawson: La	>10	5–7	0–28 28–60	Silt loam Silt loam	ML CL	A–4 A–7
Lilah: LlA, LlD	>10	>10	0–7 7–20 20–65	Sandy loam Loamy coarse sand Gravelly coarse sand	SM SM SW or SP	A–2–4 A–2–4 A–1–b
Lindstrom: LnB, LnC, LnD	>10	>10	0–29 29–60 60–70	Silt loam Silt loam Loam	ML ML ML	A–4 A–4 or A–6 A–4
Marlean: MaE, MaF	4–10	(3)	0–12 12–60	Silt loam Flaggy sandy loam	ML SM	A–4 A–2
Marsh: Md No reliable estimates can be made. Material too variable.		0–3				
Maxfield: Mf, Mo	>10	1–3	0–16 16–34 34–70	Silty clay loam Silt loam Loam	MH CL CL	A–7 A–7 A–6
McPaul: Mp	>10	5–7	0–30 30–58	Silt loam Loam and silt loam	ML ML	A–4 A–4
Mt. Carroll: MrA, MrB, MrC2	>10	>10	0–12 12–33 33–83	Silt loam Silt loam Silt loam	ML ML or CL ML	A–4 A–4 or A–6 A–4
MxA	>10	>10	0–9 9–48 48–60	Silt loam Silt loam Sand	ML ML or CL SP or SM	A–4 A–4 or A–6 A–2–4
Orion: Or	>10	1–3	0–26 26–60	Silt loam Silt loam	ML CL	A–4 A–7
Ostrander: OtB, OtC2	>10	>10	0–15 15–41 41–65	Silt loam Loam Loam	ML CL or ML ML or CL	A–4 A–6 A–6
Plainfield: PaB, PaD	>10	>10	0–5 5–65	Loamy sand Sand	SM SP or SM	A–2–4 A–2–4 or A–3
Port Byron: PbA, PbB, PbC2	>10	>10	0–19 19–40 40–65	Silt loam Silt loam Silt loam	ML ML or CL ML	A–4 A–6 or A–4 A–4
PoA	>10	>10	0–18 18–58 58–65	Silt loam Silt loam Sand	ML ML or CL SP or SM	A–4 A–6 A–2–4
Racine: RaB, RaC, RaC2, RaD2, RaE.	>10	>10	0–11 11–23 23–60	Silt loam Silt loam Loam	ML ML or CL CL, SC, SM, or ML	A–4 A–6 A–6 or A–4

See footnotes at end of table.

significant in engineering—Continued

Coarse fraction greater than 3 inches in diameter	Percentage of material less than 3 inches in diameter 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)						
Percent					*Percent*		*Inches per hour*	*Inches per inch of soil*	*pH*	
0	100	98–100	90–95	80–85	30–40	5–10	0.6–2.0	0.22–0.24	5.6–6.5	Moderate.
0	----------	100	98–100	85–95	30–40	10–15	0.6–2.0	0.16–0.18	5.1–5.5	Moderate.
0	98–100	75–85	60–70	25–35	20–25	7–12	2.0–6.0	0.11–0.13	5.1–5.5	Low.
(1)	85–90	60–70	25–30	5–10	NP	NP	6.0–20.0	0.02–0.04	6.6–7.8	Low.
0	----------	----------	100	95–100	40–50	10–20	0.6–2.0	0.18–0.22	5.6–6.5	Moderate.
0	----------	100	98–100	92–100	40–50	10–20	0.6–2.0	0.16–0.19	5.1–5.5	Moderate.
0	98–100	96–98	90–95	65–70	30–35	12–20	0.2–0.6	0.17–0.19	6.6–7.8	Moderate.
0	----------	----------	98–100	98–100	30–40	5–10	0.6–2.0	0.22–0.24	6.6–7.3	Moderate.
0	100	98–100	95–100	90–100	40–45	15–20	0.6–2.0	0.20–0.22	6.6–7.8	Moderate.
0	95–100	90–95	55–65	25–35	20–25	2–4	2.0–6.0	0.13–0.15	6.1–6.5	Low.
0	95–100	85–95	40–60	10–20	NP	NP	6.0–>20.0	0.09–0.11	5.6–6.5	Low.
5–10	90–95	75–85	35–45	2–5	NP	NP	6.0–>20.0	0.02–0.04	5.6–7.8	Low.
0	----------	100	98–100	90–95	34–40	5–10	0.6–2.0	0.22–0.24	5.6–6.5	Moderate.
0	----------	100	98–100	90–95	35–40	9–13	0.6–2.0	0.20–0.22	5.6–6.5	Moderate.
0	100	95–100	75–85	50–60	25–28	0–4	0.6–2.0	0.20–0.22	6.6–7.8	Moderate.
0	98–100	95–100	85–90	80–90	35–40	5–10	2.0–6.0	0.22–0.24	7.4–7.8	Low.
50–70	65–85	60–80	55–75	30–35	20–25	2–4	6.0–20.0	0.06–0.08	7.4–8.4	Low.
0	100	98–100	95–100	89–95	60–65	20–25	0.6–2.0	0.18–0.22	6.6–7.3	High.
0	100	98–100	98–100	92–95	40–45	20–23	0.6–2.0	0.20–0.22	7.4–7.8	Moderate.
0	98–100	90–95	85–90	55–60	30–35	12–17	0.2–0.6	0.17–0.19	7.4–7.8	Moderate.
0	----------	----------	100	98–100	NP	NP	0.6–2.0	0.20–0.24	7.4–7.8	Moderate.
0	----------	100	90–100	85–95	NP	NP	0.6–2.0	0.17–0.19	7.4–7.8	Moderate.
0	----------	100	98–100	98–100	30–40	5–10	0.6–2.0	0.22–0.24	5.6–7.3	Moderate.
0	----------	100	98–100	93–100	30–40	5–15	0.6–2.0	0.20–0.22	5.6–6.0	Moderate.
0	----------	100	98–100	75–100	25–35	0–5	0.6–2.0	0.20–0.22	5.6–7.8	Moderate.
0	----------	100	98–100	98–100	30–40	5–10	0.6–2.0	0.22–0.24	5.6–7.3	Moderate.
0	----------	100	95–100	95–100	30–40	5–15	0.6–2.0	0.20–0.22	5.6–6.0	Moderate.
0	98–100	90–100	70–80	5–12	NP	NP	6.0–20.0	0.05–0.07	5.6–6.0	Low.
0	----------	100	98–100	95–100	25–35	0–5	0.6–2.0	0.22–0.24	7.4–7.8	Low.
0	----------	100	95–100	90–100	40–45	20–25	0.6–2.0	0.22–0.24	7.4–7.8	Moderate.
0	----------	100	94–98	70–80	30–35	6–9	0.6–2.0	0.21–0.24	6.1–7.3	Moderate.
0	98–100	92–96	87–95	55–65	35–40	10–20	0.6–2.0	0.17–0.19	5.6–6.5	Moderate.
0	98–100	94–97	80–85	50–60	20–40	10–20	0.6–2.0	0.17–0.19	7.4–7.8	Moderate.
0	----------	100	55–85	5–20	NP	NP	6.0–20.0	0.10–0.12	5.1–5.5	Low.
0	100	98–100	50–80	0–15	NP	NP	6.0–20.0	0.05–0.08	5.6–7.3	Low.
0	----------	100	98–100	95–100	30–35	5–10	0.6–2.0	0.20–0.24	5.6–7.3	Low.
0	----------	100	98–100	95–100	35–40	5–15	0.6–2.0	0.20–0.22	5.6–6.5	Low.
0	----------	100	78–100	88–95	30–35	5–10	0.6–2.0	0.20–0.22	6.6–7.8	Low.
0	----------	100	98–100	95–100	30–35	5–10	0.6–2.0	0.22–0.24	5.6–7.3	Low.
0	----------	100	98–100	95–100	30–40	10–15	0.6–2.0	0.20–0.22	5.6–6.5	Low.
0	98–100	90–100	70–80	0–15	NP	NP	6.0–20.0	0.05–0.07	6.1–6.5	Low.
0	100	98–100	90–95	70–85	30–35	5–10	0.6–2.0	0.22–0.24	6.1–7.3	Moderate.
0	100	98–100	90–95	75–85	35–40	10–15	0.6–2.0	0.20–0.22	5.1–6.0	Moderate.
(1)	85–100	80–98	70–85	45–65	25–40	6–20	0.6–2.0	0.17–0.19	5.1–7.8	Moderate.

TABLE 6.— *Estimated soil properties*

Soil series and map symbols	Depth to—		Depth from surface	USDA texture	Classification	
	Bedrock	Seasonal high water table			Unified	AASHO
	Feet	*Feet*	*Inches*			
Radford: Rd	>10	5–7	0–26	Silt loam	ML	A–4
			26–60	Silt loam	CL	A–6
Salida: SaB, SaE	>10	>10	0–8	Gravelly loamy coarse sand.	SM	A–2–4 or A–1
			8–38	Gravelly coarse sand	SW–SM	A–1
			38–60	Gravel	SW or GW	A–1
*Schapville: ScC, ScD, SdE. For Sogn part of SdE, see Sogn series.	2–4	(3)	0–8	Silty clay loam	ML or CL	A–5 or A–7
			8–14	Silty clay	MH or ML	A–7
			14–45	Clay (shale)	MH or CH	A–7
*Seaton: SfA, SfB, SfC2, SfD2, SfE, ShC2, ShD2, ShE, SkC2, SkD2, SlE. For Kegonsa or Lilah part of SkC2 or SkD2, see Kegonsa series or Lilah series. For Bold or Timula part of SlE, see Bold series or Timula series.	>10	>10	0–18	Silt loam	ML	A–4
			18–45	Silt loam	CL	A–6
			45–70	Silt loam	ML or CL	A–4
Shullsburg: SmC	3–4	(3)	0–13	Silty clay loam	MH or OH	A–7
			13–50	Clay	MH or CH	A–7
			50–60	Shale (soft)	MH or CH	A–7
Skyberg: Sn	>10	1–3	0–12	Silt loam	ML or CL	A–4 or A–6
			12–22	Silty clay loam	CL	A–6 or A–7
			22–66	Loam	CL	A–6
*Sogn: SoD. For Copaston part of SoD, see CvB and CvC2 in Copaston series.	1–1½	(3)	0–6	Flaggy loam	SM or SC	A–4
			6–16	Flaggy loam	SC or CL	A–6
			16	Limestone.		
Sparta: SpA	>10	>10	0–19	Loamy sand	SM	A–2–4
			19–60	Coarse sand	SM or SP	A–2–4 or A–3
Terril: TeB, TeC, TeD	5–10	>10	0–10	Sandy loam	SM	A–2–4
			10–28	Loam	CL	A–6
			28–34	Clay loam	CL	A–6 or A–7
			34–68	Sandy loam	SM or SC	A–4
			68–70	Fine sand	SM	A–2–4
*Timula: TmB, TmC, ToD. For Bold part of ToD, see Bold series.	>10	>10	0–12	Silt loam	ML	A–4
			12–103	Silt loam	ML	A–4
Vasa: VaA	>10	>10	0–13	Silt loam	ML	A–4
			13–42	Silt loam	CL	A–6
			42–60	Loam	ML	A–4
			60–65	Loam	CL	A–6
Waukegan: WaA	>10	>10	0–13	Silt loam	ML	A–4
			13–33	Silt loam	CL or ML	A–6
			33–50	Gravelly coarse sand	SW or SP	A–1
Whalan: WhB, WhC2, WsB, WsC2, WsD2, WsE.	1½–3½	(3)	0–9	Silt loam	ML	A–4
			9–22	Silt loam	ML or CL	A–6
			22–38	Loam	CL	A–6
			38	Bedrock.		
Zumbro: Zu	>10	5–10	0–50	Loamy sand	SM	A–2–4
			50–60	Sand	SP or SM	A–2–4 or A–3

[1] Trace.
[2] NP = Nonplastic.
[3] Water table in bedrock.

significant in engineering—Continued

Coarse fraction greater than 3 inches in diameter	Percentage of material less than 3 inches in diameter 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)						
Percent					*Percent*		*Inches per hour*	*Inches per inch of soil*	*pH*	
0	----------	----------	100	95–100	25–30	2–4	0.6–2.0	0.22–0.24	6.6–7.3	Moderate.
0	----------	----------	100	95–98	30–35	10 15	0.6–2.0	0.20–0.22	6.6–7.3	Moderate.
(1)	80–90	65–80	30–55	12–20	NP	NP	>20.0	0.07–0.09	7.4–7.8	Low.
(1)	70–80	65–70	30–40	5–15	NP	NP	>20.0	0.03–0.05	7.4–7.8	Low.
15–40	40–60	35–50	20–30	2–5	NP	NP	>20.0	0.02–0.04	7.4–7.8	Low.
0	100	98–100	95–98	70–75	40–45	8–15	0.06–0.20	0.18–0.22	6.1–6.5	High.
0	100	95–100	85–98	60–80	40–60	20–30	0.06–0.20	0.16–0.19	6.1–6.5	High.
0	----------	100	97–100	90–95	60–80	30–40	0.06–0.20	0.10–0.14	6.1–8.4	High.
0	----------	----------	100	98–100	30–40	5–10	0.6–2.0	0.22–0.24	5.6–6.5	Low.
0	----------	----------	100	98–100	30–40	10–20	0.6–2.0	0.20–0.22	5.1–5.5	Moderate.
0	----------	----------	98–100	95–100	25–35	4–9	0.6–2.0	0.20–0.22	6.1–7.8	Low.
0	100	98–100	90–95	65–70	50–55	15–20	0.2–0.6	0.18–0.22	5.1–5.5	High.
0	100	98–100	97–100	80–85	55–60	25–30	0.06–0.20	0.10–0.14	5.1–6.0	High.
0	----------	98–100	97–100	90–95	60–80	30–40	0.06–0.20	0.09–0.13	7.4–7.8	High.
0	----------	100	98–100	95–100	30–40	8–15	0.6–2.0	0.22–0.24	5.1–6.5	Moderate.
0	----------	100	98–100	95–100	35–45	20–25	0.6–2.0	0.20–0.22	5.1–5.5	Moderate.
0	95–100	90–100	82–88	60–70	25–35	15–20	0.2–0.6	0.17–0.19	5.1–7.8	Moderate.
20–30	45–70	65–85	60–80	35–50	20–40	5–10	0.6–2.0	0.08–0.12	7.9–8.4	Low.
40–70	45–70	65–85	60–80	40–55	30–40	10–15	0.6–2.0	0.06–0.12	7.9–8.4	Low.
0	98–100	90–100	70–80	20–25	NP	NP	2.0–6.0	0.07–0.09	5.1–5.5	Low.
0	95–100	85–90	40–60	5–10	NP	NP	>20.0	0.02–0.05	5.6–6.0	Low.
0	95–100	90–95	55–65	25–30	20–30	2–4	2.0–6.0	0.13–0.15	6.1–6.5	Low.
0	100	98–100	80–90	50–55	25–35	10–15	0.6–2.0	0.17–0.19	5.6–6.0	Low.
0	100	98–100	95–100	90–95	35–45	15–20	0.6–2.0	0.20–0.22	5.6–6.0	Moderate.
0	95–100	85–90	45–65	15–30	20–30	2–8	0.6–2.0	0.11–0.16	5.6–6.0	Low.
0	95–100	90–95	80–90	10–20	NP	NP	2.0–6.0	0.05–0.07	5.6–6.0	Low.
0	----------	100	99–100	98–100	NP	NP	0.6–2.0	0.22–0.24	6.6–7.3	Low.
0	----------	100	99–100	95–100	NP	NP	0.6–2.0	0.20–0.22	6.6–7.8	Low.
0	----------	100	100	95–100	32–38	5–10	0.6–2.0	0.22–0.24	6.6–7.3	Low.
0	----------	100	100	95–100	35–40	12–17	0.6–2.0	0.20–0.22	6.1–7.3	Moderate.
0	100	98–100	85–95	75–85	25–30	3–6	0.6–2.0	0.20–0.22	6.6–7.3	Low.
0	90–100	90–95	70–90	55–75	25–40	10–20	0.2–0.6	0.17–0.19	6.6–7.3	Moderate.
----------	----------	100	95–100	85–95	30–35	5–10	0.6–2.0	0.22–0.24	6.1–6.5	Low.
----------	----------	100	95–100	85–95	30–40	10–15	0.6–2.0	0.20–0.22	6.1–6.5	Low.
(1)	80–90	70–80	40–50	3–10	NP	NP	6.0–20.0	0.03–0.06	6.6–7.8	Low.
----------	100	98–100	96–98	70–75	30–35	5–10	0.6–2.0	0.22–0.24	5.6–6.5	Moderate.
----------	100	98–100	96–98	75–80	30–40	10–15	0.6–2.0	0.20–0.22	5.1–5.5	Moderate.
(1)	95–100	95–98	70–75	55–65	25–30	10–15	0.6–2.0	0.17–0.19	5.1–5.5	Moderate.
----------	90–100	90–100	60–90	15–30	NP	NP	6.0–20.0	0.10–0.12	6.6–7.8	Low.
----------	80–100	70–90	50–70	5–15	NP	NP	6.0–20.0	0.06–0.08	6.6–7.8	Low.

TABLE 7.—*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 that may have in the

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption field	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill[1]	Local roads and streets
Alluvial land: 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.
An	Severe: subject to flooding.[2]	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.
Alvin: AvA	Slight[2]	Severe: rapid permeability in substratum.	Slight	Slight	Severe: rapid permeability in substratum.	Moderate: highly erodible in deep cuts.
Ankeny: AxA	Severe: subject to flooding.[2]	Severe: moderately rapid permeability.	Severe: subject to occasional flooding.	Severe: subject to occasional flooding.	Severe: rapid permeability in substratum; subject to occasional flooding.	Moderate: subject to occasional flooding; medium shear strength.
Bellechester: BaF	Severe: very steep slopes; bedrock at depth of 40 to 70 inches.	Severe: very steep slopes; bedrock at depth of 40 to 70 inches.	Severe: very steep slopes; bedrock at depth of 40 to 70 inches.	Severe: very steep slopes; bedrock at depth of 40 to 70 inches.	Severe: very steep slopes; bedrock at depth of 40 to 70 inches.	Severe: very steep slopes; bedrock at depth of 40 to 70 inches.
Billett: BbB	Moderate: bedrock at depth of 5 to 10 feet.	Severe: rapid permeability in substratum.	Slight	Slight	Severe: moderately rapid permeability, rapid in substratum; limestone bedrock in lower part of substratum.	Slight
BbC	Moderate: slope; bedrock at depth of 5 to 10 feet.[2]	Severe: slopes; rapid permeability in substratum.	Moderate: slope.	Moderate: slope.	Severe: moderately rapid permeability; rapid permeability below depth of 3 feet; limestone bedrock in lower part of substratum.	Moderate: slope.
Biscay: Bc	Severe: seasonally high water table at depth of 1 foot to 3 feet.	Severe: seasonally high water table at depth of 1 foot to 3 feet; rapid permeability in substratum.	Severe: seasonally high water table at depth of 1 foot to 3 feet.	Severe: seasonally high water table at depth of 1 foot to 3 feet.	Severe: seasonally high water table.	Severe: seasonally high water table; high susceptibility to frost action.

