SOIL SURVEY OF

Sac County, Iowa

United States Department of Agriculture
Soil Conservation Service
In cooperation with
Iowa State University Agriculture and
Home Economics Experiment Station and
Cooperative Extension Service and the
State of Iowa Department of
Soil Conservation

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. In line with Department of Agriculture policies, benefits of this program are available to all who need the information, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in the period 1968–72. Soil names and descriptions were approved in 1975. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1972. Funds appropriated by Sac County were used for part of the cost of this survey. This survey was made cooperatively by the Soil Conservation Service, Iowa State University Agriculture and Home Economics Experiment Station and Cooperative Extension Service, and the State of Iowa Department of Soil Conservation. It is part of the technical assistance furnished to the Sac County Soil 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, or other structures; and in appraising the value of tracts of land for agriculture, industry, or recreation.

Locating Soils

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

On each sheet of the detailed map, soil areas are outlined and are identified by symbol. 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 in the survey. This guide lists all of the soils of the county in numerical order by map symbol. It shows the page where each kind of soil is described, and also the page for the capability unit in which the soil has been placed.

Individual colored maps showing the relative suitability or limitations of soils for many specific purposes can be developed by using the soil map and information in the text. Interpretations not included in the text can be developed by grouping the soils according to their suitability or limitations for a particular use. 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 in the soil descriptions and in the discussions of the capability units.

Foresters and others can refer to the subsection "Windbreaks and environmental plantings."

Game managers, sportsmen, and others concerned with wildlife will find information about soils and wildlife in the section "Wildlife habitat."

Community planners and others concerned with suburban development can read about the soil properties that affect the choice of homesites, industrial sites, schools, and parks in the "Engineering" and "Recreation" sections.

Engineers and builders will find under "Soil properties" and "Engineering" tables that give engineering descriptions of the soils in the county and that name soil features that affect engineering practices and structures.

Scientists and others can read about how the soils were formed and how they are classified in the section "Formation and classification of soils."

Students, teachers, and others will find information about soils and their management in various parts of the text.

Newcomers in Sac 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 section "General nature of the county," which gives additional information about the county.

Cover: Contour tillage on Galva silty clay loam, 2 to 5 percent slopes.

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SOIL SURVEY OF SAC COUNTY, IOWA

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SAC COUNTY is in northwestern Iowa (fig. 1). It has an area of about 369,920 acres. Sac City is the county seat.

Most of the acreage in the county is in farms. Corn, soybeans, oats, hay, and pasture are the main crops. The raising of hogs and the feeding of beef cattle are the principal livestock enterprises.

Most of the soils in Sac County formed under prairie vegetation. They are dark colored and fertile.

The climate is subhumid and continental. Winters are cold, and summers are warm. The growing season is long enough for crops commonly grown in the county to mature.

How this survey was made

Soil scientists made this survey to learn what kinds of soil are in Sac 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 nature 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 be leaching or by the action of plant roots.

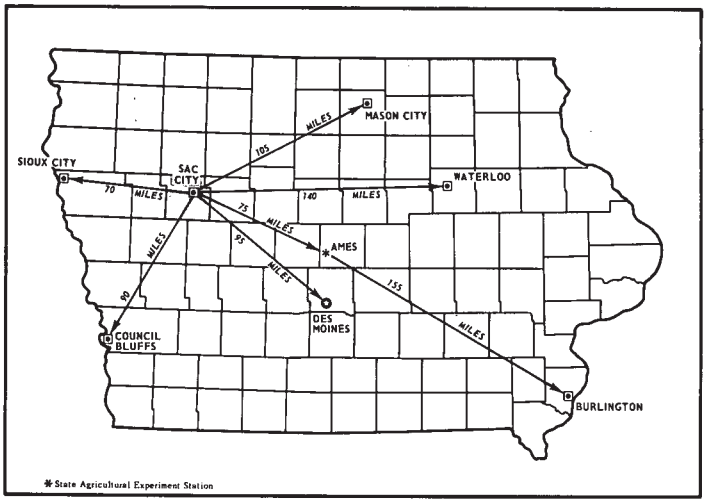

Figure 1.—Location of Sac County in Iowa.

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, management, 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. Galva and Sac, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that affect their behavior in the undisturbed landscape.

Soils of one series can differ in texture of the surface layer and in slope, stoniness, or some other characteristic that affects use of the soils by man. On the basis of such differences, a soil series is divided into phases. The name of a soil phase indicates a feature that affects management. For example, Marshall silty clay loam, 2 to 5 percent slopes, is one of several phases within the Marshall 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 map-

ping 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. One such kind of mapping unit, the soil complex, is shown on the soil map of Sac County.

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. The pattern and relative proportions of the dominant soils 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. Coland-Spillville complex 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, are described in the survey, and are given descriptive names. Alluvial land is an example in this survey.

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 farm records and from field or plot experiments on the same kind of soil. Yields under defined management are estimated for all the soils.

Soil scientists observe how soils behave when used as a growing place for native and cultivated plants and as material for structures, foundations for structures, or covering for structures. They relate this behavior to properties of the soils. For example, they observe that filter fields for onsite disposal of 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.

General soil map

The general soil map at the back of this survey shows, in color, the soil associations in Sac 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 farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, drainage, or other characteristics that affect management. The six soil associations in Sac County are described in the following paragraphs.

1. Clarion-Nicollet-Canisteo association

Well drained to poorly drained, loamy, nearly level to strongly sloping soils on uplands

This association is in the eastern part of the county. Most of the soils are nearly level or gently undulating; however, near the larger streams many of the soils are gently rolling to hilly and a few are steep or very steep (fig. 2). The soils are drained almost entirely by Raccoon River and its tributaries. The drainage pattern is not well established, and closed depressions, or "potholes," are common.

This association covers about 48 percent of the county. It is about 30 percent Clarion soils, about 14 percent Nicollet soils, about 14 percent Canisteo soils, and about 10 percent Webster soils. The remaining 32 percent is minor soils.

Clarion soils are on convex knolls and hillsides at higher elevations than most of the adjoining soils. They are gently sloping to strongly sloping and are well drained. The surface layer is black and dark brown loam about 16 inches thick. The subsoil is brown and dark yellowish brown friable loam.

Nicollet soils are at intermediate elevations between the adjoining well drained soils and the poorly drained soils. They are nearly level to gently sloping and are somewhat poorly drained to moderately well drained. The surface layer is black loam about 14 inches thick. The subsoil is very dark grayish brown, dark grayish brown, olive, and olive brown, friable clay loam and loam.

Canisteo soils are in swales or in other low-lying areas. They are nearly level and are poorly drained. The surface layer is black and very dark gray silty clay loam about 16 inches thick. The subsoil is gray, olive gray, and light olive gray, friable clay loam or loam. Canisteo soils have a high content of lime throughout the profile.

The most extensive minor soils in this association are poorly drained Webster soils. They are similar to Canisteo soils, but do not have a high content of lime in the upper part of the profile. Other minor soils include excessively drained or somewhat excessively drained, calcareous Storden and Salida soils; well drained Wadena soils; poorly drained Biscay soils; calcareous, poorly drained Talcot soils; very poorly drained Okoboji soils in depressions; and poorly drained Harps soils, which are on rims of depressions and have a high content of lime. The Salida, Wadena, Biscay, and Talcot soils in this association are underlain by sand and gravel.

The soils in this association are used intensively for corn and soybeans. Other common crops are oats and hay. Some undrained areas and some of the more sloping soils and droughty soils are in permanent pasture. Growing cash grain crops and raising livestock are the main enterprises.