See footnotes at end of table.

interpretations of soils

different properties and limitations. For this reason it is necessary to follow carefully the instructions for referring to other series that appear first column]

Suitability as source of—			Soil features affecting—				
Road fill	Sand	Topsoil	Pond reservoir areas	Embankments, dikes and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Poor to fair: variable; needs onsite inspection.	Unsuited	Fair to poor: variable; needs onsite inspection.	Subject to flooding.	Variable	Outlets are difficult to obtain; needs surface drainage; subject to flooding.	Variable; subject to flooding.	Subject to flooding; nearly level.
Poor to fair: variable; needs onsite inspection.	Fair: needs onsite inspection.	Fair to poor: variable; needs onsite inspection.	Possible site of pit pond; rapid permeability.	Medium to high permeability when compacted; piping hazard; fair to good compaction characteristics.	Well drained	Subject to flooding.	Subject to flooding.
Fair to good	Good: 4 feet overburden.	Fair: thin surface layer.	Rapid permeability in substratum.	Fair compaction characteristics; medium to high permeability when compacted.	Well drained	Moderate to high available water capacity.	Nearly level.
Fair to good: fair compaction characteristics.	Fair: amount and quality need to be evaluated.	Good	Water table at depth of 5 to 7 feet; moderately rapid permeability.	Fair to good compaction characteristics; high permeability when compacted.	Well drained	Moderate available water capacity.	Nearly level.
Poor: poor compaction characteristics; bedrock at depth of 40 to 70 inches; very steep slopes.	Poor to fair: sandstone bedrock at depth of 40 to 70 inches; very steep slopes.	Poor: sandy topsoil; very steep slopes.	Rapid permeability on foot slopes; sandstone bedrock at depth of 40 to 70 inches.	Very steep slopes; high permeability when compacted; medium to high susceptibility to piping.	Excessively drained.	Slopes too steep in most places.	Slopes too steep in most places.
Good	Good: needs onsite inspection.	Fair: thin surface layer.	Moderately rapid permeability.	High compacted permeability; fair compaction characteristics.	Well drained	Low and moderate available water capacity.	Sand at depth of 30 to 40 inches; moderately rapid permeability.
Good	Good	Fair: slopes; thin surface layer.	Moderately rapid permeability.	High compacted permeability; fair compaction characteristics.	Well drained	Low and moderate available water capacity.	Sand at depth of 30 to 40 inches; moderately rapid permeability.
Fair: seasonally high water table; moderate shrink-swell potential.	Good: seasonally high water table; quantity and quality of sand variable.	Poor: seasonally high water table.	Seasonally high water table; rapid permeability in substratum.	Medium to low compacted permeability in upper material; fair compaction characteristics; gravelly sand substratum.	Seasonally high water table at depth of 1 foot to 3 feet; rapid permeability in substratum; sloughing and caving hazard.	Poorly drained; moderate available water capacity.	Nearly level.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Degree and kind of limitations for—					
	Septic tank absorption field	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill[1]	Local roads and streets
Bold: Bold part of ToD---	Severe: slope---	Severe: slope---	Severe: slope; highly erodible.	Severe: slope; highly erodible.	Moderate: slopes of more than 10 percent; highly erodible.	Severe: highly erodible in cuts; slope.
Bold part of SIE---	Severe: slope---	Severe: slope---	Severe: slope---	Severe: slope; highly erodible.	Severe: slope; highly erodible.	Severe: slope; highly erodible.
Bremer: Bm-----	Severe: water table at depth of 1 foot to 4 feet; subject to flooding.	Severe: water table at depth of 1 foot to 4 feet; subject to flooding.	Severe: water table at depth of 1 foot to 4 feet; subject to flooding.	Severe: water table at depth of 1 foot to 4 feet; severe frost action; subject to flooding.	Severe: water table at depth of 1 foot to 4 feet; subject to flooding.	Severe: water table at depth of 1 foot to 4 feet; subject to flooding; severe frost action; low bearing capacity.
*Brodale: BoE, BoF. For Sogn part of BoE and BoF, see Sogn series.	Severe: very steep slopes; bedrock at depth of 50 to 80 inches.	Severe: very steep slopes.	Severe: very steep slopes; bedrock at depth of 50 to 80 inches.	Severe: very steep slopes; bedrock at depth of 50 to 80 inches.	Severe: very steep slopes; bedrock at depth of 50 to 80 inches.	Severe: very steep slopes.
Burkhardt: BrA-----	Slight[2]----------	Severe: rapid permeability in substratum.	Slight----------	Slight----------	Severe: rapid permeability in substratum.	Slight----------
Canisteo: Ca-----	Severe: seasonally high water table at depth of 2 to 4 feet.	Severe: seasonally high water table at depth of 2 to 4 feet.	Severe: seasonally high water table at depth of 2 to 4 feet.	Severe: seasonally high water table at depth of 2 to 4 feet; frost action potential.	Severe: seasonally high water table at depth of 2 to 4 feet.	Severe: seasonally high water table at depth of 2 to 4 feet; high susceptibility to frost action.
Chaseburg: ChA-----	Severe: subject to flooding.	Severe: subject to flooding; ML material; medium compacted permeability.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding.
Colo: Co----------	Severe: seasonally high water table at depth of 1 foot to 3 feet; moderately slow permeability.	Severe: seasonally high water table at depth of 1 foot to 3 feet; subject to flooding.	Severe: seasonally high water table at depth of 1 foot to 3 feet; subject to flooding.	Severe: seasonally high water table at depth of 1 foot to 3 feet; subject to flooding.	Severe: seasonally high water table at depth of 1 foot to 3 feet; subject to flooding.	Severe: seasonally high water table at depth of 1 foot to 3 feet; subject to flooding and frost action; low bearing values.

See footnotes at end of table.

of soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand	Topsoil	Pond reservoir areas	Embankments, dikes and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Fair: erodible; requires close control of compaction; slope.	Unsuited	Poor: less than 8 inches of suitable material; slope.	Possible site of pit pond; subject to piping; highly erodible.	Subject to piping; requires close control of compaction; medium compacted permeability.	Well drained	Too steep for irrigation; highly erodible.	Subject to piping; highly erodible.
Poor: highly erodible; requires close control of compaction; slope.	Unsuited	Poor: less than 8 inches of suitable material; slope.	Possible site of pit pond; piping hazard; highly erodible.	Subject to piping; requires close control of compaction; medium compacted permeability.	Well drained	Too steep for irrigation; highly erodible.	Subject to piping; too steep slope; erodible.
Poor: high shrink-swell potential; water table at depth of 1 foot to 4 feet; poor workability; high compressibility.	Generally unsuitable; some sources possible below depth of 6 feet.	Fair: material partly affected by water table; texture.	Possible site of pit pond; moderately slow permeability; water table at depth of 1 to 4 feet.	Low to medium compacted permeability; fair to poor compaction characteristics.	Very poorly drained; difficult to obtain outlets; moderately slow permeability.	Very poorly drained.	Nearly level.
Poor: bedrock at depth of 50 to 80 inches; slope; high strength materials; about 15 to 20 percent stones.	Unsuited	Unsuited	Potential placement of reservoirs along lower slopes; moderately slow permeability.	Too steep in most places.	Excessively drained.	Too steep in most places; rock at depth of 50 to 80 inches.	Too steep in most places; rock at depth of 50 to 80 inches.
Good	Good	Poor: thin topsoil.	Rapid permeability in substratum.	High compacted permeability; good compaction characteristics.	Not needed; somewhat excessively drained.	Shallow root zone; moderately rapid permeability.	Nearly level; generally not needed.
Poor: moderate shrink-swell potential; high compressibility.	Unsuited	Fair: contains free lime; seasonally high water table at depth of 2 to 4 feet.	Possible site of pit pond; seasonally high water table at depth of 2 to 4 feet; moderately slow permeability.	Low to medium compacted permeability; fair compaction characteristics.	Moderate permeability; poorly drained.	Poorly drained; high available water capacity.	Nearly level; generally not needed.
Fair: medium shear strength; fair compaction characteristics; requires close control.	Unsuited	Good	Usual location for dam; moderate permeability; subject to piping and silting.	Medium to low compacted permeability; fair compaction characteristics; subject to piping.	Well drained	Not needed; very high available water capacity.	In drainageways; generally not needed.
Poor: high shrink-swell potential; low shear strength; high compressibility; poor compaction characteristics.	Unsuited	Poor: potential water table when a source is needed.	Possible site of pit pond; subject to flooding; moderately slow permeability.	Poor compaction characteristics; fair to poor shear strength.	Outlets may be difficult to establish; moderately slow permeability.	Poorly drained; very high available water capacity.	Nearly level drainageways; generally not needed.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Degree and kind of limitations for—					
	Septic tank absorption field	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill[1]	Local roads and streets
Copaston: CvB, CvC2	Severe: shallow to bedrock.	Severe: shallow to bedrock; slope.	Severe: shallow to bedrock.	Severe: shallow to bedrock.	Severe: shallow to bedrock.	Severe: shallow to hard and somewhat fractured bedrock.
CwB, CwC2	Severe: bedrock at depth of 20 to 40 inches.	Severe: bedrock at depth of 20 to 40 inches.	Severe: bedrock at depth of 20 to 40 inches.	Severe: bedrock at depth of 20 to 40 inches.	Severe: bedrock at depth of 20 to 40 inches.	Moderate: bedrock at depth of 20 to 40 inches; hard and somewhat fractured.
Dakota: DaA	Slight[2]	Severe: rapid permeability in substratum.	Slight	Slight	Severe: rapid permeability in substratum.	Slight
Derinda: DeC2	Severe: shale bedrock at depth of 20 to 40 inches; slow permeability.	Severe: shale bedrock at depth of 20 to 40 inches; slope.	Severe: shale bedrock at depth of 20 to 40 inches.	Severe: shale bedrock at depth of 20 to 40 inches; high shrink-swell potential; subject to frost action.	Severe: shale bedrock at depth of 20 to 40 inches.	Severe: shale bedrock at depth of 20 to 40 inches.
DeD2	Severe: steep slope; shale bedrock at depth of 20 to 40 inches; slow permeability.	Severe: steep slopes; shale bedrock at depth of 20 to 40 inches.	Severe: steep slopes; shale bedrock at depth of 20 to 40 inches.	Severe: steep slope; shale bedrock at depth of 20 to 40 inches; high shrink-swell potential; subject to frost action.	Severe: shale bedrock at depth of 20 to 40 inches.	Severe: steep slopes; shale bedrock at depth of 20 to 40 inches.
Dickinson: DkA, DkB	Slight[2]	Severe: moderately rapid permeability, rapid in substratum.	Moderate: possible caving of cut slopes.	Slight	Severe: rapid permeability in substratum; poor trafficability in underlying material.	Slight
DkC	Moderate:[2] slopes are more than 6 percent.	Severe: moderately rapid permeability; slope.	Moderate: slope.	Moderate: slope.	Severe: rapid permeability in substratum; poor trafficability in underlying material.	Moderate: slopes subject to erosion in deep cuts.

See footnotes at end of table.

of soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand	Topsoil	Pond reservoir areas	Embankments, dikes and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Poor: shallow to hard and somewhat fractured bedrock.	Unsuited	Poor: shallow to bedrock.	Shallow to bedrock; possibility of voids and fractures in the rock.	Shallow to bedrock; medium compacted permeability.	Well drained	Shallow root zone; low available water capacity.	Shallow to bedrock.
Fair: bedrock at depth of 20 to 40 inches; hard and somewhat fractured.	Unsuited	Poor: thin topsoil.	Bedrock at depth of 20 to 40 inches.	Bedrock at depth of 20 to 40 inches; medium compacted permeability; fair to poor compaction characteristics.	Well drained	Moderate available water capacity; moderate permeability; sloping in some places.	Bedrock at depth of 20 to 40 inches.
Good	Good	Fair: substratum gravelly and sandy.	Rapid permeability in substratum.	Good compaction characteristics.	Well drained	Potential areas of moderately rapid permeability; moderate available water capacity.	Nearly level; generally not needed.
Poor: shale bedrock at depth of 20 to 40 inches; high shrink-swell potential; poor compaction characteristics.	Unsuited	Poor: thin surface layer.	Possible sites for reservoirs; slow permeability; shale bedrock at depth of 20 to 40 inches.	Shale bedrock at depth of 20 to 40 inches; low compacted permeability; fair to poor compaction characteristics.	Moderately well drained.	Sloping; subject to erosion.	Probability of developing wetness in terrace channels; shale bedrock at depth of 20 to 40 inches.
Poor: shale bedrock at depth of 20 to 40 inches; high shrink-swell potential; poor compaction characteristics.	Unsuited	Poor: thin surface layer.	Possible sites for reservoirs; slow permeability; shale bedrock at depth of 20 to 40 inches.	Shale bedrock at depth of 20 to 40 inches; low compacted permeability; fair to poor compaction characteristics.	Moderately well drained.	Too steep for irrigation.	Probability of developing wetness in terrace channels; shale bedrock at depth of 20 to 40 inches.
Good	Fair: poorly graded.	Good to fair: high sand content.	Moderately rapid permeability.	Medium to high compacted permeability; subject to piping.	Well drained	Potential areas; moderate available water capacity; moderately rapid permeability.	Nearly level to gently sloping.
Good	Fair: poorly graded.	Fair: high sand content; slope.	Moderately rapid permeability.	Medium to high compacted permeability; subject to piping.	Well drained	Moderate available water capacity; subject to runoff and erosion.	Potential cuts in sandy material; highly erodible; subject to piping.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Degree and kind of limitations for—					
	Septic tank absorption field	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill[1]	Local roads and streets
Dodgeville: DoB, DoC2	Severe: bedrock at depth of 20 to 40 inches.	Severe: bedrock at depth of 20 to 40 inches; sloping in places.	Severe: bedrock at depth of 20 to 40 inches.	Severe: bedrock at depth of 20 to 40 inches.	Severe: bedrock at depth of 20 to 40 inches.	Moderate: bedrock at depth of 20 to 40 inches.
Dubuque: DuB2, DuC2	Severe: bedrock at depth of 20 to 40 inches.	Severe: bedrock at depth of 20 to 40 inches; sloping in places.	Severe: bedrock at depth of 20 to 40 inches.	Severe: bedrock at depth of 20 to 40 inches.	Severe: bedrock at depth of 20 to 40 inches.	Moderate: bedrock at depth of 20 to 40 inches.
DuD2, DuF	Severe: bedrock at depth of 20 to 40 inches.	Severe: bedrock at depth of 20 to 40 inches; slope.	Severe: bedrock at depth of 20 to 40 inches; slope.	Severe: bedrock at depth of 20 to 40 inches; slope.	Severe: bedrock at depth of 20 to 40 inches; slope.	Severe: bedrock at depth of 20 to 40 inches; highly erodible; slope.
Eleva: EeB, EeD	Severe: sandstone bedrock at depth of 20 to 40 inches.	Severe: moderately rapid permeability; sandstone bedrock at depth of 20 to 40 inches.	Moderate: sandstone bedrock at depth of 20 to 40 inches.	Moderate: sandstone bedrock at depth of 20 to 40 inches.	Severe: sandstone bedrock at depth of 20 to 40 inches; moderately rapid permeability.	Moderate: sandstone bedrock at depth of 20 to 40 inches.
Estherville: EsA, EsC	Slight: moderate where slopes are more than 6 percent.	Severe: sand and gravel at depth of 15 to 30 inches; rapid permeability.	Moderate: gravelly substratum.	Slight: moderate where slopes are more than 6 percent.	Severe: rapid permeability; sand and gravel at depth of 15 to 30 inches.	Slight: moderate where slopes are more than 6 percent.
Fairhaven: FaA	Slight[2]	Severe: rapid permeability in substratum.	Slight	Moderate: ML material; moderate shrink-swell potential.	Severe: rapid permeability in substratum.	Moderate: ML material; moderate shrink-swell potential.
Fairhaven part of KfD.	Moderate:[2] slope.	Severe: rapid permeability; slope.	Moderate: slope.	Moderate: ML material; moderate shrink-swell potential; slope.	Severe: rapid permeability in substratum.	Moderate: slope.

See footnotes at end of table.

of soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand	Topsoil	Pond reservoir areas	Embankments, dikes and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Fair: bedrock at depth of 20 to 40 inches; moderate shrink-swell potential.	Unsuited	Good	Moderate permeability; bedrock at depth of 20 to 40 inches.	Medium to low compacted permeability; fair compaction characteristics; subject to piping.	Well drained	Subject to erosion; moderate available water capacity.	Potential cuts in bedrock at depth of 20 to 40 inches; moderate permeability.
Fair: bedrock at depth of 20 to 40 inches; moderate shrink-swell potential.	Unsuited	Fair: thin surface layer.	Moderate permeability; bedrock at depth of 20 to 40 inches.	Bedrock at depth of 20 to 40 inches; medium to low compacted compressibility; fair compaction characteristics; subject to piping.	Well drained	Moderate available water capacity; subject to erosion.	Potential cuts in bedrock at depth of 20 to 40 inches; moderate permeability.
Fair to poor: slopes are 12 to 35 percent; highly erodible; bedrock at depth of 20 to 40 inches.	Unsuited	Poor: thin surface layer.	Terrain for pond sites; moderate permeability; bedrock at depth of 20 to 40 inches, has voids or is somewhat fractured.	Medium to low compacted permeability; medium sheer strength; subject to piping.	Well drained	Too steep; bedrock at depth of 20 to 40 inches.	Bedrock at depth of 20 to 40 inches; moderate permeability.
Good to fair: sandstone bedrock at depth of 20 to 40 inches.	Poor: sandstone bedrock at depth of 20 to 40 inches; possible sand source in sandstone.	Fair to poor	Moderately rapid permeability; sandstone bedrock at depth of 20 to 40 inches.	Medium compacted permeability; good compaction characteristics.	Somewhat excessively drained.	Sloping to moderately steep; low available water capacity; moderately rapid permeability; sandstone bedrock at depth of 20 to 40 inches.	Sandstone bedrock at depth of 20 to 40 inches; moderately rapid permeability.
Good	Good	Fair: thin surface layer.	Rapid permeability; sand and gravel at depth of 15 to 30 inches.	Medium to high compacted permeability; good compaction charteristics.	Somewhat excessively drained.	Potential areas; low available water capacity; rapid permeability; subject to erosion where slopes are more than 6 percent.	Level terrain; some escarpments have short slopes; cuts would be in sand or gravel.
Good in substratum.	Good	Good	Level terrain; rapid permeability in substratum.	Medium to low compacted permeability; medium shear strength; subject to piping.	Well drained	Potential areas; moderate available water capacity; moderately rapid permesbility.	Nearly level.
Good in substratum.	Good	Fair: slope	Rapid permeability in substratum.	Medium to low compacted permeability; medium shear strength; subject to piping.	Well drained	Moderate available water capacity; limiting factor is slope.	Short slopes.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Degree and kind of limitations for—					
	Septic tank absorption field	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill[1]	Local roads and streets
Frontenac: FrE, FrF	Severe: very steep slopes.	Severe: very steep slopes.	Severe: very steep slopes; highly erodible.	Severe: very steep slopes.	Severe: very steep slopes.	Severe: very steep slopes.
Gale: GaA	Severe: sandstone bedrock at depth of 24 to 40 inches.	Severe: sandstone bedrock at depth of 24 to 40 inches.	Moderate: sandstone bedrock at depth of 24 to 40 inches.	Moderate: sandstone bedrock at depth of 24 to 40 inches.	Severe: sandstone bedrock at depth of 24 to 40 inches.	Moderate: sandstone bedrock at depth of 24 to 40 inches.
Garwin: Gm, Gr	Severe: seasonally high water table at depth of 1 foot to 3 feet.	Severe: seasonally high water table at depth of 1 foot to 3 feet; subject to flooding.	Severe: seasonally high water table at depth of 1 foot to 3 feet.	Severe: seasonally high water table at depth of 1 foot to 3 feet; susceptibility to frost action; high shrink-swell potential.	Severe: seasonally high water table at depth of 1 foot to 3 feet; subject to flooding.	Severe: seasonally high water table at depth of 1 foot to 3 feet; high susceptibility to frost action.
Gotham: GtB, GtD	Moderate:[2] rapid permeability. Severe where slopes are more than 12 percent.	Severe: rapid permeability; slopes of more than 6 percent.	Moderate: sand lacks stability in cuts. Severe where slopes are more than 12 percent.	Moderate: subject to down wasting of material. Severe where slopes are more than 12 percent.	Severe: rapid permeability; poor trafficability in loose sand.	Moderate: deep cuts in more sloping areas; difficult to vegetate. Severe where slopes are more than 12 percent.
Houghton: Ho, Hs	Severe: organic soil; high water table at depth of 1 foot to 3 feet.	Severe: organic soil; high water table at depth of 1 foot to 3 feet.	Severe: organic soil; high water table at depth of 1 foot to 3 feet.	Severe: organic soil; high water table at depth of 1 foot to 3 feet.	Severe: organic soil; high water table at depth of 1 foot to 3 feet.	Severe: organic soil; high water table at depth of 1 foot to 3 feet; avoid locating in these areas.
Joy: JoA	Severe: moderately slow permeability; somewhat poorly drained.	Moderate: somewhat poorly drained; some seepage.	Moderate: somewhat poorly drained; slight seepage during wet periods.	Moderate: somewhat poorly drained; possible seepage in basements; moderate shrink-swell potential; moderate potential for frost action.	Moderate: somewhat poorly drained; subject to some seepage in deep cuts.	Moderate: somewhat poorly drained; moderate frost action potential.
Kasson: KaA	Severe: moderately slow permeability; moderately well drained.	Slight: some seepage.	Slight: some seepage.	Moderate: moderately well drained; some potential seepage in basement; moderate frost action potential on sidewalks and driveways.	Moderate: moderately well drained; seepage in cuts; firm or very firm material in substratum; difficult to work.	Moderate: moderate or high frost action potential; some seepage in cuts.