Crops grow well on most of these soils. They do not grow well, however, on the droughty soils; on the

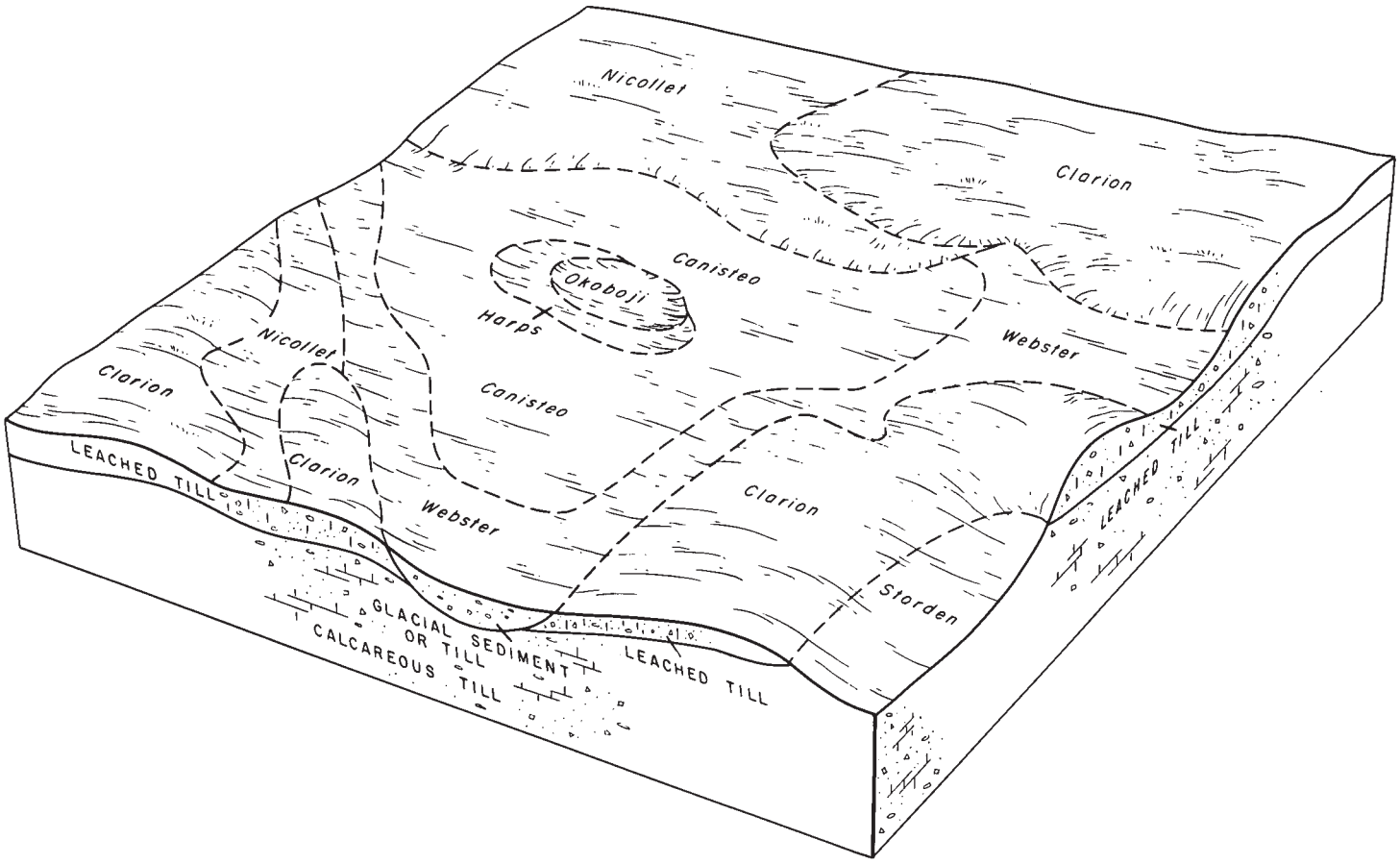

***Figure 2.*—Relationship of parent material and soils in the Clarion-Nicollet-Canisteo association.**

strongly sloping to very steep soils, which have a very severe hazard of erosion; and on the poorly drained and very poorly drained soils that have not been artificially drained. Fertility varies, but if row crops are grown intensively, nitrogen, phosphorus, and potassium are beneficial. The high content of lime in some of the soils reduces the availability of phosphorus and some other plant nutrients.

Many areas of these soils require artificial drainage. Most areas are drained by tile lines. Shallow drainage ditches are used in some depressions, and large drainage ditches are also used in places. Erosion is a hazard on the sloping soils. Terraces and other practices that involve contour tillage are difficult to establish. The soils that are subject to erosion typically have short, irregular slopes and are intermingled in an intricate pattern with nearly level soils that need drainage. Plowing in fall, which is a common practice, increases the hazard of water erosion and creates a hazard of soil blowing. Road ditches and drainage ditches tend to fill in and have to be dredged out periodically.

Farm size in this association is about average for the county. Fields are generally large. Some are irregular in shape because of drainage ditches or depressions that cannot be farmed. Roads are mostly on section lines except in a few places where they go around wet areas. They are paved or graveled.

2. *Galva-Primghar-Sac association*

Well drained to somewhat poorly drained, silty, nearly level to moderately sloping soils on uplands

This association forms a band about 3 miles wide along the east side of Boyer River. It is drained by the Boyer and its tributaries. These soils are dominantly well drained and gently sloping. Slopes are long, and there is a well established drainage pattern. The soils in the drainageways are mainly somewhat poorly drained or poorly drained and are nearly level or gently sloping. The soils near the major streams generally are moderately sloping (fig. 3).

This association covers about 12 percent of the county. It is about 35 percent Galva soils, about 20 percent Primghar soils, and about 16 percent Sac soils. The remaining 29 percent is minor soils.

Galva soils are on convex ridgetops and hillsides. They are nearly level to moderately sloping, but most areas are gently sloping. They are well drained. The surface layer is black and very dark grayish brown silty clay loam and is about 16 inches thick unless eroded. The subsoil is mostly brown, friable silty clay loam.

Primghar soils are on slightly convex ridgetops at the highest elevations and in concave positions on the upper parts of drainageways. They are nearly level to

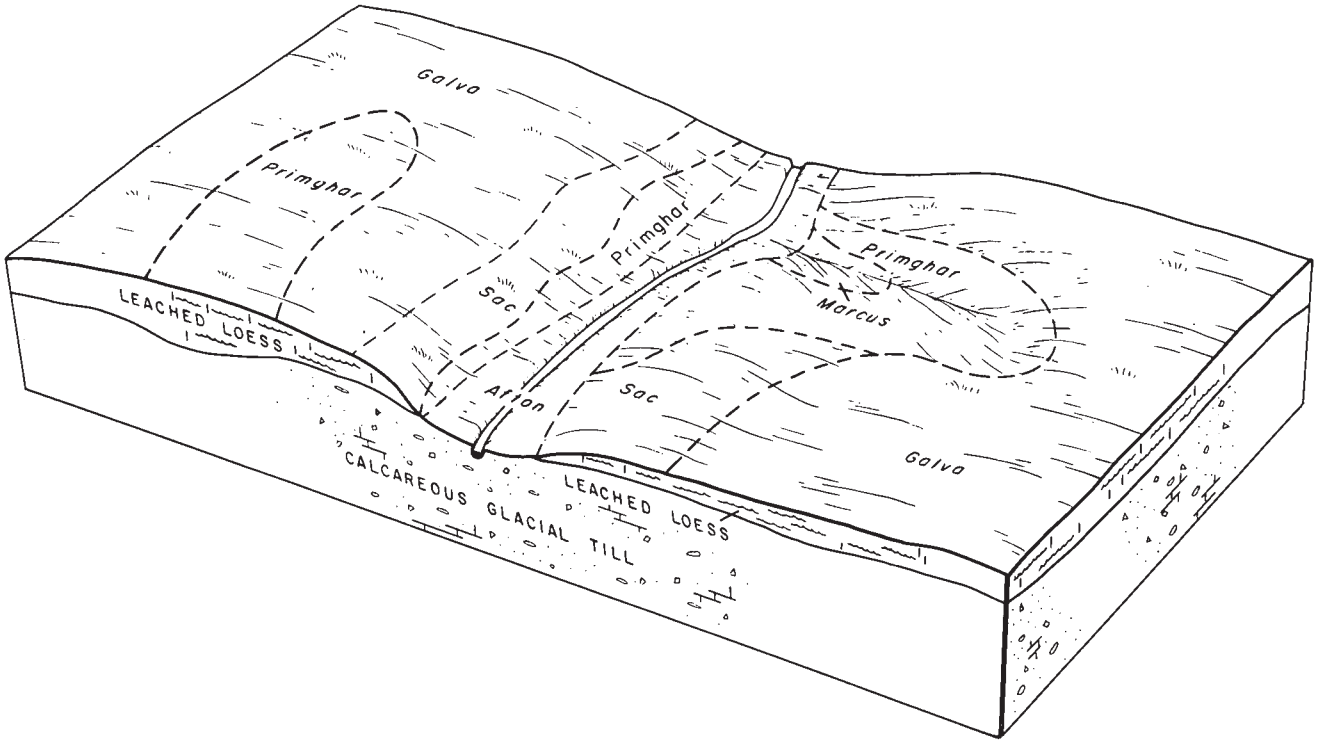

Figure 3.—**Relationship of parent material and soils in the Galva-Primghar-Sac association.**

gently sloping and are somewhat poorly drained. Typically, the surface layer is black and very dark gray silty clay loam about 20 inches thick. The subsoil is dark grayish brown and olive brown, friable silty clay loam.

Sac soils are on convex ridgetops and hillsides. They are gently sloping and moderately sloping and are well drained. The surface layer is black, very dark gray, and very dark grayish brown silty clay loam about 14 inches thick. The subsoil is brown and yellowish brown and is friable. It is silty clay loam in the upper part and clay loam in the lower part.

Minor soils in this association are poorly drained Afton, Colo, and Marcus soils; somewhat poorly drained Ackmore and Ely soils; and moderately well drained to somewhat poorly drained Spillville soils. All of these soils are in valleys or drainageways on bottom lands or foot slopes. Well drained Everly soils and somewhat excessively drained Storden soils are on convex upland positions.

The soils in this association are used intensively for corn and soybeans. Other common crops are oats and hay. The few permanent pastures are on wet soils that have not been artificially drained, in frequently flooded areas, and on short slopes next to the other areas. Cash grain crops and livestock feeding are the main enterprises. Some large livestock enterprises are in this association.

Crops grow well on these soils and respond well to nitrogen and phosphorus. In places lime or potassium, or both, is beneficial.

Erosion is a hazard on the sloping soils. The soils are well suited to terraces, contour tillage, stripcropping, and other practices that follow the contour of the land. Slopes are long and relatively smooth. Most of the soils have a friable subsoil that can be restored to reasonable productivity if it is exposed in terrace cuts. Soil blowing is a management concern when the soils are plowed in fall, especially following soybeans.

Many of the soils in the drainageways require artificial drainage for good production. Others, such as the Primghar soils, could be cultivated without artificial drainage but are drained to avoid delaying field operations. Lines of tile are installed in the drainageways, and they normally function well.

Farm size in this association is about average for the county. Fields are generally large. Contoured fields are common, and most have long rows. Roads are on a majority of the section lines, and most are graveled or paved.

3. *Galva-Primghar-Afton association*

Well drained to poorly drained, silty, nearly level to moderately sloping soils on uplands and in drainageways

This association is mainly west of Boyer River. It is drained by the Boyer and its tributaries and by tributaries of the Maple River. These soils are dominantly well drained and gently sloping. Slopes are long, and there is a well established drainage pattern. The soils in the drainageways are mainly somewhat poorly

drained or poorly drained and are nearly level or gently sloping. Some of the soils near the major streams are moderately sloping and have shorter slopes.

This association covers about 25 percent of the county. The association is about 42 percent Galva soils, about 17 percent Primghar soils, about 9 percent Afton soils, and 8 percent Sac soils. The remaining 24 percent is minor soils.

Galva soils are on convex ridgetops and hillsides. They are nearly level to moderately sloping, but most areas are gently sloping. The soils are well drained. The surface layer is black and very dark grayish brown silty clay loam and is about 16 inches thick unless eroded. The subsoil is mostly brown, friable silty clay loam.

Primghar soils are on slightly convex ridgetops at the highest elevations and, more commonly, at the heads of drainageways in concave positions. They are nearly level to gently sloping and are somewhat poorly drained. Typically, the surface layer is black and very dark gray silty clay loam and the subsoil is dark grayish brown and olive brown, friable silty clay loam.

Afton soils are in concave areas in drainageways. They are nearly level and poorly drained. The surface layer is black silty clay loam about 25 inches thick. The subsoil is very dark gray, gray, and olive gray, friable to firm silty clay loam.

Sac soils are intermingled with Galva soils on convex hillsides. They are gently sloping and moderately sloping and are well drained. Among the other minor soils are the poorly drained Colo and Marcus soils and the somewhat poorly drained Ackmore and Ely soils. These soils are on bottom lands, on foot slopes, or in drainageways. The well drained Shelby soils are on convex hillsides.

The soils in this association are used intensively for corn and soybeans. Other common crops are oats and hay. A few permanent pastures are on poorly drained soils that have not been artificially drained, in frequently flooded areas, and on moderately sloping soils that are next to these wet soils.

Crops grow well on these soils and respond well to nitrogen and phosphorus and, in places, to potassium and lime.

Erosion is a hazard on the sloping soils. The soils are well suited to terraces, contour tillage, stripcropping, and other practices that follow the contour of the land. Slopes are long and relatively smooth. Care is needed to avoid exposing the glacial till subsoil or substratum in Sac soils and in others in which the till is near the surface. The till in this association generally is firm clay loam. It is much less favorable for plant growth than the surface layer. Soil blowing is a management concern when the soils are plowed in fall, especially following soybeans.

Many of the soils in the drainageways require artificial drainage for good production. Others, such as the Primghar and Ely soils, could be cultivated without artificial drainage but are drained to avoid delaying field operations. Lines of tile are installed in these soils, and they normally function well.

Farm size in this association is about average for the county. Fields are generally large. Contoured fields are common, and most have long rows. Roads are on a majority of the section lines, and most are graveled or paved.

4. Marshall association

Well drained, silty, gently sloping to strongly sloping soils on uplands

This association is in the southwestern, most sloping part of the county. Gently sloping Marshall soils are on narrow ridgetops, and moderately sloping and strongly sloping Marshall soils are on hillsides. Other soils on hillsides range from moderately sloping to steep (fig. 4). Slopes in most places are long. This association is drained mainly by Boyer River and its tributaries. The drainage pattern is well established. Streambanks and sides of drainageways are more sloping in this part of the county than in other parts.

This association covers about 9 percent of the county. It is about 63 percent Marshall soils and 37 percent minor soils.

Marshall soils are gently sloping to strongly sloping and are well drained. Typically, the surface layer is very dark brown and very dark grayish brown silty clay loam and is about 12 inches thick unless eroded. The subsoil is dark brown, brown, and dark yellowish brown, friable silty clay loam.

Minor soils in this association are well drained Ida, Monona, Steinauer, and Shelby soils on hillsides and Kennebec, Ackmore, Colo, Judson, and Zook soils on bottom lands, on foot slopes, and in drainageways. These soils are well drained to poorly drained.

The major crop in this association is corn. Other common crops are soybeans, oats, and hay. More acreage in this association is in permanent pasture or in semipermanent pasture than in other associations because of the topography.

Crops grow well on these soils and respond well to nitrogen and phosphorus and, in places, to potassium and lime.

Erosion is a severe hazard in much of this association, and runoff is excessive in places. Terraces or other effective erosion control measures are needed on the sloping soils, especially if the soils are intensively used for row crops. These practices also help to conserve moisture by slowing runoff. Limited available moisture reduces yields in many years. The soils are reasonably well suited to practices that involve contour tillage. Practices that control erosion are more difficult to establish on the strongly sloping and moderately steep soils than on areas of less sloping soils. Droughtiness is a management concern in some years.

The main management concern in the valleys is runoff from upslope. Erosion control measures on hillsides help prevent siltation, rilling, and wetness on the soils in the valleys. Gullying is a severe hazard in some drainageways. Reducing runoff helps prevent gullying. Some of the soils are wet, and tiling is used.

Most farms are diversified. Cash grain crops and livestock are the main enterprises. This association has a wider range in farm size than other associations. Fields are smaller and more irregularly shaped than those of other associations. Roads are on a majority of the section lines, and most are paved or graveled.

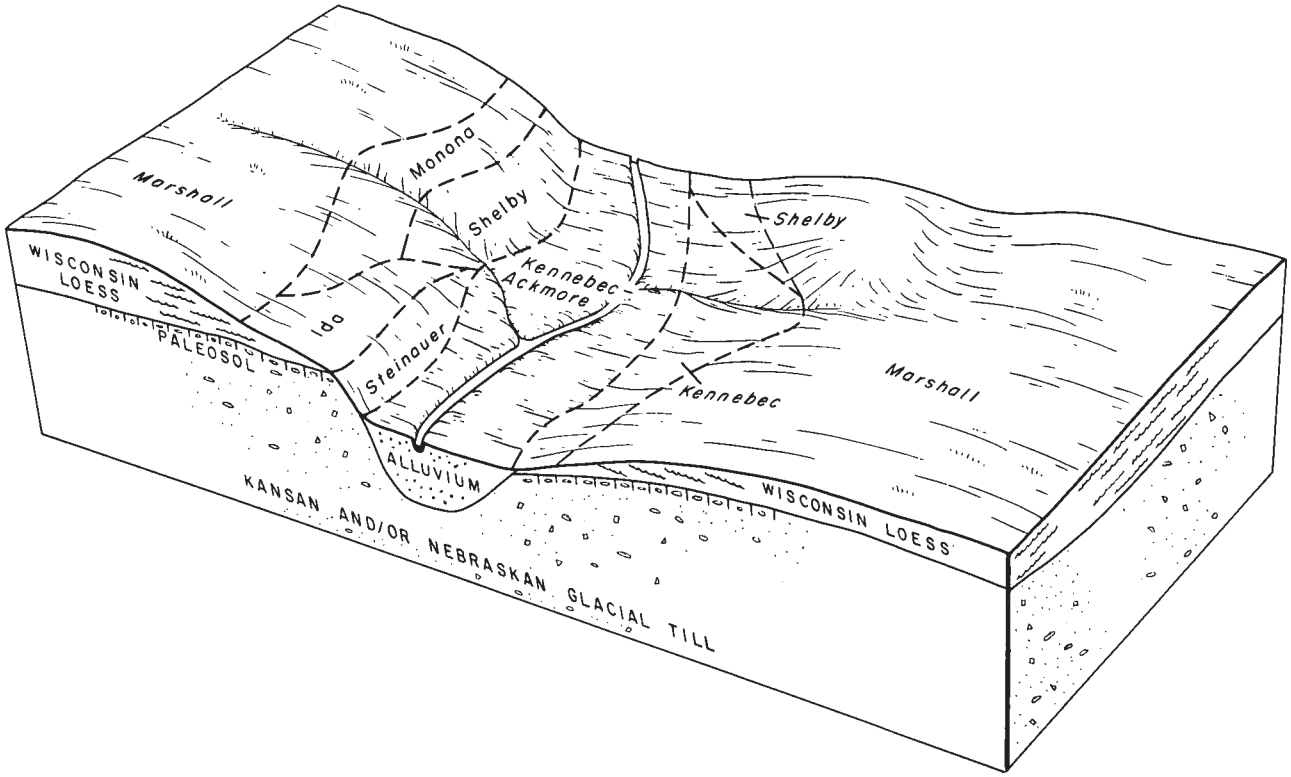

***Figure 4.*—Relationship of parent material and soils in the Marshall association.**

5. *Colo-Galva association*

Poorly drained to well drained, silty, nearly level and gently sloping soils on bottom lands and stream benches