See footnotes at end of table.

of soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand	Topsoil	Pond reservoir areas	Embankments, dikes and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Poor: very steep slopes; about 25 percent stones.	Unsuited	Poor: thin surface layer; coarse fragments; slope.	Valley walls are fractured bedrock; too porous to hold water.	Not applicable	Well drained	Not applicable; very steep slopes.	Not applicable; very steep slopes.
Fair: sandstone bedrock at depth of 24 to 40 inches; sandstone is weakly cemented.	Poor: possible source in underlying sandstone.	Fair: thin surface layer.	Level terrain; rapid permeability in sandstone.	Medium to low compacted permeability; medium shear strength; subject to piping.	Well drained	Some potential areas; moderate available water capacity; moderate permeability; sandstone at depth of 24 to 40 inches.	Nearly level in most places; sandstone at depth of 24 to 40 inches.
Poor: high shrink-swell potential; poor compaction characteristics; poor compressibility.	Unsuited	Poor: seasonally high water table.	Possible site of pit pond; seasonally high water table at depth of 1 foot to 3 feet.	Low to medium compacted permeability; fair compaction characteristics; medium to low shear strength.	Poorly drained and very poorly drained; moderately slow permeability.	Generally not needed.	Poorly drained and very poorly drained.
Fair: highly erodible.	Fair: poorly graded.	Poor: sandy	Possible sites because of terrain; rapid permeability.	Medium to high compacted permeability; good compaction characteristics; subject to piping.	Somewhat excessively drained.	Rapid permeability; low available water capacity; subject to erosion.	Rapid permeability; long concave slopes.
Unsuited	Unsuited	Poor: high water table at depth of 1 foot to 3 feet; highly organic.	High water table at depth of 1 foot to 3 feet; organic material.	Not suited for embankments; organic material.	Required; internal and open ditch; moderately rapid permeability.	Very poorly drained.	Nearly level.
Fair: moderate shrink-swell potential; fair compaction characteristics.	Unsuited	Good	Near summits of terrain; moderately slow permeability; pit ponds generally not suited.	Low to medium compacted permeability; subject to piping; fair compaction characteristics.	Somewhat poorly drained; some drainage needed; moderately slow permeability.	Generally not needed; very high available water capacity.	Sites for possible outlets; some artificial drainage needed in outlet areas and in constructed channels.
Fair: moderate shrink-swell potential; firm or very firm material.	Unsuited	Fair: thin surface layer.	Near summit of terrain; moderately slow permeability.	Low compacted permeability; fair to good compaction characteristics.	Generally not needed; moderately well drained; can be beneficial in some areas.	Generally not needed; moderately slow permeability; high available water capacity.	Low slopes; terrace channels likely to be wet; require artificial drainage in channels and outlets.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Degree and kind of limitations for—					
	Septic tank absorption field	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill[1]	Local roads and streets
*Kegonsa: KeA	Slight[2]	Severe: moderately rapid permeability in substratum.	Slight	Moderate: ML material; moderate shrink-swell potential.	Severe: rapid permeability in substratum.	Moderate: ML material; moderate shrink-swell potential.
KfD For Fairhaven part of KfD, see Fairhaven series.	Moderate:[2] slope.	Severe: slope; moderately rapid permeability.	Moderate: slope.	Moderate: slope.	Severe: rapid permeability below depth of 2½ feet.	Moderate: slope.
Klinger: KnA	Severe: moderately slow permeability; somewhat poorly drained.	Moderate: somewhat poorly drained; seepage during very wet periods.	Moderate: somewhat poorly drained; slight seepage during wet periods.	Moderate: somewhat poorly drained; possible seepage in basements; moderate shrink-swell potential; moderate frost action potential.	Moderate: somewhat poorly drained; subject to seepage in deep cuts.	Moderate: somewhat poorly drained; moderate frost action potential.
Lawson: La	Severe: water table at depth of 5 to 7 feet; subject to flooding.	Severe: water table at depth of 5 to 7 feet; subject to flooding.	Severe: water table at depth of 5 to 7 feet; subject to flooding.	Severe: water table at depth of 5 to 7 feet; subject to flooding.	Severe: water table at depth of 5 to 7 feet; subject to flooding.	Moderate: subject to flooding; moderate frost action potential.
Lilah: LlA	Slight[2]	Severe: very rapid permeability.	Slight	Slight	Severe: very rapid permeability.	Slight
LlD	Severe:[2] slope	Severe: very rapid permeability.	Severe: slope	Severe: slope	Severe: very rapid permeability.	Severe: slope

See footnotes at end of table.

of soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand	Topsoil	Pond reservoir areas	Embankments, dikes and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Good	Good	Fair: thin surface layer.	On stream benches; moderate permeability.	Medium compacted permeability; low in coarse material; fair to good compaction characteristics.	Well drained	Possible areas; moderate and high available water capacity.	Generally not needed; nearly level or short slopes.
Good	Good	Fair: thin surface layer.	Rapid permeability below depth of 2½ feet.	Medium compacted permeability in material below depth of 3½ feet; good compaction characteristics.	Well drained	Moderate available water capacity.	Short slopes; rapid permeability below depth of 3½ feet.
Fair: moderate shrink-swell potential; fair compaction characteristics.	Unsuited	Good	Near summit of terrain; moderately slow permeability; pit ponds generally not adapted.	Low compacted permeability; fair to good compaction characteristics.	Somewhat poorly drained; some drainage needed; moderately slow permeability.	Generally not needed; moderately slow permeability; high available water capacity.	On long slopes; terrace channels likely to be wet; channels and outlets require artificial drainage.
Fair: moderate shrink-swell potential; fair compaction characteristics.	Some sand possible below depth of 6 feet.	Good	On large flood plain; moderate permeability; water table at depth of 5 to 7 feet.	Low to medium compacted permeability; subject to piping; fair compaction characteristics.	Drainage not needed; water table at depth of 5 to 7 feet.	Not needed; very high available water capacity.	Nearly level.
Good to fair	Good	Poor: high content of sand and gravel.	On stream benches and small knolls; very rapid permeability.	Medium to high compacted permeability; good compaction characteristics; high strength material.	Excessively drained.	Possible on level benches; very low and low available water capacity; very rapid permeability.	Not applicable.
Fair: slope	Good	Poor: slope	On stream benches and small knolls; very rapid permeability.	Medium to high compacted permeability; good compaction characteristics; high strength material.	Excessively drained.	Too steep; very low and low available water capacity.	Short choppy slopes in most places.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption field	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill[1]	Local roads and streets
Lindstrom: LnB	Moderate: moderate permeability.	Moderate: moderate permeability; slope.	Moderate: erodible; subject to runoff from adjacent soils.	Moderate: moderate shrink-swell potential; ML material.	Moderate: erodible; subject to colluvial deposition.	Moderate: ML material; moderate shrink-swell potential.
LnC	Moderate: moderate permeability; slope.	Severe: slope	Moderate: slope; erodible.	Moderate: moderate shrink-swell potential; ML material; slope.	Moderate: erodible; subject to colluvial deposition.	Moderate: ML material; moderate shrink-swell potential.
LnD	Severe: slope	Severe: slope	Severe: slope; erodible.	Severe: slope	Moderate: slope; subject to colluvial deposition.	Severe: slope
Marlean: MaE, MaF	Severe: very steep slopes; bedrock at depth of 4 to 10 feet.	Severe: very steep slopes; bedrock at depth of 4 to 10 feet.	Severe: very steep slopes; bedrock at depth of 4 to 10 feet; highly erodible.	Severe: very steep slopes; bedrock at depth of 4 to 10 feet.	Severe: very steep slopes; bedrock at depth of 4 to 10 feet; highly erodible.	Severe: very steep slopes; bedrock at depth of 4 to 10 feet; highly erodible.
Marsh: Md	Very severe: high water table.	Very severe: high water table.	Very severe: high water table.	Very severe: high water table.	Very severe: high water table.	Very severe: high water table.
Maxfield: Mf, Mo	Severe: seasonally high water table at depth of 1 foot to 3 feet.	Severe: seasonally high water table at depth of 1 foot to 3 feet; subject to flooding in swales.	Severe: seasonally high water table at depth of 1 foot to 3 feet; subject to flooding in swales.	Severe: seasonally high water table at depth of 1 foot to 3 feet.	Severe: seasonally high water table at depth of 1 foot to 3 feet; subject to flooding in swales.	Severe: seasonally high water table at depth of 1 foot to 3 feet; high frost-action potential; high compressibility.
McPaul: Mp	Severe: subject to flooding; water table at depth of 5 to 7 feet.	Severe: subject to flooding; water table at depth of 5 to 7 feet.	Severe: subject to flooding.	Severe: subject to flooding.	Severe: subject to flooding; water table at depth of 5 to 7 feet.	Severe: severe flooding; water table at depth of 5 to 7 feet.
Mt. Carroll: MrA	Slight	Moderate: moderate permeability.	Slight	Moderate: frost-action potential where water is trapped; ML material.	Slight: erodible.	Moderate: cuts subject to erosion; ML material; moderate shrink-swell potential.

See footnotes at end of table.

of soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand	Topsoil	Pond reservoir areas	Embankments, dikes and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Fair: ML material; moderate shrink-swell potential.	Unsuited	Good	On foot slopes below valley walls; moderate permeability.	Low to medium compacted permeability; subject to piping; fair compaction characteristics.	Well drained	Generally not needed; very high available water capacity.	Diversions needed to protect from runoff and deposition from valley walls.
Fair: ML material; moderate shrink-swell potential.	Unsuited	Fair: slope	On foot slopes below valley walls; moderate permeability.	Low to medium compacted permeability; subject to piping; fair compaction characteristics.	Well drained	Generally not needed; subject to erosion.	Diversions needed to protect from runoff and deposition from valley walls.
Fair: slope; ML material; moderate shrink-swell potential.	Unsuited	Poor: slope	On foot slopes below valley walls; moderate permeability.	Low to medium compacted permeability; subject to piping; fair compaction characteristics.	Well drained	Generally not needed; subject to erosion.	Diversions needed to protect from runoff and deposition from valley walls.
Poor: very steep slopes; highly erodible.	Unsuited	Poor: thin surface layer; coarse fragments; slope.	Fractured bedrock; too porous to hold water; very steep slopes.	Not applicable	Well drained	Too steep	Not applicable; very steep slopes.
Unsuited	Unsuited	Unsuited	Standing water	Used to control or contain water.	No outlets	Standing water	Ponded.
Poor: high shrink-swell potential; high compressibility; poor compaction characteristics.	Unsuited	Poor: seasonally high water table.	Possible site of pit pond; seasonally high water table at depth of 1 foot to 3 feet; swale areas require diversion from flooding in some places.	Low compacted permeability; poor compaction characteristics.	Require drainage; moderately slow permeability.	Not applicable; poorly drained and very poorly drained; high available water capacity.	Not applicable; poorly drained and very poorly drained.
Fair: mod shrink-swell potential; medium compressibility; fair compaction characteristics; subject to piping.	Generally unsuited; possible source below depth of 7 feet in some places.	Good: subject to flooding.	On large flood plain; moderate permeability; water table at depth of 5 to 7 feet.	Low to medium compacted permeability; subject to piping; fair compaction characteristics.	Moderately well drained.	Generally not needed; very high available water capacity.	Not needed; nearly level.
Fair: medium shear strength; medium compressibility; subject to piping.	Unsuited	Fair: thin surface layer.	Near summits of upland terrain; moderate permeability; subject to piping.	Low to medium compacted permeability; medium shear strength; fair compaction characteristics.	Well drained	Generally not needed; very high available water capacity.	Not needed; nearly level.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption field	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill [1]	Local roads and streets
MrB	Slight	Moderate: moderate permeability; slope.	Slight	Moderate: frost-action potential where water is trapped; ML material.	Slight: erodible	Moderate: cuts subject to erosion; ML material; moderate shrink-swell potential.
MrC2	Moderate: slope	Severe: slope	Moderate: slope	Moderate: slope	Slight: erodible	Moderate: cuts subject to erosion; ML material; moderate shrink-swell potential.
MxA	Slight [2]	Severe: rapid permeability in substratum.	Slight	Moderate: moderate ML material; frost action potential where water is trapped.	Severe: rapid permeability in substratum.	Moderate: ML material; moderate shrink-swell potential.
Orion: Or	Severe: seasonal water table at depth of 1 foot to 3 feet; subject to flooding.	Severe: seasonal water table at depth of 1 foot to 3 feet; subject too flooding.	Severe: seasonal water table at depth of 1 foot to 3 feet; subject to flooding.	Severe: seasonal water table at depth of 1 foot to 3 feet; subject to flooding.	Severe: seasonal water table at depth of 1 foot to 3 feet; subject to flooding.	Severe: seasonal water table at depth of 1 foot to 3 feet; subject to flooding; high frost-action potential.
Ostrander:						
OtB	Moderate: moderate permeability.	Moderate: moderate permeability; slope.	Slight	Slight	Slight	Moderate: moderate shrink-swell potential.
OtC2	Moderate: moderate slope; moderate permeability.	Severe: slope	Moderate: slope	Moderate: moderate slopes; moderate shrink-swell potential.	Slight	Moderate: subject to erosion in cuts; slope.
Plainfield:						
PaB	Slight [2]	Severe: rapid permeability.	Severe: sandy material.	Slight	Severe: rapid permeability.	Slight

See footnotes at end of table.

of soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand	Topsoil	Pond reservoir areas	Embankments, dikes and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Fair: medium shear strength; medium compressibility; subject to piping.	Unsuited	Fair: thin surface layer.	Near summits of upland terrain; moderate permeability; subject to piping.	Low to medium compacted permeability; medium shear strength; fair compaction characteristics.	Well drained	Generally not needed; very high available water capacity.	Adapted to areas with long slopes.
Fair: medium shear strength; medium compressibility; subject to piping.	Unsuited	Fair: thin surface layer.	Near summits of upland terrain; moderate permeability; subject to piping.	Low to medium compacted permeability; medium shear strength; fair compaction characteristics.	Well drained	Generally not needed; very high available water capacity.	Adapted to areas with long slopes.
Good in substratum.	Good to fair	Fair: thin surface layer.	On stream benches; rapid permeability in substratum; subject to piping.	Medium shear strengtb.	Well drained	Generally not needed; high available water capacity.	Generally not needed.
Poor: poor compaction characteristics; ML material.	Unsuited	Fair: seasonal water table at depth of 1 foot to 3 feet; moderate permeability; subject to piping.	In narrow drainageway; seasonal water table; moderate permeability; subject to piping.	Seasonal water table at depth of 1 foot to 3 feet; subject to piping; low to medium compacted permeability; fair compaction characteristics.	Poorly drained; subject to flooding; difficult to find suitable outlets.	Not applicable; very high available water capacity.	Not applicable; nearly level; subject to flooding.
Fair: moderate shrink-swell potential.	Unsuited	Good	Near summits of upland; moderate permeability on some side slopes; moderate permeability.	Low compacted permeability; fair compaction characteristics.	Well drained	Generally not needed; high available water capacity.	Adapted on long slopes; some channels may need tile drainage.
Fair: moderate shrink-swell potential.	Unsuited	Fair: slope	Near summits of upland; moderate permeability on some side slopes; moderate permeability.	Low compacted permeability; fair compaction characteristics.	Well drained	Generally not needed; high available water capacity.	Adapted on long slopes; some channels may need tile drainage.
Fair: poor stability; subject to piping.	Fair: poorly graded.	Poor: sandy	On benches; rapid permeability.	High compacted permeability; subject to piping; poor stability; fair to poor compaction characteristics.	Excessively drained.	Generally not feasible; rapid permeability; low available water capacity.	On benches in most places; rapid permeability.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption field	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill[1]	Local roads and streets
PaD	Severe: slope	Severe: rapid permeability; slope.	Severe: sandy material; slope.	Severe: slope	Severe: rapid permeability; slope.	Severe: slope
Port Byron:						
PbA	Slight	Moderate: moderate permeability.	Slight	Slight	Slight	Slight
PbB	Slight	Moderate: moderate permeability.	Slight	Slight	Slight	Moderate: subject to erosion in cuts; ML material.
PbC2	Moderate: slope.	Severe: slope	Moderate: subject to erosion; slope.	Moderate: slope.	Slight	Moderate: subject to erosion in cuts; ML material.
PoA	Slight[2]	Severe: rapid permeability in substratum.	Slight	Moderate: ML material.	Severe: rapid permeability in substratum.	Moderate: ML material.
Racine:						
RaB	Moderate: moderate permeability.	Moderate: moderate permeability.	Slight	Slight	Slight	Moderate: moderate shrink-swell potential.
RaC, RaC2	Moderate: moderate permeability.	Severe: slope	Moderate: slope.	Moderate: slope.	Slight	Moderate: subject to erosion in cuts.
RaD2, RaE	Severe: slope	Severe: slope	Severe: slope; subject to erosion in cuts.	Severe: slope	Severe: slope	Severe: slope

See footnotes at end of table.

of soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand	Topsoil	Pond reservoir areas	Embankments, dikes and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Fair: poor stability; subject to piping.	Fair: poorly graded.	Poor: sandy.	Rapid permeability.	High to medium compacted permeability; fair to good compaction characteristics.	Excessively drained.	Low available water capacity; rapid permeability; too steep for irrigation.	Rapid permeability; channels and ridges need maintenance.
Fair: medium shear strength; medium compressibility; subject to piping.	Unsuited.	Good.	Near summit of terrain; moderate permeability.	Medium compacted permeability; medium shear strength; fair compaction characteristics; requires close control.	Well drained.	Generally not needed; very high available water capacity.	Suited to areas with long slopes.
Fair: medium shear strength; medium compressibility; subject to piping.	Unsuited.	Good.	Near summit of terrain; moderate permeability.	Medium compacted permeability; medium shear strength; fair compaction characteristics; requires close control.	Well drained.	Generally not needed; very high available water capacity.	Suited to areas with long slopes.
Fair: medium shear strength; medium compressibility; subject to piping.	Unsuited.	Fair: slope.	On some side slopes.	Medium compacted permeability; medium shear strength; fair compaction characteristics; requires close control.	Well drained.	Generally not needed; very high available water capacity.	Suited to areas with long slopes.
Good: good below depth of 4 feet.	Fair: sand below depth of 4 feet.	Good.	On stream benches; rapid permeability in substratum; subject to piping.	Medium shear strength; medium compacted permeability; subject to piping.	Well drained.	Generally not needed; very high available water capacity.	Generally not needed; nearly level.
Fair: moderate shrink-swell potential.	Unsuited.	Fair: thin surface layer.	Near summits of uplands; moderate permeability.	Medium compacted permeability; fair compaction characteristics.	Well drained.	Generally not needed; high available water capacity.	Suited to long slopes; some channels may need tile drainage.
Fair: moderate shrink-swell potential.	Unsuited.	Fair: thin surface layer.	On some side slopes; moderate permeability.	Medium compacted permeability; fair compaction characteristics.	Well drained.	Generally not needed; high available water capacity.	Suited to long slopes; some channels may need tile drainage.
Fair: slope.	Unsuited.	Poor: thin surface layer; slope.	On side slopes of entrenched drainageways; moderate permeability.	Medium compacted permeability; fair compaction characteristics.	Well drained.	Not applicable; too steep for irrigation.	Too steep in most places; some large diversions possible on long slopes.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption field	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill[1]	Local roads and streets
Radford: Rd	Severe: water table at depth of 5 to 7 feet; subject to flooding.	Severe: water table at depth of 5 to 7 feet; subject to flooding.	Severe: water table at depth of 5 to 7 feet; subject to flooding.	Severe: water table at depth of 5 to 7 feet; subject to flooding.	Severe: water table at depth of 5 to 7 feet; subject to flooding.	Severe: subject to flooding.
Salida: SaB	Moderate:[2] slope.	Severe: slopes of more than 6 percent; very rapid permeability.	Moderate: slopes of more than 6 percent; gravelly material.	Slight	Severe: very rapid permeability.	Slight
SaE	Severe:[2] slope	Severe: slope	Severe: slopes of more than 12 percent.	Severe: slope	Severe: very rapid permeability; slopes of more than 25 percent.	Severe: slope; erodible.
*Schapville: ScC, ScD, SdE: For Sogn part of SdE, see Sogn series.	Severe; slow permeability; slopes of more than 12 percent; shale bedrock at depth of 10 to 25 inches.	Severe: slopes of more than 6 percent; shale bedrock at depth of 10 to 25 inches.	Severe: clayey material at depth of 10 to 25 inches.	Severe: shale at depth of 10 to 25 inches; high shrink-swell potential.	Severe: shale bedrock at depth of 10 to 25 inches.	Severe: high shrink-swell potential; shale bedrock at depth of 10 to 25 inches.
*Seaton: SfA, SfB	Slight	Moderate: slope; moderate permeability.	Slight	Slight: frost action potential where water is trapped.	Slight	Moderate: ML material.
SfC2, ShC2, SkC2. For Kegonsa or Lilah parts of SkC2, see KfD in Kegonsa series or see Lilah series.	Moderate: slopes of more than 6 percent.	Severe: slopes of more than 6 percent.	Moderate: slope; subject to erosion.	Moderate: slope; frost action potential where water is trapped.	Moderate: erodible.	Moderate: slope; cuts subject to erosion; ML material.
SfD2, SfE, ShD2, ShE, SkD2, SlE. For Kegonsa or Lilah parts of ShD2, see Kegonsa series or Lilah series. For Bold or Timula parts of SlE, see Bold series or ToD in Timula series.	Severe: slope	Severe: slope	Severe: slope; severe hazard of erosion.	Severe: slope; severe hazard of erosion; frost-action potential where water is trapped.	Severe if slopes of more than 25 percent; moderate if slopes less than 25 percent: cuts subject to erosion.	Severe: cuts subject to severe erosion; slope.