This association is in the Boyer River Valley. It ranges from less than ¼ mile to about 2 miles in width. The soils of this association are mainly nearly level or gently sloping, but some thin bands of moderately sloping soils are on breaks between the stream benches and bottom lands.

This association covers about 3 percent of the county. It is about 45 percent Colo soils and about 25 percent Galva soils on benches. The remaining 30 percent is minor soils.

Colo soils are on bottom lands mainly next to streams and are subject to flooding. They are nearly level and are poorly drained. Typically, they are black silty clay loam to a depth of 3 or 4 feet.

Galva soils are on benches that are about 5 to 15 feet above the flood plain. They are nearly level and gently sloping and are well drained. Typically, the surface layer is black and very dark grayish brown silty clay loam. The subsoil is mainly brown, friable silty clay loam.

Minor soils in this association include poorly drained Zook soils and somewhat poorly drained Ackmore soils on bottom lands. Many other minor soils that have a wide range of properties are in this association.

The soils in this association that are not frequently flooded are used intensively for corn and soybeans. Other common crops are oats and hay. Frequently flooded areas are generally used for pasture.

Crops grow well on most of these soils, but not on the few droughty soils nor on those soils that are frequently flooded. Nitrogen and, in places, phosphorus, potassium, and lime are beneficial to these soils.

The soils on bottom lands are subject to flooding. Many are poorly drained or somewhat poorly drained. Flooding is usually controlled by using levees, although some channel straightening has been done. Tile normally functions satisfactorily for drainage if adequate outlets are available. Surface drains are used where outlets are not available or where the soils are too fine textured for tile to function properly.

The nearly level soils on benches have no serious limitations to intensive use for row crops. The gently sloping and moderately sloping soils along the edges of the benches have a hazard of erosion; some are droughty because they are sandy or they have a sand and gravel substratum.

Many farms are large, and many are partly in this association and partly in an adjoining association. Fields are large, and rows are straight in most areas. Many of the gravel pits of the county are in this association. Roads are on a majority of the section lines, and most are graveled.

6. *Coland-Alluvial land-Spillville association*

Well drained to poorly drained, sandy and loamy, nearly level and gently sloping soils on bottom lands

This association is in the Raccoon River valley. It ranges from about ¼ mile to about 2 miles in width.

The soils are mainly nearly level or gently sloping, except for narrow bands of more sloping soils on foot slopes or on breaks from benches to the flood plain.

This association covers about 3 percent of the county. It is about 25 percent Coland soils, about 25 percent Alluvial land, and about 20 percent Spillville soils. The remaining 30 percent is minor soils.

Coland soils are on bottom lands mainly next to the stream, and some areas are on foot slopes. These soils are nearly level and gently sloping, and they are poorly drained. Typically, these soils are black or very gray clay loam to a depth of 3 or 4 feet.

Alluvial land consists of material recently deposited by the Raccoon River. Most of the areas are nearly level, but some are gently sloping. Other properties vary widely. These soils are subject to frequent flooding.

Spillville soils are on bottom lands and foot slopes. They are nearly level and gently sloping, and they are moderately well drained to somewhat poorly drained. These soils are black and very dark grayish brown loam to a depth of 3 or 4 feet.

Minor soils in this association include well drained Wadena soils, somewhat poorly drained Cylinder soils, and poorly drained Biscay soils. All of these soils are on benches and are underlain by sand and gravel. Many other small areas of soils that range from droughty and gravelly to poorly drained and clayey are in this association.

Most of the soils on benches and higher bottom lands are used intensively for corn and soybeans. Other common crops are oats and hay. The soils that flood frequently are generally used for pasture, and many of these have stands of trees.

Some soils in this association are well suited to row crops, but droughtiness or flooding, or both, limit the suitability of many of the soils for cultivated crops. Fertility varies considerably, but crops normally respond well to nitrogen and to other nutrients.

Flooding is the major hazard, and levees have been built in places. Erosion is a hazard on the sloping soils at the edges of benches and on foot slopes. Many of these soils receive runoff from upslope. Runoff can be reduced by using conservation practices on hillsides.

Most farms in this association are partly in the Clarion-Nicollet-Canisteo association. Most are diversified. Cash grain crops and livestock are the main enterprises. Many of the gravel pits in the county are in this association. Roads are on a majority of the section lines, and most are graveled.

Descriptions of the soils

This section describes the soil series and mapping units of Sac County. The acreage and proportionate extent of each mapping unit are given in table 1.

The procedure is first to describe the soil series and then the mapping units in that series. Thus, to get full information on any one mapping unit, it is necessary to read the description of that unit and also the description of the soil series to which it belongs. As mentioned in the section "How the Survey Was Made," not all mapping units are members of a soil series. Alluvial land and Marsh, for example, do not belong to a soil series. They are listed, nevertheless, in alphabetic order along with the soil series.

In comparing a mapping unit with a soil series, many will prefer to read the short description in paragraph form. It precedes the technical description that identifies layers by A, B, and C horizons and depth ranges. The technical profile descriptions are mainly for soil scientists and others who want detailed information about soils. Unless otherwise indicated, the colors given in the descriptions are those of a moist soil. Some of the terms used to describe the soils are defined in the Glossary at the back of this soil survey. More detailed information about the terminology and the methods of mapping can be obtained from the Soil Survey Manual (*12*).[1]

Preceding the name of each mapping unit is a symbol that identifies the mapping unit on the detailed soil map. Listed at the end of each description of a mapping unit is the capability unit in which the mapping unit has been placed. The page on which each capability unit is described can be found by referring to the "Guide to Mapping Units" at the back of this survey.

Ackmore series

The Ackmore series consists of somewhat poorly drained, nearly level and gently sloping soils on bottom lands and in drainageways. These soils formed in medium textured and moderately fine textured alluvium. The native vegetation was prairie grasses and some trees.

In a representative profile the surface layer is very dark gray and very dark grayish brown silt loam about 11 inches thick. The underlying material, to a depth of 35 inches, is very dark grayish brown and very dark gray silt loam. Below this is a buried soil of black silty clay loam that extends to a depth of 70 inches or more.

Permeability is moderate, and available water capacity is high. The rooting zone is deep, but in wet seasons it is restricted by a high water table. Organic matter content is high to moderate.

Ackmore soils are generally used for cultivated crops where flooding and run-on are not severe hazards.

Representative profile of Ackmore silt loam, 0 to 2 percent slopes, in a pasture, 325 feet west and 800 feet south of the northeast corner of sec. 31, T. 87 N., R. 38 W.:

A11—0 to 2 inches; very dark gray (10YR 3/1) silt loam; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A12—2 to 11 inches; very dark grayish brown (10YR 3/2) silt loam; very dark gray (10YR 3/1) coatings on peds; some thin strata of dark grayish brown (10YR 4/2); weak platy structure parting to moderate fine subangular blocky; friable; few fine reddish iron oxide stains; neutral; clear smooth boundary.

C1—11 to 25 inches; very dark grayish brown

[1] Italic numbers in parentheses refer to Literature cited, p. 128.

TABLE 1.—*Acreage and proportionate extent of the soils*

Map symbol	Soil name	Acres	Percent
1D3	Ida silt loam, 9 to 14 percent slopes, severely eroded	695	0.2
1E3	Ida silt loam, 14 to 20 percent slopes, severely eroded	465	0.1
1F3	Ida silt loam, 20 to 30 percent slopes, severely eroded	245	0.1
5B	Kennebec-Ackmore complex, 2 to 5 percent slopes	5,325	1.4
C5B	Kennebec-Ackmore complex, channeled, 2 to 5 percent slopes	210	0.1
6	Okoboji silty clay loam, 0 to 1 percent slopes	6,620	1.8
8C	Judson silty clay loam, 3 to 8 percent slopes	345	0.1
9B	Marshall silty clay loam, 2 to 5 percent slopes	1,870	0.5
9B2	Marshall silty clay loam, 2 to 5 percent slopes, moderately eroded	1,290	0.3
9C	Marshall silty clay loam, 5 to 9 percent slopes	315	0.1
9C2	Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded	13,385	3.6
9D2	Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded	4,320	1.2
9D3	Marshall silty clay loam, 9 to 14 percent slopes, severely eroded	5,845	1.6
10D3	Monona silt loam, 9 to 14 percent slopes, severely eroded	825	0.2
10E3	Monona silt loam, 14 to 20 percent slopes, severely eroded	700	0.2
11B	Colo-Ely silty clay loams, 2 to 5 percent slopes	765	0.2
24C2	Shelby loam, 5 to 9 percent slopes, moderately eroded	770	0.2
24D2	Shelby loam, 9 to 14 percent slopes, moderately eroded	415	0.1
24E2	Shelby loam, 14 to 18 percent slopes, moderately eroded	210	0.1
26B	Kennebec silty clay loam, 2 to 5 percent slopes	1,170	0.3
27C	Terril loam, 3 to 8 percent slopes	420	0.1
31	Afton silty clay loam, 0 to 2 percent slopes	11,320	3.1
33E	Steinauer loam, 9 to 18 percent slopes	200	0.1
33F	Steinauer loam, 18 to 40 percent slopes	365	0.1
41D	Sparta loamy fine sand, 5 to 14 percent slopes	125	(1)
54	Zook silty clay loam, 0 to 2 percent slopes	1,260	0.3
55	Nicollet loam, 1 to 3 percent slopes	27,155	7.3
62C	Storden loam, 5 to 9 percent slopes	1,100	0.3
62D	Storden loam, 9 to 14 percent slopes	2,725	0.7
62E	Storden loam, 14 to 18 percent slopes	1,020	0.3
62F	Storden loam, 18 to 25 percent slopes	805	0.2
62G	Storden loam, 25 to 40 percent slopes	1,920	0.5
73C	Salida gravelly loamy sand, 5 to 9 percent slopes	515	0.1
73D	Salida gravelly loamy sand, 9 to 14 percent slopes	365	0.1
77B	Sac silty clay loam, loam substratum, 2 to 5 percent slopes	6,670	1.8
77B2	Sac silty clay loam, loam substratum, 2 to 5 percent slopes, moderately eroded	205	0.1
77C	Sac silty clay loam, loam substratum, 5 to 9 percent slopes	340	0.1
77C2	Sac silty clay loam, loam substratum, 5 to 9 percent slopes, moderately eroded	5,100	1.4
78B	Sac silty clay loam, clay loam substratum, 2 to 5 percent slopes	4,970	1.3
78B2	Sac silty clay loam, clay loam substratum, 2 to 5 percent slopes, moderately eroded	340	0.1
78C	Sac silty clay loam, clay loam substratum, 5 to 9 percent slopes	415	0.1
78C2	Sac silty clay loam, clay loam substratum, 5 to 9 percent slopes, moderately eroded	2,770	0.7
91	Primghar silty clay loam, 0 to 3 percent slopes	26,520	7.2
92	Marcus silty clay loam, 0 to 2 percent slopes	7,990	2.2
95	Harps loam, 0 to 2 percent slopes	2,140	0.6
107	Webster silty clay loam, 0 to 2 percent slopes	19,310	5.2
108	Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	1,855	0.5
108B	Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes	3,400	0.9
108C2	Wadena loam, 24 to 32 inches to sand and gravel, 5 to 9 percent slopes, moderately eroded	225	0.1
133	Colo silty clay loam, 0 to 2 percent slopes	8,535	2.3
134	Zook silty clay, 0 to 2 percent slopes	760	0.2
135	Coland clay loam, 0 to 2 percent slopes	5,085	1.5
135B	Coland clay loam, 2 to 4 percent slopes	840	0.2
138B	Clarion loam, 2 to 5 percent slopes	45,915	12.4
138C	Clarion loam, 5 to 9 percent slopes	485	0.1
138C2	Clarion loam, 5 to 9 percent slopes, moderately eroded	10,140	2.7
138D2	Clarion loam, 9 to 14 percent slopes, moderately eroded	325	0.1
174B	Bolan loam, 2 to 5 percent slopes	190	0.1
174C2	Bolan loam, 5 to 9 percent slopes, moderately eroded	485	0.1
174D2	Bolan loam, 9 to 14 percent slopes, moderately eroded	395	0.1
201B	Coland-Spillville complex, 2 to 5 percent slopes	265	0.1
C201B	Coland-Spillville complex, channeled, 2 to 5 percent slopes	645	0.2
202	Cylinder loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	710	0.2
203	Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	1,130	0.3
221	Palms muck, 0 to 1 percent slopes	405	0.1
234	Nishna silty clay loam, 0 to 2 percent slopes	685	0.2
236B	Lester loam, 2 to 7 percent slopes	1,080	0.3
259	Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	855	0.2
274	Rolfe loam, 0 to 1 percent slopes	410	0.1
308	Wadena loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	500	0.1

TABLE 1.—*Acreage and proportionate extent of the soils*—Continued

Map symbol	Soil name	Acres	Percent
308B	Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes	245	0.1
310	Galva silty clay loam, 0 to 2 percent slopes	855	0.2
310B	Galva silty clay loam, 2 to 5 percent slopes	48,470	13.1
310B2	Galva silty clay loam, 2 to 5 percent slopes, moderately eroded	435	0.1
310C	Galva silty clay loam, 5 to 9 percent slopes	2,515	0.7
310C2	Galva silty clay loam, 5 to 9 percent slopes, moderately eroded	4,220	1.1
T310	Galva silty clay loam, benches, 0 to 2 percent slopes	2,980	0.8
T310B	Galva silty clay loam, benches, 2 to 5 percent slopes	720	0.2
315	Alluvial land	3,380	0.9
323B	Terril loam, sandy substratum, 2 to 5 percent slopes	185	0.1
325	Le Sueur loam, 1 to 3 percent slopes	220	0.1
354	Marsh	220	0.1
384	Collinwood silty clay loam, 1 to 3 percent slopes	370	0.1
390	Waldorf silty clay loam, 0 to 2 percent slopes	1,050	0.3
397B	Letri silty clay loam, 1 to 4 percent slopes	500	0.1
428	Ely silty clay loam, 1 to 3 percent slopes	1,010	0.3
430	Ackmore silt loam, 0 to 2 percent slopes	2,280	0.6
430B	Ackmore silt loam, 2 to 5 percent slopes	330	0.1
485	Spillville loam, 0 to 2 percent slopes	3,740	1.0
485B	Spillville loam, 2 to 5 percent slopes	2,990	0.8
506	Wacousta silty clay loam, 0 to 1 percent slopes	700	0.2
507	Canisteo silty clay loam, 0 to 2 percent slopes	27,385	7.4
511	Blue Earth silty clay loam, 0 to 1 percent slopes	2,345	0.6
559	Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	385	0.1
577C2	Everly clay loam, 4 to 9 percent slopes, moderately eroded	600	0.2
577D2	Everly clay loam, 9 to 14 percent slopes, moderately eroded	260	0.1
606	Lanyon silty clay loam, 0 to 1 percent slopes	320	0.1
733	Calco silty clay loam, 0 to 2 percent slopes	1,110	0.3
823B	Flagler sandy loam, calcareous subsoil variant, 2 to 5 percent slopes	865	0.2
823C2	Flagler sandy loam, calcareous subsoil variant, 5 to 9 percent slopes, moderately eroded	450	0.1
	Gravel pits and quarries	1,065	0.3
	Water, borrow areas, and miscellaneous land	550	0.1
	Total	369,920	100.0

[1] Less than 0.1 percent.

(10YR 3/2) silt loam; some thin strata of dark grayish brown (10YR 4/2); moderate thin platy structure; friable; common medium distinct reddish mottles; neutral; clear smooth boundary.

C2—25 to 35 inches; very dark gray (N 3/0) heavy silt loam; common fine faint very dark grayish brown (2/5Y 3/2) mottles; moderate thin platy structure; friable; common medium reddish brown mottles; slightly acid; abrupt smooth boundary.

A11b—35 to 39 inches; black (10YR 2/1) light silty clay loam; common fine faint very dark gray (10YR 3/1) mottles; moderate fine and very fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

A12b—39 to 57 inches; black (10YR 2/1) silty clay loam; weak fine and very fine subangular blocky structure; friable; neutral; gradual smooth boundary.

A13b—57 to 70 inches; black (10YR 2/1) heavy silty clay loam; weak fine and very fine subangular blocky structure; friable; few fine reddish accumulations (oxides); mildly alkaline.