See footnotes at end of table.

of soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand	Topsoil	Pond reservoir areas	Embankments, dikes and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Fair: moderate shrink-swell potential; fair compaction characteristics.	Unsuited	Good	On flood plain; water table at depth of 5 to 7 feet; moderate permeability.	Low to medium compacted permeability; fair compaction characteristics; subject to piping.	Drainage not needed; water table at depth of 5 to 7 feet.	Not needed; very high available water capacity.	Not needed; nearly level; on flood plain.
Good to fair	Good	Poor: high content of sand and gravel.	On stream benches; very rapid permeability.	High compacted permeability; good compaction characteristics; high strength material.	Excessively drained.	Excessively drained; very rapid permeability; very low available water capacity.	Not needed; very rapid permeability.
Good to fair	Good	Poor: high content of sand and gravel; slope.	Escarpments; very rapid permeability.	High compacted permeability; good compaction characteristics; high strength material.	Excessively drained; slope.	Slope	Short choppy slopes; very rapid permeability.
Poor: high shrink-swell potential.	Unsuited	Fair: high clay content.	Side slopes in most places; slow permeability; shale bedrock at depth of 10 to 25 inches.	Low to medium compacted permeability; poor compaction characteristics.	Moderately well drained; slow permeability.	Not suited: slow permeability; gradients more than 2 percent.	Not suited: shale bedrock at depth of 10 to 25 inches.
Fair: medium shear strength; medium compressibility; subject to piping.	Unsuited	Fair: thin surface layer.	Near the side slopes of some uplands; moderate permeability.	Medium compacted permeability; subject to piping; fair compaction characteristics; medium shear strength.	Well drained	Very high available water capacity.	Terraces and diversions suited to slopes more than 300 feet long.
Fair: medium shear strength; medium compressibility; subject to piping. Poor if slopes are more than 25 percent.	Unsuited; parts of SkC2 contain some sand and gravel.	Fair: thin surface layer.	On side slopes of uplands, some foot slopes; moderate permeability.	Medium compacted permeability; subject to piping; fair compaction characteristics; medium shear strength.	Well drained	Very high available water capacity.	Terraces and diversions suited to slopes more than 300 feet long.
Fair: medium shear strength; medium compressibility; subject to piping; slope.	Unsuited: parts of SkD2 contain some sand or gravel.	Poor: slopes of more than 12 percent; thin surface layer.	On side slopes and foot slopes; moderate permeability.	Medium to low compacted permeability; subject to piping; fair compaction characteristics; medium shear strength.	Well drained	Not suited: too steep.	Possible sites for diversions on long slopes and below valley walls.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption field	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill[1]	Local roads and streets
Shullsburg: SmC.	Severe: slow permeability.	Severe: severe where slopes are more than 6 percent; susceptible to soil creeping.	Severe: shale bedrock at depth of 20 to 40 inches; cuts lack stability.	Severe: high shrink-swell potential; shale bedrock at depth of 20 to 40 inches; subject to soil creeping.	Severe: shale bedrock at depth of 20 to 40 inches; poor workability; somewhat poorly drained.	Severe: high shrink-swell potential; poor compaction characteristics; high compressibility.
Skyberg: Sn	Severe: seasonal water table at depth of 1 foot to 3 feet; moderately slow permeability.	Severe: seasonal water table at depth of 1 foot to 3 feet; moderately slow permeability.	Severe: seasonal water table at depth of 1 foot to 3 feet.	Severe: seasonal water table at depth of 1 foot to 3 feet; frost action potential.	Severe: seasonal water table at depth of 1 foot to 3 feet; material difficult to work.	Severe: moderate or high frost-action potential.
*Sogn: SoD For Copaston part of SoD, see CvB, CvC2 in Copaston series.	Severe: slope; bedrock at depth of 10 to 20 inches.	Severe: bedrock at depth of 10 to 20 inches.	Severe: bedrock at depth of 10 to 20 inches.	Severe: bedrock at depth of 10 to 20 inches.	Severe: bedrock at depth of 10 to 20 inches.	Severe: bedrock at depth of 10 to 20 inches.
Sparta: SpA	Slight[2]	Severe: very rapid permeability.	Slight	Slight	Severe: very rapid permeability.	Slight
Terril: TeB	Moderate: moderate permeability.	Moderate: moderate permeability; slope.	Moderate: erodible; subject to flooding from adjacent soils.	Moderate: moderate shrink-swell potential; ML material.	Moderate: position on landscape; erodible.	Moderate: ML material; moderate shrink-swell potential.
TeC	Moderate: moderate permeability; slope.	Severe: slope	Moderate: slope; erodible.	Moderate: moderate shrink-swell potential; ML material; slope.	Moderate: position on landscape; erodible.	Moderate: ML material; moderate shrink-swell potential.
TeD	Severe: slope	Severe: slope	Severe: slope; erodible.	Severe: slope erodible.	Moderate: slope; subject to colluvial deposition.	Severe: slope
*Timula: TmB	Slight	Moderate: slope; moderate permeability.	Slight	Slight	Slight	Moderate: largely ML material.

See footnotes at end of table.

of soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand	Topsoil	Pond reservoir areas	Embankments, dikes and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Poor: high shrink-swell potential; poor compaction characteristics; high compressibility.	Unsuited	Fair: high content of clay; shale bedrock at depth of 20 to 40 inches.	On side slopes; slow permeability; somewhat poorly drained; shale bedrock at depth of 20 to 40 inches.	Low compacted permeability; poor compaction characteristics; medium shear strength.	Slow permeability.	Not needed; shale bedrock at depth of 20 to 40 inches; somewhat poorly drained.	Not suited; short slopes; shale bedrock at depth of 20 to 40 inches.
Fair: moderate shrink-swell potential.	Unsuited	Fair: seasonal water table at depth of 1 foot to 3 feet.	Possible site of pit pond; seasonal water table at depth of 1 foot to 3 feet; moderately slow permeability.	Low compacted permeability; fair to good compaction characteristics.	Somewhat poorly drained; moderately slow permeability.	Not needed; somewhat poorly drained; moderately slow permeability.	Not needed: nearly level.
Poor: bedrock at depth of 10 to 20 inches.	Unsuited	Poor: less than 8 inches of suitable material.	On valley walls; bedrock at depth of 10 to 20 inches.	Bedrock at depth of 10 to 20 inches.	Bedrock at depth of 10 to 20 inches.	Too steep	Bedrock at depth of 10 to 20 inches.
Good to fair: poor stability.	Good: poorly graded.	Poor: sandy material.	On stream benches; very rapid permeability.	Medium to low compacted permeability; subject to piping; fair to good compaction characteristics.	Excessively drained.	Very rapid permeability.	Nearly level.
Fair: ML material; moderate shrink-swell potential.	Unsuited; some potential sand in lower part of substratum.	Good	On foot slopes below valley walls; moderate permeability.	Low to medium compacted permeability; subject to piping; fair compaction characteristics.	Well drained	Generally not needed; high available water capacity; subject to erosion.	Diversions needed to protect from runoff and deposition from valley walls.
Fair: ML material; moderate shrink-swell potential.	Unsuited; some potential sand in lower part of substratum.	Fair: slope	On foot slopes below valley walls; moderate permeability.	Low to medium compacted permeability; subject to piping; fair compaction characteristics.	Well drained	Generally not needed; high available water capacity; subject to erosion.	Diversions needed to protect from runoff and deposition from valley walls.
Fair: slope; ML material; moderate shrink-swell potential.	Unsuited; some potential sand in lower part of substratum.	Poor: slope	On foot slopes below valley walls; moderate permeability.	Low to medium compacted permeability; subject to piping; fair compaction characteristics.	Well drained	Generally not needed; high available water capacity; subject to erosion.	Diversions needed to protect from runoff and deposition from valley walls.
Fair: ML material.	Unsuited	Fair: thin surface layer.	Near summits in uplands; moderate permeability.	Medium to low shear strength; medium to low compacted permeability; high susceptibility to piping.	Well drained	Generally not needed; very high available water capacity.	Suited to slopes longer than 150 feet.

TABLE 7.—*Engineering interpretations*

Soil series and map symbols	Degree and kind of limitation for—					
	Septic tank absorption field	Sewage lagoons	Shallow excavations	Dwellings with basements	Sanitary landfill[1]	Local roads and streets
TmC	Moderate: slope.	Severe: slope	Moderate: slope; erodible.	Moderate: slope.	Moderate: erodible.	Moderate: slope; ML material; erodible.
ToD For Bold part of ToD, see Bold series.	Severe: slope	Severe: slope	Severe: slope; erodible.	Severe: slope	Severe: slopes of more than 25 percent; erodible.	Severe: slope; erodible.
Vasa: VaA	Moderate: moderate permeability; moderately well drained.	Moderate: moderate permeability.	Moderate: moderately well drained; some seepage at contact with till.	Moderate: moderate shrink-swell and frost action potential; possible seepage in basements.	Moderate: moderately well drained; possible seepage in deep cuts.	Severe: susceptibility to frost action.
Waukegan: WaA	Slight[2]	Severe: rapid permeability in substratum.	Slight	Slight	Severe: rapid permeability in substratum.	Slight
Whalan: WhB, WhC2, WsB, WsC2, WsD2, WsE.	Severe: bedrock at depth of 20 to 40 inches.	Severe: bedrock at depth of 20 to 40 inches.	Severe: bedrock at depth of 20 to 40 inches.	Severe: bedrock at depth of 20 to 40 inches.	Severe: bedrock at depth of 20 to 40 inches.	Moderate: bedrock at depth of 20 to 40 inches.
Zumbro: Zu	Severe: subject to flooding; water table at depth of 5 to 10 feet.	Severe: subject to flooding; rapid permeability.	Moderate: subject to flooding.	Severe: subject to flooding; moderately well drained.	Severe: rapid permeability; subject to flooding.	Severe: subject to flooding.

[1] Onsite study is needed of the underlying strata and water table to determine the hazards of aquifer pollution and drainage into ground water in landfill deeper than 5 or 6 feet.

[2] Hazard of pollution of ground water to considerable depth in the sand and gravel.

of soils—Continued

Suitability as source of—			Soil features affecting—				
Road fill	Sand	Topsoil	Pond reservoir areas	Embankments, dikes and levees	Drainage of cropland and pasture	Irrigation	Terraces and diversions
Fair: ML material.	Unsuited	Fair: thin surface layer.	On side slopes in upland terrain; moderate permeability.	Medium to low shear strength; medium to low compacted permeability; high susceptibility to piping.	Well drained	Generally not needed; high available water capacity.	Suited to slopes longer than 150 feet.
Poor: slopes of more than 25 percent; fair amount of ML material.	Unsuited	Poor: slope	On side slopes in upland terrain; moderate permeability.	Medium to low shear strength; medium to low compacted permeability; high susceptibility to piping.	Well drained	High available water capacity; subject to erosion.	Slopes are generally too steep or choppy.
Fair: medium shear strength; medium compressibility; subject to piping.	Unsuited	Fair: thin topsoil.	Near summits in uplands; moderate permeability.	Low to medium compacted permeability; subject to piping; fair compaction characteristics.	Not generally needed; moderately well drained; some drainageways benefit.	Not generally needed; very high available water capacity.	If installed, artificial drainage needed along channels.
Good	Good	Good	On stream benches; moderate to rapid permeability in substratum.	Medium compacted permeability; subject to piping; fair compaction characteristics.	Well drained	Moderate to high available water capacity.	Nearly level.
Poor: bedrock at depth of 20 to 40 inches.	Unsuited	Poor: thin surface layer.	Moderate permeability; bedrock at depth of 20 to 40 inches.	Medium to low compacted permeability; fair compaction characteristics; bedrock at depth of 20 to 40 inches.	Well drained	Slopes of more than 2 percent generally too steep; moderate permeability.	Bedrock at depth of 20 to 40 inches.
Good: subject to piping.	Poor: poorly graded.	Fair: high content of sand.	On flood plain; rapid permeability.	Medium to high compacted permeability; good compaction characteristics; subject to piping.	Generally not needed; moderately well drained; rapid permeability.	Water table at depth of 5 to 10 feet; subject to flooding.	Rapid permeability; subject to flooding.

TABLE 8.—*Engineering*

[Tests performed by the Minnesota Department of Highways in cooperation with U. S. Department of Commerce, Bureau of

Soil and location	Parent material	Minn. report number	Depth from surface	Moisture density [1]		Mechanical analysis [2]			
				Maximum dry density	Optimum moisture	Percentage of material less than 3 inches in diameter passing sieve—			
						1 in	¾ in	⅜ in	No. 4 (4.7 mm)
			Inches	*Lb/cu ft*	*Pct*				
Bold silt loam:									
SW1/4SE1/4NE1/4 sec. 32, T. 112 N., R. 16 W. (Modal)	Loess.	SS63–1695	0–6	106	16				
		SS63–1696	11–70	108	16				
Brodale flaggy loam: [6]									
NE1/4NE1/4NW1/4 sec. 22, T. 112 N., R. 14 W. (Modal)	Colluvium and bedrock residuum.	SS72–125	10–40	124.7	8	84	78	76	75
Burkhardt loam:									
NE1/4NE1/4SW1/4 sec. 24, T. 112 N., R. 13 W. (Modal)	Glacial outwash.	SS73–123	16–35	139	7	89	81	63	50
		SS73–124	35–70	127	10	98	97	88	70
Dickinson sandy loam:									
SW1/4NW1/4SW1/4 sec. 36, T. 112 N., R. 18 W. (Modal)	Glacial outwash.	SS63–1730	0–7	119	11				100
		SS63–1731	22–28	126	9			100	99
		SS63–1732	32–55	117	11			100	99
Kasson silt loam:									
SE1/4SE1/4SE1/4 sec. 31, T. 109 N., R. 17 W. (Modal)	Loess over glacial (Iowan) till (dense).	SS63–1750	0–9	96	22				
		SS63–1751	24–33	112	14			100	99
		SS63–1752	52–83	114	15			100	99
Mt. Carroll silt loam:									
200 feet north of southwest corner of SE1/4 NE1/4 sec. 11, T. 110 N., R. 17 W. (Modal)	Loess.	SS63–1697	0–6	97	21				
		SS63–1698	18–30	103	18				
		SS63–1699	41–70	106	18				
Plainfield loamy sand:									
SW1/4SW1/4SW1/4 sec. 31, T. 114 N., R. 15 W. (Modal)	Alluvial sand (terrace).	SS63–1705	0–5	107	14				
		SS63–1706	45–100	106	16				
Plainfield fine sand:									
NW1/4NW1/4SE1/4 sec. 4, T. 113 N., R. 16 W. (Finer than modal)	Alluvial sand (terrace).	SS63–1693	0–6	108	13				
		SS63–1694	16–70	108	13				
Racine silt loam:									
SE1/4SE1/4 sec. 25, T. 109 N., R. 18 W. (Modal)	Thin loess over glacial till (Iowan).	SS63–1735	0–8	102	17			100	99
		SS63–1736	29–36	126	11		100	96	86
		SS63–1737	44–70	117	13		100	96	92
Schapville silty clay loam:									
NE1/4NW1/4NE1/4 sec. 29, T. 112 N., R. 17 W. (Modal)	Loess over shale (Decorah) over limestone.	SS63–1707	0–8	97	22				
		SS63–1708	8–15	91	25				100
		SS63–1709	15–24	86	31				
Seaton silt loam:									
SW1/4SW1/4SW1/4 sec. 34, T. 112 N., R. 17 W. (Modal)	Loess.	SS63–1741	0–9	106	17				
		SS63–1742	9–15	103	18				
		SS63–1743	41–103	106	18				
Shullsburg silty clay loam:									
SW1/4NE1/4NW1/4 sec. 30, T. 112 N., R. 17 W. (Modal)	Thin loess over shale (Decorah).	SS63–1718	0–7	85	27			100	99
		SS63–1719	11–17	98	24				
		SS63–1720	24–53	95	25				

[1] Based on AASHO Designation T 99–57, Method C.

[2] Mechanical analysis according to the AASHO Designation T 88. Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soil.

test data

Public Roads, in accordance with standard procedures of the American Association of State Highway Officials (AASHO)]

Mechanical analysis—Continued[2]						Liquid limit	Plasticity index	Classification	
Percentage of material less than 3 inches in diameter passing sieve—Continued			Percentage smaller than—						
No. 10 (2.0 mm)	No. 40 (0.42 mm)	No. 200 (0.074 mm)	0.05 mm	0.005 mm	0.002 mm			AASHO[3]	Unified[4]
						Pct			
----------	100	97	87	19	11	27	[5]NP	A–4(8)	ML
----------	100	98	79	13	10	24	NP	A–4(8)	ML
74	72	34	24.5	----------	9	-----	----------	A–2–4	SM
42	21	6	3.4	----------	3	NP	NP	A–1–a	SW–SM
48	16	2	----------	----------	3	NP	NP	A–1–a	SP
99	78	26	23	12	8	NP	NP	A–2–4(0)	SM
97	79	22	20	8	7	NP	NP	A–2–4(0)	SM
97	73	10	----------	----------	----------	NP	NP	A–3(0)	SP–SM
100	97	91	84	30	21	35	6	A–4(8)	ML
98	90	65	57	28	24	33	10	A–4(6)	ML–CL
97	87	63	55	27	23	30	11	A–6(6)	CL
100	99	98	88	26	19	36	6	A–4(8)	ML
----------	100	99	90	28	22	37	9	A–4(8)	ML
----------	100	99	78	19	16	30	3	A–4(8)	ML
100	55	2	----------	----------	----------	NP	NP	A–3(0)	SP
100	54	1	----------	----------	----------	NP	NP	A–3(0)	SP
100	91	8	----------	----------	----------	NP	NP	A–3(0)	SP–SM
100	93	4	----------	----------	----------	NP	NP	A–3(0)	SP–SM
98	94	84	78	25	16	34	8	A–4(8)	ML
80	69	31	26	13	10	NP	NP	A–2–4(0)	SM
86	75	46	43	21	18	28	7	A–4(2)	SM
100	98	71	67	37	28	42	13	A–7–6(8)	ML
97	90	66	61	31	24	42	8	A–5(6)	ML
100	98	94	94	74	62	80	37	A–7–5(20)	MH
100	99	96	84	26	21	33	7	A–4(8)	ML
----------	----------	97	85	31	29	35	8	A–4(8)	ML
----------	----------	98	82	16	12	26	NP	A–4(8)	ML
96	93	69	64	40	32	54	16	A–7–5(12)	MH or OH
100	98	82	80	63	54	59	29	A–7–5(19)	MH–CH
100	97	91	87	65	52	69	39	A–7–5(20)	CH

[3] Based on AASHO Designation M 145–49.