The A and C horizons are black (10YR 2/1) to very dark grayish brown (10YR 3/2) silt loam but are light silty clay loam in places. The Ab horizon is black (N 2/0, 10YR 2/1, or 5Y 2/1) or very dark gray (5Y 3/1).

The upper boundary of the Ab horizon generally is at a depth of 20 to 40 inches, but in mapping unit 430B the boundary is below a depth of 40 inches. This is not within the defined range of the Ackmore series, but this difference does not significantly affect the use and behavior of the soil.

Ackmore and Kennebec soils formed in similar parent material and are in similar landscape positions. Ackmore soils are more stratified than Kennebec soils, and they typically have a buried soil that Kennebec soils do not have.

430—Ackmore silt loam, 0 to 2 percent slopes. This soil is generally in areas near streams. Most areas are 2 to 10 acres in size and are long and narrow in shape. This soil has the profile described as representative of the series.

The main management concern is wetness. This soil is well suited to cultivated crops if it is adequately drained and if flooding is controlled. Undrained and unprotected areas are better suited to pasture than to cultivated crops. This soil is usually farmed with other nearly level bottom land soils, some of which are poorly drained. Capability unit IIw–2.

430B—Ackmore silt loam, 2 to 5 percent slopes. This

soil is on foot slopes. Most areas are 2 to 20 acres in size and are long and narrow in shape.

This soil has a moderate erosion hazard. It receives runoff from adjoining slopes, which, if not controlled, causes rilling, siltation, and, in places, wetness. This soil is well suited to cultivation if runoff is controlled. This soil is generally farmed with nearly level bottom land soils, but some areas are farmed with the adjoining upland soils. Capability unit IIe–1.

Afton series

The Afton series consists of poorly drained, nearly level soils in drainageways. These soils formed in moderately fine textured loess and local alluvium. The native vegetation was tall grasses and some sedges.

In a representative profile the surface layer is black silty clay loam about 25 inches thick. The subsoil is silty clay loam about 23 inches thick and has distinct yellowish brown mottles. The upper part of the subsoil is very dark gray, and the lower part is gray and olive gray. The underlying material is gray silty clay loam that has distinct yellowish brown mottles.

Permeability is moderately slow, and available water capacity is high. The rooting zone is deep, but in wet seasons it is restricted by a high water table. Organic matter content is high.

Afton soils are generally used for cultivated crops. Undrained areas are generally used for pasture.

Representative profile of Afton silty clay loam, 0 to 2 percent slopes, in a cultivated area, 1,100 feet south and 100 feet east of the northwest corner of sec. 1, T. 89 N., R. 38 W.:

Ap—0 to 8 inches; black (N 2/0) heavy silty clay loam; cloddy; friable; neutral; abrupt smooth boundary.

A12—8 to 19 inches; black (N 2/0) medium silty clay loam; weak medium angular blocky structure parting to moderate fine granular and moderate very fine subangular blocky; firm; thin discontinuous shiny coats on ped surfaces; neutral; gradual smooth boundary.

A3—19 to 25 inches; black (N 2/0) heavy silty clay loam; moderate fine granular and very fine and fine subangular blocky structure; firm; thin discontinuous shiny coats on ped surfaces; neutral; clear smooth boundary.

B21g—25 to 32 inches; very dark gray (5Y 3/1) heavy silty clay loam; few fine distinct yellowish brown (10YR 5/6) mottles; moderate fine granular and fine and very fine subangular blocky structure; firm; thin discontinuous shiny coats on ped surfaces; neutral; clear smooth boundary.

B22g—32 to 39 inches; gray (5Y 5/1) and olive gray (5Y 5/2) medium silty clay loam with dark gray (5Y 4/1) coats on ped surfaces; common fine distinct yellowish brown (10YR 5/6) mottles; moderate fine and fine subangular blocky structure; friable; mildly alkaline; gradual smooth boundary.

B31g—39 to 43 inches; olive gray (5Y 5/2) light silty clay loam with some gray (5Y 5/1) and dark gray (5Y 4/1) coats on ped surfaces; many fine distinct yellowish brown (10YR 5/6) mottles; moderate very fine and fine subangular blocky structure; friable; mildly alkaline; gradual smooth boundary.

B32g—43 to 48 inches; gray (5Y 5/1) light silty clay loam; many fine distinct yellowish brown (10YR 5/6 and 5/8) mottles; weak fine subangular blocky structure; friable; few fine dark accumulations (oxides); mildly alkaline; gradual smooth boundary.

Cg—48 to 60 inches; gray (5Y 5/1) light silty clay loam; many medium distinct yellowish brown (10YR 5/6 and 5/8) mottles; very weak coarse prismatic structure; friable; few fine dark accumulations (oxides); strong effervescence; moderately alkaline.

The A horizon is neutral or mildly alkaline and is 20 to 30 inches thick. The upper part of the B horizon is mildly alkaline or neutral, and the lower part is mildly alkaline or moderately alkaline. The B horizon is very dark gray (5Y 3/1) or dark gray (5Y 4/1) in the upper part and dark gray (5Y 4/1) to light olive gray (5Y 6/2) in the lower part. It has distinct yellowish brown or strong brown mottles and is 20 to 30 inches thick. The C horizon is gray (5Y 5/1) to light olive gray (5Y 6/2) light silty clay loam or heavy silt loam.

Afton, Primghar, and Marcus soils formed in similar material. Afton soils have a thicker A horizon than Marcus and Primghar soils, and they are more poorly drained than Primghar soils.

31—Afton silty clay loam, 0 to 2 percent slopes. This soil is in concave or plane areas in drainageways. Most areas are 5 to 20 acres in size and are long and narrow in shape. Most areas of this soil are cut by a waterway.

Included with this soil in mapping are some calcareous soils similar to this Afton soil. Also included are a few areas of wet, seepy land and a few areas that have deep cuts.

The main management concern is wetness, which limits use of farm equipment for long periods in some areas. Excess water from the adjoining areas of soils runs onto this soil. This soil is well suited to cultivated crops if it is adequately drained, but is better suited to pasture or wildlife habitat if it is undrained. Most areas are farmed with the better drained adjoining soils. Artificial drainage is essential to avoid long delays in field operations. Maintaining good tilth is difficult because of the wetness and the silty clay loam texture of the surface layer. Capability unit IIw–1.

Alluvial land

315—Alluvial land is bottom lands that are in low-lying areas next to streams. Most areas are 5 to 50 acres in size and are long and narrow in shape. They are mostly stratified loam and sand with little or no soil horizon development.

Most areas are subject to frequent flooding. Some

areas have old stream channels, many of which are ponded for long periods after floods. Many areas are somewhat droughty because of the limited available water capacity. These miscellaneous areas are generally used for pasture or woodland. They are suited to pasture and hay if flooding is infrequent, and they are well suited to wildlife habitat and woodland. Capability unit Vw–1.

Biscay series

The Biscay series consists of poorly drained, nearly level soils on uplands and stream benches. These soils formed in alluvial sediment over sand and gravel. The native vegetation was tall prairie grasses and sedges.

In a representative profile the surface layer is black and very dark gray clay loam and loam about 17 inches thick. The subsoil is about 21 inches thick. The upper part is dark olive gray loam, and the lower part is dark gray and olive gray sandy loam and sandy clay loam. The underlying material is olive gray loamy sand, sand, and gravel.

Permeability is moderate in the upper part of the profile and rapid in the underlying material. Available water capacity is moderate. The rooting zone is restricted by a shallow depth to sand and gravel and in wet seasons by a high water table. Organic matter content is high.

Biscay soils are mainly used for cultivated crops.

Representative profile of Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, in a cultivated area, 55 feet south and 535 feet west of the northeast corner of SE¼NE¼, sec. 7, T. 89 N., R. 35 W.:

Ap—0 to 12 inches black (N 2/0) clay loam; cloddy; parting to friable; neutral; abrupt smooth boundary.

A3—12 to 17 inches; very dark gray (5Y 3/1) loam; few fine and medium faint dark olive gray (5Y 3/2) mottles; weak fine subangular blocky structure; friable; few medium dark accumulations (oxides); neutral; clear smooth boundary.

B1g—17 to 24 inches; dark olive gray (5Y 3/2) loam; weak medium prismatic structure parting to weak medium subangular blocky; friable; neutral; abrupt smooth boundary.

B2g—24 to 28 inches; dark gray (5Y 4/1) sandy clay loam; weak medium prismatic structure parting to weak medium subangular blocky; friable; neutral; abrupt smooth boundary.

B3g—28 to 38 inches; olive gray (5Y 4/2) sandy loam; very weak medium prismatic structure parting to very weak medium subangular blocky; very friable; mildly alkaline; gradual smooth boundary.

IIC1g—38 to 47 inches; olive gray (5Y 4/2) loamy sand; some fine gravel; few fine distinct olive mottles; single grained; loose; mildly alkaline; gradual wavy boundary.

IIC2g—47 to 84 inches; olive gray (5Y 5/2) sand; some gravel; single grained; loose; weak effervescence; mildly alkaline.

The A horizon is slightly acid to mildly alkaline and is 14 to 24 inches thick. It is loam or light clay loam. In some places to lower part is black (N 2/0). The B horizon is loam, sandy clay loam, or light clay loam and is 10 to 24 inches thick. The B2 and B3 horizons are gray (5Y 5/1), dark gray (5Y 4/1), or olive gray (5Y 4/2 or 5/2). The IIC horizon is loamy sand, sand, or gravel. It is commonly calcareous and moderately alkaline throughout, but in places the upper part is leached of carbonates and is mildly alkaline. The IIC horizon is gray (5Y 5/1), olive gray (5Y 5/2), light gray (5Y 6/1), or olive gray (5Y 5/3). Colors are stratified and mixed.

In places the lower part of the B horizon is sandy loam and is thicker than the defined range of the Biscay series, but these differences do not significantly alter the use and behavior of the soils.

Biscay and Talcot soils formed in similar parent material. Biscay soils are noncalcareous in the solum, and Talcot soils are calcareous. Biscay soils and Webster soils are poorly drained, but Biscay soils are coarser textured and are underlain by sand and gravel.

259—Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This soil is generally at lower elevations than adjoining soils. Most areas are 2 to 10 acres in size and are irregular in shape.

Included with this soil in mapping are similar soils that have sand and gravel at a depth of 24 to 32 inches. Also included are areas in the upper Boyer River valley that have more silt in the upper part of the profile than this Biscay soil.

The main management concern is wetness. Excess water from adjoining areas runs onto this soil. The limited available water capacity of the underlying sand and gravel makes this soil droughty during dry seasons. This soil is well suited to cultivated crops if the soil is adequately drained. Root growth is restricted by the underlying sand and gravel and by a high water table during wet seasons. The sand and gravel also limit the use of tile drains. Capability unit IIw-1.

Blue Earth series

The Blue Earth series consists of very poorly drained, nearly level, calcareous soils in depressions. These soils formed in moderately fine textured glacial lake sediment. The native vegetation was marsh-grasses, sedges, and other grasses tolerant to excess wetness.

In a representative profile this soil is black silty clay loam to a depth of 60 inches.

Permeability is moderate to slow, and available water capacity is high. The rooting zone is deep, but in wet seasons it is restricted by a high water table. Organic matter content is high.

Blue Earth soils are generally used for cultivated crops and pasture. Undrained areas are better suited to pasture than to cultivated crops.

Representative profile of Blue Earth silty clay loam, 0 to 1 percent slopes, in a cultivated area, 200 feet west and 500 feet north of the southeast corner of NW¼ of sec. 13, T. 86 N., R. 37 W.:

Lcop—0 to 9 inches; black (N 2/0) silty clay

loam; weak fine granular and weak very fine subangular blocky structure; friable; strongly effervescent; moderately alkaline; abrupt smooth boundary.

Lco2—9 to 14 inches; black (5Y 2/1) silty clay loam; few thin sandy lenses; few fine faint very dark gray (5Y 3/1) mottles; weak fine subangular blocky structure; friable; numerous snail shells; strongly effervescent; moderately alkaline; abrupt smooth boundary.

Lco3—4 to 22 inches; black (5Y 2/1) silty clay loam; few fine very dark gray (5Y 3/1) mottles; moderate weak fine prismatic structure; friable; few snail shells; strongly effervescent; moderately alkaline; clear smooth boundary.

Lco4—22 to 28 inches; black (5Y 2/1) silty clay loam; weak fine subangular blocky structure; friable; layer of clam shells; many fine reddish accumulations (oxides); silt coats on peds; strongly effervescent; moderately alkaline; clear smooth boundary.

Lco5—28 to 33 inches; black (5Y 2/1) silty clay loam; few thin sandy lenses; friable; many fine reddish accumulations (oxides) in root channels; strongly effervescent; moderately alkaline; clear smooth boundary.

Lco6—33 to 40 inches; black (5Y 2/1) silty clay loam; weak fine angular and subangular blocky structure; friable; ash layer at a depth of 38 to 39 inches; strongly effervescent; moderately alkaline; clear smooth boundary.

Lco7—40 to 60 inches; black (5Y 2/1) silty clay loam; few thin sandy lenses; weak fine subangular blocky structure; friable; strongly effervescent; moderately alkaline.

Depth to the glacial till or glacial sediment ranges from about 30 inches to more than 80 inches. The underlying material is black (10YR 2/1) to olive gray (5Y 5/2) silty clay loam or clay loam.

Blue Earth, Okoboji, and Palms soils formed on similar landscapes. Blue Earth soils have a higher organic matter content than Okoboji soils and a lower organic matter content than Palms soils. Blue Earth soils are calcareous throughout, and Okoboji soils are noncalcareous.

511—Blue Earth silty clay loam, 0 to 1 percent slopes. This soil is in depressions that are surrounded by better drained soils. Most areas are 2 to 20 acres in size, but Goose Lake, which is southwest of Wall Lake, Iowa, is about 960 acres in size. Most areas are irregular in shape.

The main management concern is wetness. Crops are generally more susceptible to frost on this soil than on the surrounding soils, which are a few feet higher in elevation. This soil is suited to cultivated crops if drainage is adequate and if flooding and ponding are controlled. Undrained areas are better suited to pasture or to wildlife habitat than to most other uses. Capability unit IIIw–1.

Bolan series

The Bolan series consists of well drained, gently sloping to strongly sloping soils on uplands. These soils formed in mixed, moderately fine textured loess and loamy sand or sand over loamy sand and sand of eolian origin. The native vegetation was prairie grasses.

In a representative profile the surface layer is 11 inches thick. The upper part is very dark brown loam, and the lower part is very dark grayish brown and dark brown loam. The subsoil is about 21 inches thick. The upper part is dark brown loam, the middle part is dark yellowish brown loam, and the lower part is dark yellowish brown loamy fine sand. The underlying material is yellowish brown fine sand.

Permeability is moderate in the surface layer and subsoil, and it is rapid in the coarse textured underlying material. Available water capacity is moderate. The rooting zone is restricted by depth to sand. Organic matter content is moderate to low, depending on the thickness of the surface layer.

Bolan soils are used for cultivated crops and pasture.

Representative profile of Bolan loam, 5 to 9 percent slopes, moderately eroded, in a pasture, 580 feet north and 300 feet east of the southwest corner of the NW¼ of sec. 6, T. 86 N., R. 38 W.:

Ap—0 to 7 inches; very dark brown (10YR 2/2) loam; cloddy; friable; slightly acid; abrupt smooth boundary.

A3—7 to 11 inches; very dark grayish brown (10YR 3/2) and dark brown (10YR 4/3) loam; weak very fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B1—11 to 14 inches; dark brown (10YR 4/3) loam; many very dark grayish brown (10YR 3/2) ped coatings; weak fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

B21—14 to 19 inches; dark yellowish brown (10YR 4/4) heavy loam, few dark brown (10YR 3/3) ped coatings; weak fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

B22—19 to 24 inches; dark yellowish brown (10YR 4/4) ped coatings; weak fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

IIB3—24 to 32 inches; dark yellowish brown (10YR 4/4) loamy fine sand; weak medium subangular blocky structure; very friable; slightly acid; clear smooth boundary.

IIC—32 to 60 inches; yellowish brown (10YR 5/4) fine sand; single grained; loose; neutral.

The solum is slightly acid or neutral and is 10 to 16 inches thick unless eroded. The A horizon is black (10Y 2/1) or very dark brown (10YR 2/2) in the upper part and very dark gray (10YR 3/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2) in the lower part. Some brown (10YR 4/3) material is mixed in places. The A horizon is loam or silt loam high in content of sand.

The upper part of the B horizon is dark brown (10YR 3/3) to dark yellowish brown (10YR 4/4) loam or silt loam that is high in content of sand, and it is brown (10YR 4/3) to dark yellowish brown (10YR 4/4) fine sandy loam to loamy fine sand in the lower part. It is 20 to 32 inches thick. The underlying material is dark yellowish brown (10YR 4/4) or yellowish brown (10YR 5/4) loamy fine sand or fine sand.

Bolan and Wadena soils formed in layers of contrasting soil material. Bolan soils formed in wind-deposited loess mixed with fine sand over fine sand that contains little or no gravel or coarse sand, but Wadena soils formed in medium textured outwash and glacial sediment that has numerous pebbles over medium to coarse sand and gravel.

174B—Bolan loam, 2 to 5 percent slopes. This soil is on convex ridgetops. Most areas are 2 to 20 acres in size and are irregular in shape. This soil has a profile similar to the one described as representative of the series, but the surface layer is very dark brown to a depth of 10 or 12 inches.