[4] Soil Conservation Service and Bureau of Public Roads have agreed to consider that all soils having plasticity indexes within 2 points from A-line are to be given a borderline classification.

[5] NP = Nonplastic.

[6] 30 to 60 percent flaggy material more than 3 inches in diameter estimated not run.

interpretations for various engineering uses; and results of engineering laboratory tests on soil samples.

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 community development and outdoor recreation groupings, and it also can be used to make other useful maps.

This information, however, does not eliminate the need for further investigation at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables, generally depths of more than 6 feet. Also, inspection of sites, especially small ones, is needed because many delineated areas of a given soil mapping unit may contain small areas of other kinds of soils that have strongly contrasting properties and different suitabilities or limitations for soil engineering.

Some of the terms used in this soil survey have special meaning in soil science that may be unfamiliar to engineers. The Glossary defines many 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 *(7)* used by the SCS engineers, Department of Defense, and others, and the AASHO system *(1)* adopted by the American Association of State Highway Officials.

In the Unified system soils are classified according to particle-size distribution, plasticity, liquid limit, and content of organic matter. Soils are grouped in 15 classes. There are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example, ML–CL.

The AASHO system 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 tested soils, with group index numbers in parentheses, is shown in table 8; the estimated classification, without group index numbers, is given in table 6 for all soils mapped in the survey area.

Soil properties significant to engineering

Several estimated soil properties significant in engineering are given in table 6. 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 counties. Following are explanations of some of the columns in table 6.

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 6 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 6, but in table 8 the data on liquid limit and plasticity index are based on tests of soil samples.

Permeability is that quality that enables a soil to transmit water or air. It is estimated on the basis of those soil characteristics observed in the field, particularly structure and texture. The estimates in table 6 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 which 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 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

The estimated interpretations in table 7 are based on the engineering properties of soils shown in table 6, 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 Goodhue County. In table 7, ratings summarize the 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 7 lists those soil features not to be overlooked in planning, installation, and maintenance.

Soil limitations are indicated by the ratings slight, moderate, severe, and very severe. *Slight* means that soil properties generally are favorable for the rated use, or in other words, limitations are minor and are easily overcome. *Moderate* means that some soil properties are unfavorable but can be overcome or modified by special planning and design. *Severe* indicates soil properties so unfavorable and so difficult to correct or overcome that major soil reclamation, special designs, or intensive maintenance is required. *Very severe* indicates one or more soil properties so unfavorable for a particular use that overcoming the limitations is most difficult and costly and is commonly not practical for the rated use.

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 7.

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 is evaluated from a depth of 18 inches to 6 feet. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that affect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope is a soil property that affects difficulty of layout and construction and also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage within a depth of 2 to 5 feet long enough for bacteria to decompose the solids. A lagoon has a nearly level floor and sides, or embankments, of compacted soil material. 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, content of 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 outcrop or big stones, and freedom from flooding or a high water table.

Dwellings, as rated in table 7, are no more than three stories high and are supported by foundation footings placed in undisturbed soil. The features that affect the rating of a soil for dwellings 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 7 apply only to a depth of about 6 feet, and therefore limitation ratings of *slight* or *moderate* may not be valid if trenches are much deeper than that. For some soils reliable predictions can be made to a depth of 10 to 15 feet, but every site should be investigated before it is selected.

Local roads and streets, as rated in table 7, 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 the predicted performance of soil after it has been placed in an embankment that has been properly compacted and provided with adequate drainage, and the relative ease of excavating the material at borrow areas.

Sand is used in great quantities in many kinds of construction. The ratings in table 7 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 materials, 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 in preparing a seedbed; natural fertility of the material, or the response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and its content of stone fragments are characteristics that affect suitability, but also considered in the ratings is damage that will result at the area from which topsoil is taken.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have little seepage, which is related to their permeability and depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compactibility. Stones or organic material in a soil are among factors that are unfavorable.

Drainage of cropland and pasture is affected by such soil properties as permeability, texture, and structure; depth to claypan, rock, or other layers that influence rate of water movement; depth to the water table; slope, stability in ditchbanks; susceptibility to stream overflow; 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; 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.

Soil test data

Table 8 contains engineering test data for some of the major soils in Goodhue County. These tests were made to help evaluate the soils for engineering purposes. The engineering classifications given are based on data obtained by mechanical analyses and by tests to determine liquid limits and plastic limits. The mechanical analyses were made by combined sieve and hydrometer methods.

Compaction (or moisture-density) data are important in earthwork. If a soil material is compacted at successively higher moisture content, assuming that the compactive effort remains constant, the density of the compacted material increases until the *optimum moisture content* is reached. After that, density decreases with increase in moisture content. The highest dry density obtained in the compactive test is termed *maximum dry density*. As a rule, maximum strength of earthwork is obtained if the soil is compacted to the maximum dry density.

Tests to determine liquid limit and plastic limit measure the effect of water on the consistence of soil material, as has been explained for table 8.

Shrinkage limit is the percentage of moisture at which shrinkage of the soil material stops.

Shrinkage ratio is the relation of change in volume of the soil material to the water content of the soil material when at the shrinkage limit. The change in volume is expressed as a percentage of the air-dry volume of the soil material, and the water content is expressed as a percentage of the weight of the soil material, when ovendry.

Linear shrinkage is the decrease in one dimension, expressed as a percentage of the original dimension, of the soil mass when the moisture content is reduced from the given value to the shrinkage limit.

Town and Country Planning

Goodhue County is in a region of expanding population that is developing around the small towns and along major highways. Some small housing areas are also being developed in wooded areas away from major communities or highways. This section is intended as a guide to potential developers or planners who wish to consider shopping and parking areas, parks and playgrounds, streets or roads, factories, and schools. A number of characteristics of a soil and its terrain affect such uses. Some of these characteristics are a high or low water table, erodibility, runoff, percolation rate (for septic tank absorption fields), shrink-swell potential, and frost heaving. Conversely, the use of a soil has an effect on the soil and its related environment.

Restrictions on the use of some soils are incorporated in local ordinances. This section points out factors that need to be considered or should be allowed for in planning any type of development. Incorporating compensating measures into buildings or roads during construction is easier than correcting problems afterwards. Extra borings can be made by consulting firms that study the extent of any problems identified and the compensating measures required.

Any overall plan should allow for such things as control of erosion and runoff. Where development is intensive, as in housing areas or shopping centers, the amount of runoff to be discharged is increased significantly. For example, a large number of natural soil absorption areas are displaced by nonabsorbing areas, such as roofs, parking lots, and streets, which readily shed and channel the runoff into lower areas and at considerably faster rates. Control of erosion is needed also, especially during initial stages of any construction when the plant cover has been destroyed. It is also needed in the runoff discharge areas where gullying is possible. Assistance in determining the management needed is available at the local Soil Conservation District office.

A large acreage in the county is prime farmland. For this reason, the compatibility of farming and de-

velopments, such as subdivisions, should be considered.

Most factors that influence use of the soils for community developments are covered in nine overall soil groupings described on the following pages. The soils are grouped by common properties that are significant in most types of developments. Each grouping points out major problems requiring attention. More precise evaluation for each soil in the county is in the engineering tables.

COMMUNITY DEVELOPMENT GROUP 1

This group consists of all soils on which a hazard of flooding occurs. These are soils of the Ankeny, Bremer, Chaseburg, Colo, Lawson, McPaul, Orion, Radford, and Zumbro series and Alluvial land and Marsh. They occupy natural drainageways throughout the county, including some that finger into watersheds as small as 40 acres in size. Alluvial land and the Chaseburg, Colo, McPaul, and Orion soils are flooded frequently or very frequently after heavy rain. They are adjacent to streams or are on the lowest part of the sides of tributary valleys. The remaining soils in the group are less frequently flooded and occupy the more elevated flood plains at greater distances from the stream channels. Most of the flooding follows heavy storms or snowmelt.

Development of flooded areas should be limited to filled-in areas or to uses that do not obstruct or diminish the natural flood plain. The kind or extent of possible uses varies with degree of flooding. Any use of frequently flooded or very frequently flooded soils is hazardous. Such soils should be left idle or limited to pasture.

The less frequently flooded soils are mostly used for crops. Some, however, are idle or are used for pasture because they are ponded or have too high a water table. Other areas of these soils have been developed for parks, harbors, or low-hazard farm uses. Future developments should be restricted to those that do not obstruct the flood plain or drive the higher lying floodwaters downstream.

Wetness is a hazard on Marsh, Alluvial land, flooded, and the Bremer, Colo, and Orion soils. The water table is generally at the surface or within a depth of 3 feet, and frost action is a typical concern in the construction of roads, parking areas, or concrete slabs of any size. Bearing strength is low in the Bremer, Colo, Houghton, Orion, and Radford soils.

COMMUNITY DEVELOPMENT GROUP 2

This group consists of soils that have a seasonal high water table or a permanent water table at a depth of 1 foot to 4 feet. These are soils of the Biscay, Canisteo, Garwin, Houghton, Maxfield, and Skyberg series. Late in summer or in dry years this water table can disappear, but it is generally perched because the substratum is dense or has a high content of clay and does not allow much water in or through it. Houghton muck, seepy, is at the base of hillsides and receives seepage or subsurface flowage from inside the hill. Biscay soils are on low terraces that have a more permanent water table.

The water table severely limits use of these soils because it affects excavations for basements, foundations for buildings, and sewage absorption systems for septic tanks and frost action in roads, parking lots, sidewalks, and driveways. In some places, subsurface drainage can correct part of the wetness. If feasible, tile drainage could be installed around footings of foundations, under parking lots, and along road sides. Houghton muck, seepy, is very difficult to drain.

Bearing strength is variable, and onsite determinations should be made before any major building is planned. The underlying loamy glacial till in the Canisteo, Maxfield, Skyberg, and Biscay soils has fairly high strength.

COMMUNITY DEVELOPMENT GROUP 3

This group consists of soils that are mainly favorable for development because they require very little leveling or movement of earth. These soils are mostly level to gently sloping and are on stream benches. They are soils of the Alvin, Billett, Burkhardt, Dakota, Dickinson, Estherville, Fairhaven, Gotham, Kegonsa, Lilah, Plainfield, Salida, Sparta, and Waukegan series. They are excessively drained to well drained. Permeability is moderate to very rapid. Runoff is slow to medium, and much of it is absorbed.

Many areas of these soils have existing communities on or near them. The underlying material in all areas is sandy or gravelly. Pollution of ground water is a hazard if these soils are used as sewage absorption fields for septic tanks, because the substratum is rapidly permeable. This hazard is very severe if a water table is within a depth of 10 feet. The coarse material in the substratum mostly filters solids from the effluent and does little to filter nutrients in the liquid. The depth to a potential water table corresponds in places to the approximate elevation of nearby streams. Well logs should be studied for precise positions.

These soils have good bearing strength and are capable of supporting large structures, especially those soils that have a high content of pebbles. No serious problems affect installation of parking lots, roads, or streets. Billett, Burkhardt, Estherville, Gotham, Lilah, Plainfield, Salida, and Sparta soils are too droughty for most lawn or yard needs, because available water capacity is very low to low. Moisture has to be applied very frequently if a dense lawn and garden is desired. Where possible some topsoil should be hauled from other areas.

In most areas these soils, especially the droughty soils, are subject to soil blowing. Sediment from blowing collects in houses and causes cleaning problems, or it drifts in road ditches and along lot borders. Most soil blowing is in the vicinity of large cultivated fields where wind can rework bare soil.

In most areas, especially level areas, water is absorbed readily and very little runs off. In subdivisions some means of channeling runoff, such as surface waterways, are needed. During the potential rapid thaws, for example, the soil is frozen and little runoff is absorbed.

COMMUNITY DEVELOPMENT GROUP 4

This group consists of nearly level to sloping soils that have bedrock at a depth of 1 foot to 3 feet. These soils are of the Copaston, Dodgeville, Dubuque, Eleva, Gale, and Whalan series. They are well drained or somewhat excessively drained. Permeability is moderate or

moderately rapid. These soils occupy the upper parts of narrow upland ridges and some stream benches.

Pollution of aquifers in bedrock is a potential hazard where any of these soils are used as sewage absorption fields. Sandstone or limestone bedrock is at a depth of less than 3 feet. Much of the limestone bedrock is fractured and cavernous and absorbs effluent readily without any filtering, and the sandstone is very porous. If housing developments have a central collection system for sewage, the hazard of pollution is reduced.

The limitation to extensive excavation is moderate or severe. Excavating bedrock is expensive and should be minimized by planning developments on the contour.

Disposal of runoff is a concern, because many areas generally discharge into steep ravines. The added runoff from a housing development can cause serious gullying in the lower drainageways on floors of ravines. Runoff can generally be controlled by building the development on the contour. Terraces, small dams, and some streets should be constructed to temporarily hold water, especially in areas that cross small drainageways.

Most of these soils have medium or high bearing strength.

COMMUNITY DEVELOPMENT GROUP 5

This group consists of moderately well drained or somewhat poorly drained soils that have moderate to slow permeability. These soils are of the Derinda, Joy, Kasson, Klinger, Schapville, Shullsburg, and Vasa series. They are mainly on broad uplands. All but Derinda and Schapville soils are wet or have some seepage. All but Derinda, Schapville, and Shullsburg soils are nearly level to gently sloping. Those soils are sloping.

The wetness in these soils mainly affects areas that require sewage absorption fields for septic tanks. Percolation rates are slow, generally more than 60 minutes per inch. Wetness is a concern in basements, and frost action or heaving is a hazard on sidewalks, driveways, patios, roads, streets, and alleys. Tile drainage around a homesite or building helps to correct this condition. If feasible, tile drainage can be installed along streets and roads also.

The more sloping soils require control of runoff and erosion. Derinda, Schapville, and Shullsburg soils have a high shrink-swell potential that can cause basement or retaining walls to collapse. This potential is highly significant because the amount of moisture in the soil ranges from low to high. Some Shullsburg and Schapville soils are naturally slipping along a shear plane at some depth. Some county surveyors indicate that some of these soil masses are moving downslope, which can easily cause disruption of building foundations.

COMMUNITY DEVELOPMENT GROUP 6

This group consists of deep, well-drained soils of the Lindstrom, Mt. Carroll, Ostrander, Port Byron, Racine, Seaton, Terril, and Timula series. These soils are nearly level to moderately steep on crests and side slopes of uplands and are level on some benches along streams and foot slopes below valley walls.

These soils are in broad, continuous areas and mostly have moderate limitations that affect use. Steep slopes, runoff, and erosion are the principal limitations. Permeability is moderate, and available water capacity is high. Runoff is mostly medium, but on some of the more level areas it is slow. In most areas these soils can be used as sewage absorption fields for septic tanks, but percolation tests are needed for final evaluation.

If developments are planned, consideration should be given to the disposal of runoff. Intensive development greatly increases the rate of runoff as the absorptive surface of the soils is displaced by a hard surface. Erosion is a serious concern in areas that lack vegetative cover or are exposed by excavation. Sediment is readily carried to streams by runoff.

Development on the contour helps control erosion and runoff, and all streets or roads should be planned on the contour. Where possible, runoff should be stored in low or natural drainageways by installing dams and terraces, and roads also can be partly used as a dam. These areas slowly release runoff to lower drainageways and into some of the deeper ravines.

COMMUNITY DEVELOPMENT GROUP 7

This group consists of steep or very steep soils that are underlain by bedrock or its residuum at a depth of 10 to 40 inches. These soils are of the Bellechester, Brodale, Copaston, Dubuque, Frontenac, Marlean, Schapville, Sogn, and Whalan series. They are on walls of stream valleys, in deep ravines, and in entrenched drainageways. The steep slope affects runoff, erosion, and deposition of rock debris. These soils are well drained to excessively drained. Permeability is moderate to rapid. Runoff is rapid or very rapid in all but the Bellechester soils, which absorb a large amount of the runoff.

Most development is severely limited and use of the soils for this purpose has been minimal. In some areas the soils are graded, but roads are difficult or expensive to maintain because of erosion of the roadbeds and ditches, falling rock and debris, and increased amounts of runoff caused by disturbances in natural infiltration. Also, runoff is channeled along these road ditches and concentrated in specific discharge areas, which causes gullying and sedimentation in the soil below. Well-designed roads should be properly graded to contain or slow runoff. Some storage areas, such as small ravines, can be partly dammed to contain some of the runoff.

Where buildings are constructed near or on areas of these soils, erosion and runoff are concerns. Falling rock is a hazard to buildings at the base of these soils.

These soils should be left as natural as possible for the best control of erosion and runoff. Pasturing and excess traffic should be minimized.

COMMUNITY DEVELOPMENT GROUP 8

This group consists of deep, well-drained, moderately steep to very steep soils. These soils are of the Bold, Lindstrom, Racine, Seaton, Terril, and Timula series. They occupy sides of entrenched drainageways or small ravines, some walls of stream valleys, and some foot slopes at the base of valley walls. The steep slope causes runoff and severe susceptibility to erosion in unprotected areas. These soils are normally too steep to be used as sewage absorption fields for septic tanks.

A central system of collecting sewage is needed. Available water capacity is high and very high, and permeability is moderate. Runoff is rapid or very rapid.

Most development is severely limited by steep slopes, runoff, and erosion. If any areas are developed, safe disposal of runoff and control of potential erosion are needed. As much as possible of the development should be on the contour, terraces should be used to control runoff and erosion, and dams should be used in natural storage sites, such as ravines or small coves, to contain or release the runoff very slowly. Grading should be minimized, and bare exposure of any areas should be as brief as possible. Where possible, small grades should be pushed up to catch sediment along the lower edge of building sites.

The hazard of rock and other debris falling from the valley walls should be considered if developments are planned on foot slopes of valley walls.

Very steep areas should be wooded to control runoff, and traffic or pasturing should be restricted or minimized.

Frost action can be a concern in constructing patios, driveways, or sidewalks if water is trapped around houses and not allowed to drain away.

COMMUNITY DEVELOPMENT GROUP 9

This group consists of mostly moderately steep to very steep, well-drained to excessively drained soils of the Estherville, Fairhaven, Gotham, Kegonsa, Lilah, Plainfield, and Salida series. These soils chiefly occupy escarpments of stream benches, but some are on uplands. The hazard of erosion is very severe, especially in gullies, and deep cuts and raw banks are very good sources of sediment that can be carried to nearby flood plains or streams.

Most development is severely limited by steep slopes, runoff, and erosion. If any areas are developed, safe disposal of runoff and control of erosion are needed. As much as possible of the development should be on the contour, terraces should be used to control runoff and erosion, and dams should be used in natural storage sites, such as ravines and small coves, to contain the runoff or release it very slowly. Grading should be minimized, and bare exposure of any areas should be as brief as possible. Where possible, small grades should be pushed up to catch sediment along the lower edge of building sites.

These soils should be planted to permanent vegetation, preferably trees. Runoff from valley walls and drainageways should be controlled to avoid gullying. Traffic and pasturing should be limited or restricted to avoid excess runoff.

Sanitary landfills

Sanitary landfills are not evaluated under community development groupings because they require special study and evaluation by consulting engineers. They are briefly described here to give lay people serving on planning commissions an idea of factors to be considered. Also, consulting engineers can use this information in screening potential sites that require onsite investigation.

Sites for these facilities require careful evaluation. Only a few landfills are generally needed, but many soils in the county are not suitable for this purpose. The less suitable soils can be used if special precautions are taken to overcome the hazards and limitations. Use of the soils for sanitary landfills is evaluated in table 7.

Soils in community development groupings 5, 6, and 8 are most favorable for sanitary landfills. All but Derinda, Schapville, and Shullsburg soils formed in a thick mantle of loess or glacial till. They have moderate to moderately slow permeability. The compacted permeability is medium to low. Some of the soils in group 5 have some seepage that can cause wetness in deep trenches. These soils could provide a well-sealed base to any landfill. Some of the soils in group 8 are too steep.

Most of the other groupings have severe limitations or are unsuited to sanitary landfill for these reasons: flood hazard in group 1; permanent or seasonal water table in group 2; rapidly permeable substratum in group 3; depth to bedrock is 1 foot to 3 feet in group 4 and in some of the soils in group 7; and steepness of slope in groups 7, 8, and 9.

Sewage lagoons

Sewage lagoons are needed in some of the developments that are not near municipal disposal systems or that are in communities that use lagoons as part of their systems. Degree and kind of limitation of each soil if used for lagoons is given in table 7. Soils in community development groups 5 and 6 are most favored for this use because they are deep, especially those in group 5 that have moderately slow or slow permeability. The rest of the groups have severe limitations and are unsuitable for sewage lagoons for these reasons: flood hazard in group 1; water table in group 2; soil shallow over bedrock or bedrock residuum in groups 3 and 7; steepness of slope in groups 7, 8, and 9; and special sealing needed in group 3.

Outdoor recreation grouping

This section deals specifically with use of the soils for intensive play areas, camp and picnic areas, and paths and trails. Suitable sites are also indicated for outdoor classrooms.

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.

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 free of coarse fragments and rock outcrops, good drainage, freedom from flooding during periods of heavy use, and a surface that is firm after rains but not dusty when dry. If grading and leveling are required, depth to rock is important.

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.

The main soil limitations considered in the groupings are wetness, flooding, slope, texture of surface layer, and presence of coarse material or rock outcrop on the surface. These limitations are identified and rated as slight, moderate, or severe. Other characteristics are also listed, but not all are rated. Some of the severe limitations can be corrected or adjusted for in the layout of recreation areas. Preventive measures should be taken to control limitations rated moderate. Soils that have only slight limitations require little or no attention.

Sewage facilities are not considered in this section, but are needed in the overall use of any facility. In some of the groupings the use of sewage absorption facilities is severely limited. The information given in table 7 should be checked. Many of these soils have natural woodland that can be used for hiking trails or outdoor classrooms. Refer to the woodland section for guidance in developing these sites.

Soils that have common characteristics are grouped as they affect these recreation uses in about the same way. A description of each of the 13 groups follows.

OUTDOOR RECREATION GROUP 1

This group consists of very frequently flooded and frequently flooded Chaseburg, Colo, McPaul, and Orion soils and Alluvial land. These soils range from well drained to poorly drained. They occupy all parts of natural drainageways. Permeability is moderate or moderately slow. Except for Alluvial land, texture is medium and moderately coarse.

The hazard of flooding severely limits use of these soils for permanent campsites, picnic areas, or playgrounds. Flooding is hazardous to life, and although trails can be planned in some areas, precautions need to be taken against flash flooding. Wetness also severely limits the use of Colo and Orion soils.

Soils in this group provide sites for environmental studies on the evolution of flood plains and the kinds of sediment in which they formed. Some areas of Alluvial land are ideal for rock collectors because small stones are scattered over the surface.

OUTDOOR RECREATION GROUP 2

This group consists of infrequently flooded, well-drained to somewhat poorly drained, level soils of the Ankeny, Lawson, Radford, and Zumbro series. These soils are on the more elevated parts of flood plains that are more distant from natural stream channels. Flooding is infrequent, but is most likely following periods of extensive snowmelt or after very heavy seasonal rain. Radford soils flood somewhat more frequently than the other soils.

The hazard of flooding is moderate for playgrounds, picnic areas, or camping areas. This hazard is significant, but some developments can be established because floods are infrequent. Most of these soils are in scenic valleys and are protected from prevailing winds. Evacuation plans should be developed in the event of a serious flood.

Lawson and Radford soils are somewhat poorly drained and have moderate limitations. Runoff remains longer than on the other soils and causes campsites to be wet and some access roads that service picnic areas, campsites, and playgrounds to be soft. More surface drainage, such as shallow waterways, is needed to remove the slow runoff from rain showers. Roads require a firm base because of potential softening of the surface layer in very wet periods.

OUTDOOR RECREATION GROUP 3

This group consists of poorly drained and very poorly drained, nearly level soils of the Biscay, Bremer, Canisteo, Garwin, Houghton, and Maxfield series and Marsh. These soils occupy flood plains and drainageways or sides of drainageways. A seasonal or permanent water table is at a depth of less than 4 feet and severely limits any potential recreation development. Runoff is slow or very slow. Most areas are frequently very wet, and some areas are ponded for brief periods. Access roads are difficult to maintain because the surface layer is soft and has very low bearing strength. Frost heaving is common also.

The hazard of flooding severely limits the use of most soils in this group, although flooding is infrequent. The Maxfield and Garwin soils in swales are more frequently flooded than the other soils.

Dugout ponds can be easily developed in these areas because the water table is high. These soils can be used for waterfowl habitat or as an aquatic outdoor study area. Because some soils that have a seasonal water table tend to dry out during part of the summer, holes should be bored to the desired depth for a pond, and the water level should be observed for a period before construction.

OUTDOOR RECREATION GROUP 4

This group consists of moderately well drained soils of the Joy, Kasson, Klinger, Shullsburg, Skyberg, and Vasa series. Most of these soils are nearly level to gently sloping, but Shullsburg soils have slopes of as much as 14 percent. These soils are on crests and sides of drainageways on broad uplands. Permeability is moderate or moderately slow. Runoff is medium or slow.

Wetness is a moderate limitation if these soils are used for campsites, picnic areas, or playgrounds. During very wet periods, the surface layer is commonly soft and has very low bearing strength. Strength can be added by using gravelly material as a base for access roads and parking areas. Campsites are likely to remain wet longer and surface drainage, such as waterways, should be considered. The hazard of frost heaving is very common in all road and parking areas.

Most areas are farmed and lack permanent natural vegetation. Trees can be reestablished in many areas.

OUTDOOR RECREATION GROUP 5

This group consists of deep, well-drained soils of the Lindstrom, Mt. Carroll, Ostrander, Port Byron, Racine, Seaton, Terril, and Timula series. These soils are mostly nearly level to gently sloping. They are mainly on high crests or summits on uplands, but some are on benches or foot slopes. They are medium textured. Permeability is moderate. Runoff is medium.

These soils have slight or no limitations that affect use for playgrounds, picnic areas, campsites, and trails. The silt loam surface layer affects trafficability because it can be slippery when wet and very dusty when dry. During very wet periods all soils of this group are commonly soft; therefore all access roads and parking areas should have a gravel surface for adequate strength.

Some of these soils, such as Racine and Seaton soils, have stands of timber that provide excellent outdoor facilities. Permanent vegetation can be reestablished in many areas.

OUTDOOR RECREATION GROUP 6

This group consists of deep, well-drained, sloping to steep soils of the Lindstrom, Mt. Carroll, Port Byron, Ostrander, Racine, Seaton, Terril, and Timula series. These soils are mostly on side slopes between crests and small drainageways on uplands or on foot slopes below very steep soils such as those on valley walls. Some are on side slopes above valley walls. These soils are mostly medium textured. Permeability is moderate. Runoff is medium to rapid.

The steepness of slope is the major limitation. It is severely limiting to playgrounds, is moderately to severely limiting to picnic areas and campsites, and is slightly limiting to trails. Slope primarily affects installation, and where practical all facilities should be on the contour, especially access roads. All access roads should be gravelled as they tend to become dusty when dry or slippery when wet. Although erosion and runoff are not considered limitations, they need to be controlled in these areas. Some runoff can be stored in impoundments. The local Soil Conservation District office can assist in planning a layout to accommodate various recreation facilities.

Some of these soils are wooded and can be developed as natural areas, especially the Racine and Seaton soils.

OUTDOOR RECREATION GROUP 7

This group consists of well drained and somewhat excessively drained, nearly level and gently sloping soils of the Copaston, Dodgeville, Dubuque, Eleva, Gale, and Whalan series. These soils are mostly on crests of narrow upland ridges. They are medium textured and moderately coarse textured, and the depth to limestone or sandstone ranges from 20 to 40 inches. Permeability is moderate or moderately rapid. Runoff is medium.

The underlying bedrock severely limits the development of playgrounds and moderately limits picnic areas and campsites. The main concern is to avoid extensive grading. These soils are slightly limited for trails. Control of runoff and erosion and a better overall utilization of a site can be obtained if all development is on the contour. Assistance is available from the local Soil Conservation District office for layout that helps control erosion and runoff.

Some soils, such as Eleva, Dubuque, and Whalan soils, have never been cultivated and have some natural woodland. These areas can be developed for outdoor classrooms.

OUTDOOR RECREATION GROUP 8

This group consists of well-drained and moderately well drained, sloping to moderately steep soils of the Copaston, Derinda, Dodgeville, Dubuque, Eleva, Schapville, and Whalan series. These soils are mostly on the upper sides of narrow upland ridges, just above very steep soils on valley walls. They are mostly medium textured and moderately coarse textured, and the depth to bedrock ranges from 20 to 40 inches. Derinda and Schapville soils are moderately fine textured to fine textured. Permeability is mostly moderate. Runoff is medium to rapid.

The steepness of slope and depth to bedrock are severe limitations for playgrounds and moderate to severe limitations for campsites and picnic areas. The limitation for trails is slight. All facilities should be on the contour as much as possible for better control of runoff and erosion and better overall utilization of these sites. Assistance is available from the local Soil Conservation District office for layout that helps control erosion and runoff.

Some soils in this group have never been cultivated and are either natural prairies or woodland.

OUTDOOR RECREATION GROUP 9

This group consists of well drained and moderately well drained, steep to very steep soils of the Bold, Copaston, Derinda, Dubuque, Racine, Schapville, Seaton, Sogn, Timula, and Whalan series. These soils are mostly on sides of walls of entrenched drainageways or deep ravines, but some are on foot slopes or walls of stream valleys. These soils are mostly medium textured, but Schapville soils are moderately fine textured. The depth to bedrock is shallow or very deep. Permeability is moderate in most of these soils but is slow in Derinda and Schapville soils. Runoff is rapid.

The steepness of slope severely limits such uses as campsites, picnic areas, and playgrounds and moderately limits trails. Control of erosion and runoff is needed. Where needed, access roads should be on the contour. Trails should be on the contour because they provide scenic walks for people of most ages, especially where some scenic overlooks are available. Most areas are natural woodland, and some that are in pasture can be replanted to woodland.

OUTDOOR RECREATION GROUP 10

This group consists of well-drained soils of the Alvin, Billett, Dakota, Dickinson, Kegonsa, Fairhaven, and Waukegan series. They are nearly level to gently sloping. These soils are mostly on benches along streams, but some are on uplands. These soils are mostly medium textured or moderately coarse textured and have sand or gravel at a depth of 20 to 40 inches. Permeability is moderate or moderately rapid. Runoff is slow to medium.

These soils have slight or no limitations for playgrounds, picnic areas, campsites, and trails. The Fairhaven, Kegonsa, and Waukegan soils have a silt loam surface layer that commonly is slippery when wet and

very dusty when dry. Most facilities require some gravel for access roads and parking.

Most areas are in stream valleys and are good settings for campsites or picnic areas. They do not provide much permanent vegetation, although some can be established. They are near flood-plain soils or very steep soils that have a heavier cover of vegetation.

OUTDOOR RECREATION GROUP 11

This group consists of nearly level and gently sloping, excessively drained to somewhat excessively drained soils of the Burkhardt, Estherville, Gotham, Lilah, Plainfield, Salida, and Sparta series. These soils have a mostly coarse textured surface layer and subsoil. Much runoff is absorbed because permeability is moderately rapid to very rapid.

These soils have mostly moderate or slight limitations that affect use for campsites, picnic, or playground areas. Soils that have a sandy surface layer, such as Gotham, Plainfield, and Sparta soils, have the most limitations and are likely to be loose and cause problems in trafficability. In open areas these soils are commonly subject to soil blowing. The surface layer of Salida soils is gravelly and contains many stones, and in some places, campsites or playgrounds are difficult to install. Most access roads and parking areas are fairly easy to maintain and require little or no grading and little or no gravel on the surface.

These soils are droughty and can only support limited vegetative cover. They are suited to specific kinds of trees.

OUTDOOR RECREATION GROUP 12

This group consists of excessively drained and well drained, very steep soils of the Bellechester, Brodale, Frontenac, Marlean, and Sogn series. These soils are on walls of most stream valleys or deep ravines. They are medium textured or coarse textured. Permeability is rapid to moderate. Runoff is rapid or very rapid.

The steepness of slope severely limits all recreation uses, such as campsites, picnic areas, playgrounds, and trails. Some steep, rigorous trails can be established, but the number of trails should be minimized because of potential increases in runoff.

These areas can be used for nature studies because some unique plants grow on them. On most south-facing and west-facing slopes, mostly the Bellechester, Brodale, and Sogn soils, the microclimate is very warm and dry. Warm-season grasses grow in these areas, and tree growth is limited. The other soils are mostly on north-facing and east-facing slopes and are much cooler and moister. Much of the native hardwood forest is in these areas.

OUTDOOR RECREATION GROUP 13

This group consists of well-drained to excessively drained, sloping to steep soils of the Billett, Dickinson, Estherville, Fairhaven, Gotham, Kegonsa, Lilah, Plainfield, and Salida series. These soils are on escarpments along benches of streams or on foot slopes at the base of valley walls. They are medium textured to coarse textured. Permeability is very rapid to moderate. Runoff is slow to rapid, although much of it is absorbed.

The steepness of slope severely limits uses such as picnic areas, playgrounds, and campsites, especially where slopes are more than 12 percent. Less sloping areas are more favorable for these uses. The loose sandy surface layer of Gotham and Plainfield soils is moderately limiting because it makes hiking or other travel difficult. These soils are very susceptible to erosion, especially gullying where runoff collects. Runoff from developed sites is faster and heavier because the natural soil is disturbed. Much of the runoff gets into stream channels. More of these areas should be left in permanent vegetation.

Formation and Classification of the Soils

This section consists of two main parts. The first part explains how factors of soil formation have affected the development of soil classification currently used and places the soil series in classes of that system.

Factors of Soil Formation

Soil is formed by weathering and other processes that act upon parent material. The characteristics of the soil at any given point depend upon the physical and mineral composition of the parent material; the climate under which the soil material has accumulated and existed since accumulation; the plant and animal life on and in the soil; the relief, or lay of the land; and the length of time the forces of soil formation have acted on the soil material.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material also affects the kind of soil profile that is formed and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil profile. It may be much or little, but some time is always required for differentiation of soil horizons. Usually a long time is required for the formation of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four. Many of the processes of soil formation are unknown.

Parent material

The soils of Goodhue County formed mainly in loess, glacial till, glacial outwash, alluvium, and bedrock or its residuum. Loess, basically a silty material, covers most areas of the county. It occurs as two different materials. The first is a fine loess averaging 20 to 40 inches in thickness. It is dominantly particles less than 20 microns in diameter and is the uppermost in a sequence of deposits on the upland areas of most of the county. Underlying this fine loess is a coarse loess that is dominantly particles coarser than 20 microns in diameter. The coarse silt and very fine sand are mainly on the broad uplands. Port Byron soils are an example

of soils formed in this material. The loess ranges from 4 to 10 feet to as much as 30 feet in thickness adjacent to some river valleys. The principal loess areas are around the Cannon and Mississippi River tributaries. The loess is lacking next to most of the principal streams and in large areas west and southwest of Cannon Falls. In the southwestern and western areas of the county, the loess thins to 24 to 40 inches (*3*).

Glacial till underlies the loess in most of the southern two-thirds of the county at a depth of 2 to 8 feet. Soils such as Klinger soils formed in 24 to 40 inches of loess over glacial till. In some areas Garwin soils formed in 8 feet of loess, and the underlying material commonly has glacial till at this depth. The upper 24 to 40 inches of this loess is fine particles dominantly less than 20 microns in diameter.

Outwash and alluvial sediments are in most stream valleys or tributaries. The outwash deposited from earlier glacial periods is generally more than 10 feet thick. In some areas, soils such as Fairhaven soils have 20 to 50 inches of loamy or silty material over sand and gravel. Other soils, such as Salida soils, are gravelly or sandy to the surface. The alluvium in stream bottoms is cobbly to silty. Part of the sediment is recent deposition from eroding farmland. The composition of the alluvium varies with the landscape. Most soils along drainageways on uplands, such as the McPaul soils, have approximately 10 to 60 inches of recent silty sediment. They are largely silt loams and range from 10 to 18 percent clay. They also contain some thin strata of sand. Below this are buried soils, made up of loam, silt loam, silty clay loam, or strata of sandy or gravelly sediment. These drainageways have slopes that mainly range from 1 to 4 percent, but the drainageways that extend through areas of steep and very steep soils on valley walls along the major streams have slopes that range from 3 to 12 percent. The alluvium here is largely fragmented or cobbly material deposited by runoff from high-velocity floods. Near the large flood plains, where most of these drainageways terminate, the sediment is sandy or silty. Many of these areas are alluvial.

Alluvium in major flood plains is of both recent and older sediment. The sediment is thickest in the path of side-valley tributaries or in areas adjacent to a stream channel. The parts of the flood plains that are at higher elevations and are farther from stream channels consist of older alluvium, as in the Bremer soils. The recent sediment is very thin or is absent in these areas. Some flood plains are made up mainly of sandy material.

Bedrock material is also a part of soils as it occurs as outcroppings on valley walls and on narrow upland divides. In places, it is weathered to a clayey residuum or a cobbly debris such as in Frontenac soils. The major formations are the Oneota Limestone and Jordan Sandstone, which outcrop along very steep hillsides near the Mississippi River and some of the key tributaries. Outcroppings of the Oneota Limestone, Shakopee Limestone, and St. Peter Sandstone occur farther upstream from these areas and extend across northern and midcentral and southeastern parts of the county. Outcrops of Platteville Limestone, Decorah Shale, and Galina Limestone start in the vicinity of Belle Creek Township and extend west and south from that area. For more information regarding extent and more precise locations, refer to geological maps published by the University of Minnesota Geological Survey (*8*).

Climate

Climate is a major factor in determining the kinds of soils that form from different kinds of parent material. It determines the vegetation and influences the rate and intensity of the physical, chemical, and biological relationships in the soil profile, chiefly through the effects of precipitation and temperature. In turn, the effects of climate and vegetation vary according to the topography and the length of time the parent material has been in place.

The climate is essentially uniform throughout Goodhue County. It is described in detail in the section "General Nature of the County." The entire county is warm in summer and very cold in winter, although the very steep south-facing and west-facing slopes tend to be comparatively sunny, warm, and very dry.

Plants and animals

Plants and animals, and particularly plants, are among the key factors in the formation of soils of Goodhue County. Most of these soils formed under deciduous hardwood forest, and a lesser acreage formed under prairie. A few soils that have very young profiles are essentially unweathered and are not influenced greatly by either kind of vegetation. Most of these soils are on flood plains in recent alluvium.

Soils formed under deciduous hardwood forest show considerable leaching in the upper part of the profile. Most soluble minerals are removed from the solum. A large amount of clay particles are translocated from the A horizon into the B horizon. They accumulate as films on ped faces and as threads in fine pores in the B horizon. They usually appear dark and shiny.

Soils formed under forest, such as Seaton soils, have a thin dark A1 horizon. Below this is an ashy or grayish A2 horizon. The main part of the B horizon is the B2t horizon, which is the zone of greatest clay accumulation. A B3 horizon may occur as a transition to the parent material or C horizon.

Soils formed under prairie, such as Port Byron soils, are also leached, but they do not have the movement of clay as do soils formed under the hardwood forests. Not all prairie soils are leached, and some contain small amounts of calcium carbonate in the profile. Some soils, such as Mt. Carroll soils, show displacement of fine clay and are regarded as soils intergrading between prairie and forest soils. The surface layer of a prairie soil is about 10 to 24 inches thick. It is usually subdivided into an A1 horizon and an A3 horizon. The A3 horizon is thin and transitional to the B horizon.

Relief

Relief, through its effect upon drainage, aeration, and erosion, is an important factor in the formation of soils. The importance of relief is apparent in the very steep soils of Goodhue County that adjoin river terraces. Runoff is more rapid from steep soils than from nearly level soils, and much of the soil material is likely to be washed away before a profile forms. Less water also percolates through the steep soils, and some of them, such as the Brodale and Sogn soils, have free

lime accumulations in the upper part of the profile. The soils in swales and other low areas are wet during much of the growing season. They receive more water than can percolate through them, and they are sometimes leached of salts in the upper part of the profile.

Time

The soils of Goodhue County vary in maturity, depending on the length of time the soil-forming forces have been active. Most of the soils formed within the last 3,000 to 20,000 years. Many soils in the county are young because they formed along streams where sediment is still being laid down. Soils such as Marsh are young because they formed in thin layers of organic material. Very young soils such as the Chaseburg soils formed or are forming on the flood plain in recent sediment.

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.

The system of classifying soils used in the United States in recent years was developed in the early 1960's (*4*) and was adopted in 1965 (*6*). 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 the soil series of Goodhue County by family, subgroup, and order, according to the current system.

ORDER.—Ten soil orders are recognized. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are the Entisols and Histosols, which occur in many different climates. The five orders represented in Goodhue County are Inceptisols, Entisols, Mollisols, Alfisols, and Histosols. Entisols are young mineral soils that have only the beginnings of genetic horizons or none. Inceptisols are young mineral soils in which horizons have definitely started to form. Mollisols formed mostly under grass, and they have a thick, dark-colored surface layer. Alfisols have a clay-enriched B horizon that is low in base saturation. Histosols are organic soils.

SUBORDER.—Each order is divided into suborders that are based primarily on those soil characteristics that seem to produce classes with the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging or soil differences resulting from the climate or vegetation.

GREAT GROUP.–Each suborder is divided into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated; those that have pans that interfere with growth of roots, movement of water, or both; and thick, dark-colored surface horizons. The features used are the self-mulching properties of clay, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), dark-red and dark-brown colors associated with basic rocks, and the like. The names of great groups have three or four syllables and are made by adding a prefix to the name of the suborder. An example is *Haplaquoll.*

SUBGROUP.—Each great group is 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 of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group.

FAMILY.—Soil families are established within a subgroup primarily on the basis of properties important to the growth of plants or on the behavior of soils when used for engineering. Among the properties considered are texture, mineral composition, reaction, soil temperature, permeability, thickness of horizons, and consistence. A family name consists of a series of adjectives preceding the subgroup name.

SERIES.—The series consists of a group of soils that formed from a particular kind of parent material and that have genetic horizons that are similar in differentiating characteristics and in arrangement in the profile.

General Nature of the County

This section is provided mainly for those who are not familiar with the county. It describes the topography and climate and gives general statistics on farming in the county.

Topography

Goodhue County is dissected by a very detailed and intricate pattern of creeks or rivers and their numerous tributaries, all leading to the Mississippi River. Most parts of the county have some system of natural surface drainage. Topography ranges from very steep in numerous entrenched river and creek valleys to gently sloping and nearly level on the broad uplands. Most valleys of rivers and tributaries near the Mississippi River have a difference of 350 to 400 feet in elevation. In more distant areas elevations vary from 150 to 250

TABLE 9.—*Soil series classified according to current system of classification*

Series	Family	Subgroup	Order
Alvin	Coarse-loamy, mixed, mesic	Typic Hapludalfs	Alfisols.
Ankeny	Coarse-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Bellechester	Sandy, mixed, mesic	Entic Hapludolls	Mollisols.
Billett	Coarse-loamy, mixed, mesic	Mollic Hapludalfs	Alfisols.
Biscay	Fine-loamy over sandy or sandy-skeletal, mixed, mesic	Typic Haplaquolls	Mollisols.
Bold	Coarse-silty, mixed, calcareous, mesic	Typic Udorthents	Entisols.
Bremer	Fine, montmorillonitic, mesic	Typic Argiaquolls	Mollisols.
Brodale	Loamy-skeletal, carbonatic, mesic	Typic Hapludolls	Mollisols.
Burkhardt	Sandy, mixed, mesic	Typic Haplaquolls	Mollisols.
Canisteo	Fine-loamy, mixed, calcareous, mesic	Typic Haplaquolls	Mollisols.
Chaseburg	Coarse-silty, mixed, mesic, nonacid	Typic Udifluvents	Entisols.
Colo	Fine-silty, mixed, mesic	Cumulic Haplaquolls	Mollisols.
Copaston [1]	Loamy, mixed, mesic	Lithic Hapludolls	Mollisols.
Dakota	Fine-loamy over sandy or sandy-skeletal, mixed, mesic	Typic Argiudolls	Mollisols.
Derinda [1]	Fine, mixed, mesic	Typic Hapludalfs	Alfisols.
Dickinson	Coarse-loamy, mixed, mesic	Typic Hapludolls	Mollisols.
Dodgeville [1]	Fine-silty over clayey, mixed, mesic	Typic Argiudolls	Mollisols.
Dubuque	Fine-silty, mixed, mesic	Typic Hapludalfs	Alfisols.
Eleva	Coarse-loamy, mixed, mesic	Typic Hapludalfs	Alfisols.
Estherville	Coarse-loamy over sandy or sandy-skeletal, mixed, mesic	Typic Hapludolls	Mollisols.
Fairhaven	Fine-loamy over sandy or sandy-skeletal, mixed, mesic	Typic Hapludolls	Mollisols.
Frontenac	Fine-loamy, mixed, mesic	Typic Hapludolls	Mollisols.
Gale	Fine-silty over sandy or sandy-skeletal, mixed, mesic	Typic Hapludalfs	Alfisols.
Garwin	Fine-silty, mixed, mesic	Typic Haplaquolls	Mollisols.
Gotham	Sandy, mixed, mesic	Psammentic Hapludalfs	Alfisols.
Houghton [1]	Euic, mesic	Typic Medisaprists	Histosols.
Joy	Fine-silty, mixed, mesic	Aquic Hapludolls	Mollisols.
Kasson	Fine-loamy, mixed, mesic	Aquollic Hapludalfs	Alfisols.
Kegonsa	Fine-silty over sandy or sandy-skeletal, mixed, mesic	Mollic Hapludalfs	Alfisols.
Klinger [1]	Fine-silty, mixed, mesic	Aquic Argiudolls	Mollisols.
Lawson	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Lilah [1]	Sandy, mixed, mesic	Psammentic Hapludalfs	Alfisols.
Lindstrom	Fine-silty, mixed, mesic	Cumulic Hapludolls	Mollisols.
Marlean	Loamy-skeletal, mixed, mesic	Typic Hapludolls	Mollisols.
Maxfield	Fine-silty, mixed, mesic	Typic Haplaquolls	Mollisols.
McPaul	Coarse-silty, mixed, calcareous, mesic	Mollic Udifluvents	Entisols.
Mt. Carroll	Fine-silty, mixed, mesic	Mollic Hapludalfs	Alfisols.
Orion	Coarse-silty, mixed, nonacid, mesic	Aquic Udifluvents	Entisols.
Ostrander	Fine-loamy, mixed, mesic	Typic Hapludolls	Mollisols.
Plainfield	Mixed, mesic	Typic Udipsamments	Entisols.
Port Byron	Fine-silty, mixed, mesic	Typic Hapludolls	Mollisols.
Racine	Fine-loamy, mixed, mesic	Mollic Hapludalfs	Alfisols.
Radford [1]	Fine-silty, mixed, mesic	Fluventic Hapludolls	Mollisols.
Salida	Sandy-skeletal, mixed, mesic	Entic Hapludolls	Mollisols.
Schapville [1]	Fine, mixed, mesic	Typic Argiudolls	Mollisols.
Seaton	Fine-silty, mixed, mesic	Typic Hapludalfs	Alfisols.
Shullsburg [1]	Fine, mixed, mesic	Aquic Argiudolls	Mollisols.
Skyberg	Fine-loamy, mixed, mesic	Udollic Ochraqualfs	Alfisols.
Sogn	Loamy, mixed, mesic	Lithic Haplustolls	Mollisols.
Sparta [1]	Sandy, mixed, mesic	Entic Hapludolls	Mollisols.
Terril [1]	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Timula	Coarse-silty, mixed, mesic	Typic Eutrochrepts	Inceptisols.
Vasa	Fine-silty, mixed, mesic	Aquollic Hapludalfs	Alfisols.
Waukegan	Fine-silty over sandy or sandy-skeletal, mixed, mesic	Typic Hapludolls	Mollisols.
Whalan	Fine-loamy, mixed, mesic	Typic Hapludalfs	Alfisols.
Zumbro	Sandy, mixed, mesic	Entic Hapludolls	Mollisols.

[1] The following soils in Goodhue County are taxadjuncts because they are outside the range defined for the series:
Copaston soils have limestone bedrock at a depth of 20 to 40 inches.
Derinda soils have a darker colored A horizon.
Dodgeville soils do not have an argillic horizon and have a thinner IIB horizon.
Houghton soils contain more plant fibers, and Houghton muck, seepy, is more sloping.
Klinger soils do not have an argillic horizon.
Lilah soils are less acid in the solum and are coarser textured.
Radford soils have fine stratification throughout.
Schapville soils have a thinner solum and do not have a loess mantle.
Shullsburg soils have grayer colors in the B horizon.
Sparta soils have a coarse sand content in excess of 20 percent.
Terril soils are coarser textured in the upper part of the solum and are sandy loam in the lower part.

feet near Cannon Falls and from 60 to 120 feet near Wanamingo and Kenyon. The highest part of the county is in Cherry Grove Township, where the elevation is approximately 1,260 feet; the lowest part is the flood plain along the Mississippi River that has an elevation of about 680 feet.

Climate [5]

Goodhue County is near the center of the great land mass of the North American continent, and its location is the chief factor in determining its climate. Summers are warm. Southerly winds bring warm, moist air from the Gulf of Mexico, and this is the season of greatest precipitation. Winters are in sharp contrast. The land cools rapidly, and solar heating is less effective when the days are short and the sun is low on the horizon. Prevailing northerly winds cause additional cooling. The air masses are relatively dry, therefore winter is the season of least precipitation. The climate is uniform over the county because there are no sharply marked differences in topography.

Approximately 74 percent, or almost 20.6 inches, of the annual precipitation falls from April through September. Measurable precipitation of 0.01 inch can be expected on about 112 days per year, 5 of which will have 1 inch or more. Rainfall of about 1½ inches an hour can be expected to recur once in two years. Table 10 lists the highest and lowest precipitation expected to occur one year in 10 for each of the 12 months. Annual amounts ranged from a low of 12.74 inches in 1910 to a high of 42.12 inches in 1968. The most precipitation occurred in Zumbrota and was 12.94 inches in June of 1914. About 40 thunderstorms occur on the average each year, and some are accompanied by hail and damaging winds. Nine tornadoes were reported in Goodhue County during the period 1916–1971.

Drought occurs whenever the supply of water for crops, either in the form of rainfall or soil moisture, becomes inadequate. Each day that there is inadequate moisture in the root zone is defined as a drought day. Severe drought conditions have occurred in 4 years between 1931–1970 in southeast Minnesota; 1934 was the worst, and other years were 1931, 1940, and 1964.

The mean temperature of the winter months of December, January, and February is 17.1° F. The cold winters were 1916–1917 and 1935–1936 when the average temperature was 8.8° and 9.1°, respectively. Almost all winters average 3 to 4 days that have a reading of −20° or lower. The first measurable snowfall occurs early in November 2 years out of 10, and the last occurs in April 2 out of 10 years. Annual snowfall averages 34.3 inches. The extreme ranged from 9.7 in 1967–1968 to 70.1 in 1935–1936. Information on snow cover and average depths is given in table 10.

The mean temperature of the summer months of June, July, and August is 68.5°, and daily maximums are in the lower 80's and daily minimums are in the upper 50's. Temperatures of 100° or more occur about 1 in 5 years, and 90° or more about 17 times a year. The all-time highest recorded temperature was 109° on July 14, 1936; the lowest was −45° on January 30, 1951.

The freeze-free period is long enough so that the staple crops of the county reach maturity without danger from frost. The probability of certain temperatures occurring in the spring and fall is shown in table 11 (*2*). For example, 5 years out of 10, or 50 percent of the time, a temperature of 32° or lower can be expected

[5] By JOSEPH STRUB, JR., State climatologist, National Weather Service, U.S. Department of Commerce.

TABLE 10.—*Temperature and precipitation*

[All data recorded at Zumbrota. Based on the normal period 1941–1970, except data for snow cover based on the period 1903–1970]

Month	Temperature				Precipitation				
	Average		Extreme		Average monthly total	One year in 10 will have—		Days with snow cover 1 inch or more	Average depth of snow on days with snow cover
	Daily maximum	Daily minimum	Monthly maximum	Monthly minimum		Less than—	More than—		
	°F	°F	°F	°F	Inches	Inches	Inches	Number	Inches
January	24.0	3.3	41.9	—24.9	0.70	0.15	1.94	26	6
February	28.7	6.8	45.3	—18.2	.56	.15	1.60	21	8
March	39.4	18.7	60.3	—5.6	1.40	.47	2.62	21	7
April	57.9	33.6	78.6	19.7	2.41	.72	4.04	1	0
May	70.4	44.9	87.5	28.0	3.47	1.55	5.55	0	0
June	79.2	55.3	92.3	39.2	4.66	2.03	8.40	0	0
July	84.5	59.0	94.8	45.5	4.23	1.14	6.48	0	0
August	82.8	57.2	93.6	41.7	3.48	1.40	5.33	0	0
September	72.9	47.9	88.0	29.0	3.34	1.10	7.03	0	0
October	63.1	37.9	77.8	20.3	2.30	.66	4.23	(1)	0
November	42.7	24.1	63.4	1.8	1.08	.15	2.84	4	4
December	28.9	10.5	48.2	—15.8	.96	.19	1.78	18	5
Year	56.2	33.3	[2]96.0	[3]—26.8	28.50	20.28	34.74	91	

[1] Less than 0.5 day.
[2] Average annual highest temperature.
[3] Average annual lowest temperature.

TABLE 11.—*Probabilities of last freezing temperature in spring and first in fall*

[All data recorded at Zumbrota]

Probability	Dates for given probabilities and temperatures				
	16° F or lower	20° F or lower	24° F or lower	28° F or lower	32° F or lower
Spring:					
1 year in 10 later than	April 9	April 23	May 2	May 16	May 28
2 years in 10 later than	April 3	April 17	April 26	May 10	May 22
5 years in 10 later than	March 24	April 6	April 16	April 30	May 12
Fall:					
1 year in 10 earlier than	October 21	October 12	October 3	September 17	September 11
2 years in 10 earlier than	October 27	October 18	October 8	September 23	September 17
5 years in 10 earlier than	November 9	October 30	October 19	October 4	September 26

to occur after May 12. In the fall the 50 percent probability of a temperature of 32° is September 26th.

Long term records of humidity, cloudiness, and windspeed are not available for Goodhue County but are available from National Weather Service stations at nearby airports. The following information is based on Rochester, Minnesota, records. The average windspeed and prevailing wind direction for winter is 12.5 miles per hour from the northwest, and for summer is 10.5 miles per hour from the south-southeast. Noontime humidity averages near 59 percent in summer and 59 percent in winter. In an average year 100 days are clear, 95 are partly cloudy, and 170 are cloudy.

Farming

Goodhue County is largely rural. In 1970, according to Minnesota agricultural statistics, 1,834 farms were in the county, and the total land area was about 388,226 acres. In 1970, approximately 7,572 people lived on these farms. The early farms raised wheat, and little attention was paid to any other crops. In 1873 the wheat acreage increased to 134,647 acres, the crop was 3,225,000 bushels, and Red Wing was the largest primary wheat market in the world. Grain was hauled to Red Wing from as far as Owatonna, Albert Lea, and Austin. In the early 1880's, chinch bugs and other pests almost caused a complete crop failure, which forced farmers to diversify crops and to develop dairy and livestock farming. Barley became a leading crop. In the 1930's, declining yields, erosion, and barley diseases caused an increase in alfalfa acreage and a decline in small grain acreage. Since that time, the corn crop has increased and the amount of alfalfa grown for hay has decreased. In the last few years, soybeans as a cash crop have increased rapidly. Corn is now the leading crop, followed by hay, soybeans, and oats.

A total of 111,600 acres of corn and 45,300 acres of soybeans was harvested for grain in 1971. In that year, oats was grown for all purposes on 36,400 acres, and hay was cut from 60,400 acres.

Livestock is a major source of income in Goodhue County. In 1969 there were 84,000 cattle and calves, 47,800 hogs and pigs, and 101,000 chickens. Some sheep and turkeys were also raised.

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Glossary

Alluvial fan. A fan-shaped deposit of sand, gravel, and fine material dropped by a stream where its gradient lessens abruptly.

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.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Chert. Coarse fragments in soil that are angular and less than 3 inches in diameter.

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.

Clay film. A thin coating of clay on the surface of a soil aggregate. Synonyms: clay coat, clay skin.

Cobblestone. A rounded or partly rounded fragment of rock, 3 to 10 inches in diameter.

Colluvium. Soil material, rock fragments, or both, moved by

creep, slide, or local wash and deposited at the base of steep slopes.

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.

Deep soil. One in which the R horizon is at a depth of 40 inches or more.

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 horizon and upper part of the B horizon and have mottling in the lower part of the B horizon and the C horizon.

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.

Drift (geology). Material of any sort deposited by geologic processes in one place after having been removed from another; includes drift materials deposited by glaciers and by streams and lakes associated with them.

Erosion. The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

Esker (geology). A narrow, winding ridge or mound of stratified gravelly and sandy drift that was deposited by a subglacial stream.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors such as light, moisture, temperature, and the physical condition of the soil are favorable.

Flaggy soils. Soils that contain thin fragments, 6 to 15 inches long, of sandstone, limestone, slate, shale, or schist.

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Glacial outwash (geology). Cross-bedded gravel, sand, and silt deposited by melt water as it flowed from glacial ice.

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Ground moraine (geology). Glacial till accumulated beneath the advancing ice and deposited from it during its dissolution, rather than aggregated in a thickened belt at the ice edge; the deposit is relatively thin and characteristically forms an undulating plain with gently sloping swells, sags, and closed depressions.

Ground water (geology). Water that fills all the unblocked pores of underlying material below the water table, which is the upper limit of saturation.

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.

Internal soil drainage. The downward movement of water through the soil profile. The rate of movement is determined by the texture, structure, and other characteristics of the soil profile and underlying layers, and by height of the water table, either permanent or perched. Relative terms for expressing internal drainage are *none, very slow, slow, medium, rapid,* and *very rapid.*

Kame (geology). An irregular, short ridge or hill or stratified glacial drift.

Lacustrine deposit (geology). Material deposited in lake water and exposed by lowering of the water level or elevation of the land.

Leaching. The removal of soluble materials from soils or other material by percolating water.

Loess. Fine-grained material, dominantly of silt-sized particles, that has been deposited by wind.

Moderately deep soil. Soil in which the R horizon is at a depth of 20 to 40 inches.

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.

Organic soil. A general term applied to a soil or to a soil horizon that consists primarily of organic matter, such as peat soils, muck soils, and peaty soil layers. In chemistry, organic refers to the compounds of carbon.

Paha (geology). Longitudinal dunelike landforms about 20 to 50 feet high, 200 to 1,000 feet wide, and 1,000 to 2,500 feet long. They are silt loams or very fine sandy loams, and the dominant soil particles are coarse silts or very fine sands. They generally rest on glacial tills or bedrock benches.

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.*

Pore space. That fraction of the total space in a soil that is not occupied by solid particles.

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
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline	9.1 and higher

Runoff (hydraulics). The part of the precipitation upon a drainage area that is discharged from the area in stream channels. The water that flows off the land surface without sinking in is called surface runoff; that which enters the ground before reaching surface streams is called groundwater runoff or seepage flow from ground water.

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.

Shallow soil. Soil in which the R horizon is at a depth of 20 inches or less.

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.

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 grained* (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.

Subsurface soil. The A2 horizon, or layer just below the surface layer.

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.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt 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."

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.

Wheel-track planting. Planting a crop in a plowed field in the tractor wheel tracks. The weight of the wheels crushes and firms the soil, leaving a rough surface that reduces the hazard of erosion.

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GUIDE TO MAPPING UNITS

For complete information about a mapping unit, read both the description of the mapping unit and that of the soil series to which the mapping unit belongs. Other information is given in tables as follows:

Acreage and extent, table 1, page 10.
Predicted yields, table 2, page 73.
Woodland, table 3, page 76.
Engineering, tables 6, 7, and 8, pages 80 to 113.

Map symbol	Mapping unit	Page	Capability unit		Woodland group	Community development group	Outdoor recreation group
			Symbol	Page	Number	Number	Number
Af	Alluvial land, frequently flooded	9	VIw-2	71	7	1	1
An	Alluvial land, sloping	9	VIw-3	71	7	1	1
AvA	Alvin fine sandy loam, 0 to 3 percent slopes	11	IIs-1	66	3	3	10
AxA	Ankeny sandy loam, 0 to 3 percent slopes	12	IIs-1	66	8	1	2
BaF	Bellechester sand, 25 to 45 percent slopes	12	VIIs-1	71	6	7	12
BbB	Billett sandy loam, 2 to 6 percent slopes	13	IIIe-4	68	3	3	10
BbC	Billett sandy loam, 6 to 12 percent slopes	13	IVe-4	70	3	3	13
Bc	Biscay loam	14	IIw-1	66	9	2	3
Bm	Bremer silty clay loam, wet	15	IIIw-3	69	9	1	3
BoE	Brodale-Sogn flaggy loams, steep	15	VIIs-2	71	6	7	12
BoF	Brodale-Sogn flaggy loams, very steep	15	VIIIs-1	72	6	7	12
BrA	Burkhardt loam, 0 to 3 percent slopes	17	IIIs-1	69	4	3	11
Ca	Canisteo silty clay loam	18	IIw-1	66	9	2	3
ChA	Chaseburg silt loam, 0 to 3 percent slopes	18	IIw-3	66	7	1	1
Co	Colo silty clay loam	19	IIIw-3	69	9	1	1
CvB	Copaston loam, 1 to 6 percent slopes	19	IIIe-3	67	3	4	7
CvC2	Copaston loam, 6 to 12 percent slopes, eroded	19	IVe-3	70	3	4	8
CwB	Copaston loam, moderately deep, 0 to 6 percent slopes	20	IIe-2	65	3	4	7
CwC2	Copaston loam, moderately deep, 6 to 12 percent slopes, eroded	20	IIIe-2	67	3	4	8
DaA	Dakota loam, 0 to 3 percent slopes	21	IIs-1	66	3	3	10
DeC2	Derinda silt loam, 5 to 12 percent slopes, eroded	21	IIIe-2	67	3	5	8
DeD2	Derinda silt loam, 12 to 25 percent slopes, eroded	21	IVe-2	69	3	5	9
DkA	Dickinson sandy loam, 0 to 2 percent slopes	22	IIIs-1	69	3	3	10
DkB	Dickinson sandy loam, 2 to 6 percent slopes	22	IIIe-4	68	3	3	10
DkC	Dickinson sandy loam, 6 to 12 percent slopes	22	IVe-4	70	3	3	13
DoB	Dodgeville silt loam, 1 to 6 percent slopes	23	IIe-2	65	3	4	7
DoC2	Dodgeville silt loam, 6 to 12 percent slopes, eroded	23	IIIe-2	67	3	4	8
DuB2	Dubuque silt loam, 2 to 6 percent slopes, eroded	24	IIe-2	65	3	4	7
DuC2	Dubuque silt loam, 6 to 12 percent slopes, eroded	24	IIIe-2	67	3	4	8
DuD2	Dubuque silt loam, 12 to 18 percent slopes, eroded	24	IVe-2	69	3	4	8
DuF	Dubuque silt loam, 18 to 35 percent slopes	24	VIIe-2	71	5	7	9

Map symbol	Mapping unit	Page	Capability unit		Woodland group	Community development group	Outdoor recreation group
			Symbol	Page	Number	Number	Number
EeB	Eleva sandy loam, 2 to 6 percent slopes--	25	IIIe-4	68	3	4	7
EeD	Eleva sandy loam, 6 to 18 percent slopes-	25	IVe-4	70	3	4	8
EsA	Estherville loam, 0 to 6 percent slopes--	26	IIIs-1	69	4	3	11
EsC	Estherville soils, 6 to 18 percent slopes----------	26	IVe-4	70	4	9	13
FaA	Fairhaven silt loam, 0 to 3 percent slopes----------	27	IIs-1	66	3	3	10
FrE	Frontenac soils, steep----------	28	VIIe-2	71	5	7	12
FrF	Frontenac soils, very steep----------	28	VIIe-2	71	5	7	12
GaA	Gale silt loam, 0 to 3 percent slopes----	29	IIs-1	66	3	4	7
Gm	Garwin silty clay loam----------	29	IIw-1	66	9	2	3
Gr	Garwin silty clay loam, swales----------	30	IIIw-1	68	9	2	3
GtB	Gotham fine sand, 2 to 12 percent slopes-	30	IVs-1	70	4	3	11
GtD	Gotham fine sand, 12 to 35 percent slopes----------	30	VIIs-1	71	4	9	13
Ho	Houghton muck----------	31	VIw-1	70	9	2	3
Hs	Houghton muck, seepy----------	31	VIw-1	70	9	2	3
JoA	Joy silt loam, 0 to 3 percent slopes-----	32	I-2	65	2	5	4
KaA	Kasson silt loam, 1 to 3 percent slopes--	33	IIs-2	66	2	5	4
KeA	Kegonsa silt loam, 0 to 3 percent slopes-	33	IIs-1	66	3	3	10
KfD	Kegonsa and Fairhaven silt loams, 6 to 18 percent slopes----------	34	IIIe-2	67	3	9	13
KnA	Klinger silty clay loam, 1 to 3 percent slopes----------	34	I-2	65	2	5	4
La	Lawson silt loam----------	35	IIw-2	66	8	1	2
LlA	Lilah sandy loam, 0 to 6 percent slopes--	36	IVs-1	70	4	3	11
LlD	Lilah sandy loam, 6 to 35 percent slopes-	36	VIIs-1	71	4	9	13
LnB	Lindstrom silt loam, 2 to 6 percent slopes----------	36	IIe-1	65	1	6	5
LnC	Lindstrom silt loam, 6 to 12 percent slopes----------	36	IIIe-1	67	1	6	6
LnD	Lindstrom silt loam, 12 to 25 percent slopes----------	37	IVe-1	69	1	8	6
MaE	Marlean soils, steep----------	37	VIIs-2	71	5	7	12
MaF	Marlean soils, very steep----------	38	VIIs-2	71	5	7	12
Md	Marsh----------	38	VIIIw-1	71	9	1	3
Mf	Maxfield silty clay loam----------	39	IIw-1	66	9	2	3
Mo	Maxfield silty clay loam, swales---------	39	IIIw-1	68	9	2	3
Mp	McPaul silt loam----------	39	IIw-3	66	7	1	1
MrA	Mt. Carroll silt loam, 0 to 2 percent slopes----------	40	I-1	64	1	6	5
MrB	Mt. Carroll silt loam, 2 to 6 percent slopes----------	41	IIe-1	65	1	6	5
MrC2	Mt. Carroll silt loam, 6 to 12 percent slopes, eroded----------	41	IIIe-1	67	1	6	6
MxA	Mt. Carroll silt loam, benches, 0 to 3 percent slopes----------	41	I-1	64	1	6	5
Or	Orion silt loam, wet----------	41	IIIw-3	69	9	1	1
OtB	Ostrander silt loam, 1 to 6 percent slopes----------	42	IIe-1	65	1	6	5
OtC2	Ostrander silt loam, 6 to 12 percent slopes, eroded----------	42	IIIe-1	67	1	6	6
PaB	Plainfield loamy sand, 0 to 6 percent slopes----------	43	IVs-1	70	4	3	11
PaD	Plainfield loamy sand, 6 to 25 percent slopes----------	43	VIIs-1	71	4	9	13

Map symbol	Mapping unit	Page	Capability unit		Woodland group	Community development group	Outdoor recreation group
			Symbol	Page	Number	Number	Number
PbA	Port Byron silt loam, 0 to 2 percent slopes	44	I-1	64	1	6	5
PbB	Port Byron silt loam, 2 to 6 percent slopes	44	IIe-1	65	1	6	5
PbC2	Port Byron silt loam, 6 to 12 percent slopes, eroded	45	IIIe-1	67	1	6	6
PoA	Port Byron silt loam, benches, 0 to 3 percent slopes	45	I-1	64	1	6	5
RaB	Racine silt loam, 1 to 6 percent slopes	46	IIe-1	65	1	6	5
RaC	Racine silt loam, 6 to 12 percent slopes	46	IIIe-1	67	1	6	6
RaC2	Racine silt loam, 6 to 12 percent slopes, eroded	46	IIIe-1	67	1	6	6
RaD2	Racine silt loam, 12 to 18 percent slopes, eroded	46	IVe-1	69	1	8	6
RaE	Racine soils, 18 to 35 percent slopes	47	VIIe-1	71	1	8	9
Rd	Radford silt loam	47	IIw-2	66	8	1	2
SaB	Salida gravelly coarse sand, 1 to 12 percent slopes	49	IVs-1	70	4	3	11
SaE	Salida gravelly coarse sand, 12 to 45 percent slopes	49	VIIs-1	71	4	9	13
ScC	Schapville silty clay loam, 2 to 12 percent slopes	49	IIIe-2	67	3	5	8
ScD	Schapville silty clay loam, 12 to 18 percent slopes	50	IVe-3	70	3	5	8
SdE	Schapville-Sogn complex, 18 to 35 percent slopes	50	VIIs-2	71	6	7	9
SfA	Seaton silt loam, 0 to 2 percent slopes	51	I-1	64	1	6	5
SfB	Seaton silt loam, 2 to 6 percent slopes	51	IIe-1	65	1	6	5
SfC2	Seaton silt loam, 6 to 12 percent slopes, eroded	51	IIIe-1	67	1	6	6
SfD2	Seaton silt loam, 12 to 18 percent slopes, eroded	51	IVe-1	69	1	6	6
SfE	Seaton silt loam, 18 to 25 percent slopes	51	VIe-1	70	1	8	9
ShC2	Seaton silt loam, valleys, 6 to 12 percent slopes, eroded	52	IIIe-1	67	1	6	6
ShD2	Seaton silt loam, valleys, 12 to 18 percent slopes, eroded	52	IVe-1	69	1	6	6
ShE	Seaton silt loam, valleys, 18 to 25 percent slopes	52	VIe-1	70	1	8	9
SkC2	Seaton complex, 6 to 12 percent slopes, eroded	52	IIIe-1	67	1	6	6
SkD2	Seaton complex, 12 to 25 percent slopes, eroded	52	IVe-1	69	1	6	6
SlE	Seaton, Timula, and Bold silt loams, steep	53	VIIe-1	71	1	8	9
SmC	Shullsburg silty clay loam, 2 to 14 percent slopes	53	IIIw-2	68	2	5	4
Sn	Skyberg silt loam	54	IIIw-2	68	2	2	4
SoD	Sogn and Copaston soils, 12 to 25 percent slopes	56	VIIs-2	71	6	7	9
SpA	Sparta loamy sand, 0 to 3 percent slopes	56	IVs-1	70	4	3	11
TeB	Terril sandy loam, 2 to 6 percent slopes	57	IIe-1	65	1	6	5

Map symbol	Mapping unit	Page	Capability unit		Woodland group	Community development group	Outdoor recreation group
			Symbol	Page	Number	Number	Number
TeC	Terril sandy loam, 6 to 12 percent slopes	57	IIIe-1	67	1	6	6
TeD	Terril sandy loam, 12 to 25 percent slopes	57	IVe-1	69	1	8	6
TmB	Timula silt loam, 2 to 6 percent slopes	59	IIe-1	65	1	6	5
TmC	Timula silt loam, 6 to 12 percent slopes	59	IIIe-1	67	1	6	6
ToD	Timula-Bold silt loams, 12 to 25 percent slopes	59	VIe-1	70	1	8	6
VaA	Vasa silt loam, 0 to 3 percent slopes	60	I-2	65	2	5	4
WaA	Waukegan silt loam, 0 to 3 percent slopes	60	IIs-1	66	3	3	10
WhB	Whalan silt loam, 1 to 6 percent slopes	61	IIe-2	65	3	4	7
WhC2	Whalan silt loam, 6 to 12 percent slopes, eroded	61	IIIe-2	67	3	4	8
WsB	Whalan silt loam, moderately shallow, 1 to 6 percent slopes	61	IIIe-3	67	3	4	7
WsC2	Whalan silt loam, moderately shallow, 6 to 12 percent slopes, eroded	62	IVe-3	70	3	4	8
WsD2	Whalan silt loam, moderately shallow, 12 to 18 percent slopes, eroded	62	IVe-3	70	3	4	8
WsE	Whalan silt loam, moderately shallow, 18 to 35 percent slopes	62	VIIe-2	71	5	7	9
Zu	Zumbro loamy sand	63	IIIs-1	69	7	1	2

U.S. DEPARTMENT OF AGRICULTURE
Washington, D.C. 20250
Soil Survey of Goodhue County, Minnesota

ERRATUM

SOIL LEGEND

The first capital letter is the initial one of the soil name. A second capital letter, A, B, C, D, E, or F, shows the slope. Most symbols without a slope letter are for nearly level soils, but some are for land types that have a considerable range of slope. A final number 2 in the symbol shows that the soil is eroded.

SYMBOL	NAME
Af	Alluvial land, frequently flooded
An	Alluvial land, sloping
AvA	Alvin fine sandy loam, 0 to 3 percent slopes
AxA	Ankeny sandy loam, 0 to 3 percent slopes
BaF	Bellechester sand, 25 to 45 percent slopes
BbB	Billett sandy loam, 2 to 6 percent slopes
BbC	Billett sandy loam, 6 to 12 percent slopes
Bc	Biscay loam
Bm	Bremer silty clay loam, wet
BoE	Brodale-Sogn flaggy loams, steep
BoF	Brodale-Sogn flaggy loams, very steep
BrA	Burkhardt loam, 0 to 3 percent slopes
Ca	Canisted silty clay loam
ChA	Chaseburg silt loam, 0 to 3 percent slopes
Co	Colo silty clay loam
CvB	Copaston loam, 1 to 6 percent slopes
CvC2	Copaston loam, 6 to 12 percent slopes, eroded
CwB	Copaston loam, moderately deep, 0 to 6 percent slopes
CwC2	Copaston loam, moderately deep, 6 to 12 percent slopes, eroded
DaA	Dakota loam, 0 to 3 percent slopes
DeC2	Derinda silt loam, 5 to 12 percent slopes, eroded
DeD2	Derinda silt loam, 12 to 25 percent slopes, eroded
DkA	Dickinson sandy loam, 0 to 2 percent slopes
DkB	Dickinson sandy loam, 2 to 6 percent slopes
DkC	Dickinson sandy loam, 6 to 12 percent slopes
DoB	Dodgeville silt loam, 1 to 6 percent slopes
DoC2	Dodgeville silt loam, 6 to 12 percent slopes, eroded
DuB2	Dubuque silt loam, 2 to 6 percent slopes, eroded
DuC2	Dubuque silt loam, 6 to 12 percent slopes, eroded
DuD2	Dubuque silt loam, 12 to 18 percent slopes, eroded
DuF	Dubuque silt loam, 18 to 35 percent slopes
EeB	Eleva sandy loam, 2 to 6 percent slopes
EeD	Eleva sandy loam, 6 to 18 percent slopes
EsA	Estherville loam, 0 to 6 percent slopes
EsC	Estherville soils, 6 to 18 percent slopes
FaA	Fairhaven silt loam, 0 to 3 percent slopes
FrE	Frontenac soils, steep
FrF	Frontenac soils, very steep
GaA	Gale silt loam, 0 to 3 percent slopes
Gm	Garwin silty clay loam
Gr	Garwin silty clay loam, swales
GtB	Gotham fine sand, 2 to 12 percent slopes
GtD	Gotham fine sand, 12 to 35 percent slopes
Ho	Houghton muck
Hs	Houghton muck, seepy
JoA	Joy silt loam, 0 to 3 percent slopes
KaA	Kasson silt loam, 1 to 3 percent slopes
KeA	Kegonsa silt loam, 0 to 3 percent slopes
KfD	Kegonsa and Fairhaven silt loams, 6 to 18 percent slopes
KnA	Klinger silty clay loam, 1 to 3 percent slopes
La	Lawson silt loam
LlA	Lilah sandy loam, 0 to 6 percent slopes
LlD	Lilah sandy loam, 6 to 35 percent slopes
LnB	Lindstrom silt loam, 2 to 6 percent slopes
LnC	Lindstrom silt loam, 6 to 12 percent slopes
LnD	Lindstrom silt loam, 12 to 25 percent slopes
MaE	Marlean soils, steep
MaF	Marlean soils, very steep
Md	Marsh
Mf	Maxfield silty clay loam
Mo	Maxfield silty clay loam, swales
Mp	McPaul silt loam
MrA	Mt. Carroll silt loam, 0 to 2 percent slopes
MrB	Mt. Carroll silt loam, 2 to 6 percent slopes
MrC2	Mt. Carroll silt loam, 6 to 12 percent slopes, eroded
MxA	Mt. Carroll silt loam, benches, 0 to 3 percent slopes
Or	Orion silt loam, wet
OtB	Ostrander silt loam, 1 to 6 percent slopes
OtC2	Ostrander silt loam, 6 to 12 percent slopes, eroded
PaB	Plainfield loamy sand, 0 to 6 percent slopes
PaD	Plainfield loamy sand, 6 to 25 percent slopes
PbA	Port Byron silt loam, 0 to 2 percent slopes
PbB	Port Byron silt loam, 2 to 6 percent slopes
PbC2	Port Byron silt loam, 6 to 12 percent slopes, eroded
PoA	Port Byron silt loam, benches, 0 to 3 percent slopes
RaB	Racine silt loam, 1 to 6 percent slopes
RaC	Racine silt loam, 6 to 12 percent slopes
RaC2	Racine silt loam, 6 to 12 percent slopes, eroded
RaD2	Racine silt loam, 12 to 18 percent slopes, eroded
RaE	Racine soils, 18 to 35 percent slopes
Rd	Radford silt loam
SaB	Salida gravelly coarse sand, 1 to 12 percent slopes
SaE	Salida gravelly coarse sand, 12 to 45 percent slopes
ScC	Schapville silty clay loam, 2 to 12 percent slopes
ScD	Schapville silty clay loam, 12 to 18 percent slopes
SdE	Schapville-Sogn complex, 18 to 35 percent slopes
SfA	Seaton silt loam, 0 to 2 percent slopes
SfB	Seaton silt loam, 2 to 6 percent slopes
SfC2	Seaton silt loam, 6 to 12 percent slopes, eroded
SfD2	Seaton silt loam, 12 to 18 percent slopes, eroded
SfE	Seaton silt loam, 18 to 25 percent slopes
ShC2	Seaton silt loam, valleys, 6 to 12 percent slopes, eroded
ShD2	Seaton silt loam, valleys, 12 to 18 percent slopes, eroded
ShE	Seaton silt loam, valleys, 18 to 25 percent slopes
SkC2	Seaton complex, 6 to 12 percent slopes, eroded
SkD2	Seaton complex, 12 to 25 percent slopes, eroded
SlE	Seaton, Timula, and Bold silt loams, steep
SmC	Shullsburg silty clay loam, 2 to 14 percent slopes
Sn	Skyberg silt loam
SoD	Sogn and Copaston soils, 12 to 25 percent slopes
SpA	Sparta loamy sand, 0 to 3 percent slopes
TeB	Terril sandy loam, 2 to 6 percent slopes
TeC	Terril sandy loam, 6 to 12 percent slopes
TeD	Terril sandy loam, 12 to 25 percent slopes
TmB	Timula silt loam, 2 to 6 percent slopes
TmC	Timula silt loam, 6 to 12 percent slopes
ToD	Timula-Bold silt loams, 12 to 25 percent slopes
VaA	Vasa silt loam, 0 to 3 percent slopes
WaA	Waukegan silt loam, 0 to 3 percent slopes
WhB	Whalan silt loam, 1 to 6 percent slopes
WhC2	Whalan silt loam, 6 to 12 percent slopes, eroded
WsB	Whalan silt loam, moderately shallow, 1 to 6 percent slopes
WsC2	Whalen silt loam, moderately shallow, 6 to 12 percent slopes, eroded
WsD2	Whalan silt loam, moderately shallow, 12 to 18 percent slopes, eroded
WsE	Whalan silt loam, moderately shallow, 18 to 35 percent slopes
Zu	Zumbro loamy sand

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