Included with this soil in mapping are some areas of soils that have a thinner surface layer than this Bolan soil. Also included are areas of soils that are stratified with fine sandy loam in the upper part of the subsoil and with silty layers in the lower part. In places, the layer between depths of 40 and 60 inches is light silty clay loam or silt loam.

This soil has moderate erosion and drought hazards. It is well suited to cultivated crops if erosion is controlled. Conservation practices that reduce runoff increase the amount of water that is stored in the soil and is available to plants. Practices that leave crop residue on the surface also help to conserve moisture. Capability unit IIe–2.

174C2—Bolan loam, 5 to 9 percent slopes, moderately eroded. This soil is on convex hillsides. Most areas are 2 to 20 acres in size and are irregular in shape. This soil has a profile similar to the one described as representative of the series, but in most cultivated areas erosion has removed part of the original surface layer so that the plow layer is very dark grayish brown and is partly mixed with the brown subsoil.

Included with this soil in mapping are areas of soils that are stratified with fine sandy loam material in the upper part of the subsoil and other areas of soils that have silty lenses in the lower part of the subsoil. In places the layer between depths of 40 and 60 inches is light silty clay loam or silt loam.

This soil has severe erosion and drought hazards. It is suited to cultivated crops if erosion is controlled. The hazard of drought is increased if runoff is not controlled. Terraces, contour tillage, and other conservation practices that reduce runoff increase the amount of water that is stored in the soil and is available to plants. Practices that leave crop residue on the surface also help to conserve moisture. Capability unit IIIe-3.

174D2—Bolan loam, 9 to 14 percent slopes, moderately eroded. This soil is on convex hillsides. Most areas are 2 to 5 acres in size and are irregular in shape. This soil has a profile similar to that described as representative of the series, but in cultivated areas the plow layer is very dark grayish brown and is partly mixed with material from the brown subsoil.

Included with this soil in mapping are areas of soils that are stratified with fine sandy loam in the upper part of the subsoil and other areas that are stratified with silty lenses in the lower part of the subsoil. In places the layer between depths of 40 and 60 inches is light silty clay loam or silt loam.

This soil has severe erosion and drought hazards. It is suited to hay or pasture. These areas can sometimes be planted to cultivated crops if erosion is controlled. The hazard of drought is severe because of the limited available water capacity, especially if runoff is not controlled. Practices that conserve moisture, such as contour tillage and tillage that leaves crop residue on the surface, are needed. Capability unit IVe-2.

Calco series

The Calco series consists of poorly drained, nearly level soils on bottom lands. These soils formed in moderately fine textured alluvium. The native vegetation was grasses, sedges, and some trees.

In a representative profile the surface layer is black silty clay loam about 36 inches thick. The subsoil and underlying material are black silty clay loam that has distinct mottles.

Permeability is moderately low, and available water capacity is high. The rooting zone is deep, but in wet seasons it is restricted by a high water table. Organic matter content is high.

Calco soils are generally used for cultivated crops, but most undrained areas are used for pasture.

Representative profile of Calco silty clay loam, 0 to 2 percent slopes, in a cultivated area, 125 feet east and 200 feet south of the northwest corner of SW¼SW¼ of sec. 7, T. 88 N., R. 35 W.:

A11—0 to 17 inches; black (N 2/0) light silty clay loam; weak very fine subangular blocky structure; friable; strongly effervescent; moderately alkaline; clear smooth boundary.

A12—17 to 24 inches; black (N 2/0) medium silty clay loam; weak fine subangular blocky structure; firm; strongly effervescent; moderately alkaline; gradual boundary.

A13—24 to 36 inches; black (N 2/0) heavy silty clay loam; weak fine prismatic structure parting to weak fine subangular blocky; firm; mildly alkaline; clear smooth boundary.

Bg—36 to 49 inches; black (5Y 2/1) medium silty clay loam; very dark gray (10YR 3/1) kneaded; common fine distinct dark yellowish brown (10YR 4/4) mottles; weak fine prismatic structure; friable; mildly alkaline; abrupt smooth boundary.

C1g—49 to 59 inches; black (5Y 2/1) light silty clay loam; very dark gray (10YR 3/1) kneaded; many fine distinct dark yellowish brown (10YR 4/4) mottles; massive;

friable; strongly effervescent; moderately alkaline; abrupt smooth boundary.

C2g—59 to 63 inches; black (5Y 2/1) light silty clay loam; massive; friable; yellowish red (5YR 4/8) coats on root channels; light gray (5Y 6/1) streaks; strongly effervescent; moderately alkaline; abrupt smooth boundary.

The A horizon is 24 to 36 inches thick. The B horizon, if present, is black (N 2/0) to very dark gray (5Y 3/1) and is less than 15 inches thick. The C horizon is mainly black (N 2/0 or 5Y 2/1) and very dark gray (5Y 3/1) to gray (5Y 6/1) silty clay loam, but in places it is stratified with clay loam, silt loam, or loam.

Calco, Colo, and Coland soils are poorly drained and formed in alluvial material. Calco soils are calcareous, and Colo and Coland soils are noncalcareous. Calco soils have less sand in the solum than Coland soils.

733—Calco silty clay loam, 0 to 2 percent slopes. This soil is in areas next to streams or waterways. Most areas are 5 to 20 acres in size and are long and narrow in shape.

Included with this soil in mapping are areas of soils that are more sandy than this Calco soil. Also included are areas of noncalcareous Colo soils.

The main management concern is wetness. Another management concern is the reduced availability of some plant nutrients caused by the high content of lime. This soil is well suited to cultivated crops if it is adequately drained and if flooding is controlled. Most areas can be farmed separately or with other nearly level soils. Maintaining good tilth is a moderate concern. Inadequately drained areas are generally better suited to pasture than to cultivated crops. Capability unit IIw-2.

Canisteo series

The Canisteo series consists of poorly drained, nearly level soils on uplands. Canisteo soils formed in medium textured and moderately fine textured glacial sediment. The native vegetation was tall grasses and sedges.

In a representative profile the surface layer is silty clay loam about 16 inches thick. The upper part is black, and the lower part is very dark gray. The subsoil is gray, olive gray, and light olive gray light clay loam and loam about 30 inches thick. The underlying material is olive gray loam and light clay loam that has brownish mottles.

Permeability is moderate, and available water capacity is high. This soil is mildly alkaline and is calcareous throughout. The rooting zone is deep, but in wet seasons it is restricted by a high water table. Organic matter content is high.

Canisteo soils are used mostly for cultivated crops.

Representative profile of Canisteo silty clay loam, 0 to 2 percent slopes, in a cultivated area, 480 feet west and 170 feet south of the northeast corner of the SE¼NE¼ sec. 36, T. 87 N., R. 36 W.:

Ap—0 to 8 inches; black (N 2/0) light silty clay loam; cloddy; friable; strongly effervescent; moderately alkaline; abrupt smooth boundary.

A12—8 to 11 inches; black (N 2/0) light silty clay loam; weak fine granular and weak very fine subangular blocky structure; friable; strongly effervescent; moderately alkaline; gradual smooth boundary.

A3—11 to 16 inches; very dark gray (10YR 3/1) medium silty clay loam; common very fine olive gray (5Y 4/2) mottles; weak fine granular and weak very fine subangular blocky structure; friable; strongly effervescent; moderately alkaline; gradual smooth boundary.

B1g—16 to 23 inches; gray (5Y 5/1) and very dark gray (5Y 3/1) light clay loam; weak fine granular and weak very fine subangular blocky structure; friable; yellowish brown (10YR 5/6) accumulations (oxides); strongly effervescent; moderately alkaline; clear smooth boundary.

B2g—23 to 31 inches; gray (5Y 5/1) and olive gray (5Y 5/2) light clay loam; weak very fine subangular blocky structure; friable; few fine distinct yellowish brown accumulations (oxides); dark gray fills in wormholes and root channels; strongly effervescent; moderately alkaline; gradual smooth boundary.

B3g—31 to 46 inches; light olive gray (5Y 6/2) loam; weak fine subangular blocky structure; friable; common fine distinct yellowish brown accumulations (oxides); strongly effervescent; moderately alkaline; gradual smooth boundary.

C1—46 to 64 inches; olive gray (5Y 5/2) loam; common medium yellowish brown (10YR 5/8) mottles; massive; friable; few reddish concretions; strongly effervescent; moderately alkaline; gradual smooth boundary.

C2—64 to 70 inches; olive gray (5Y 5/2) light clay loam; strong brown (7.5YR 5/6) mottles; massive; friable; few reddish concretions; strongly effervescent; moderately alkaline.

The A horizon is loam, silty clay loam, or clay loam 14 to 24 inches thick. The B horizon is very dark gray (5Y 3/1) or dark gray (5Y 4/1) in the upper part and in a few places is gray (5Y 3/1) or light gray (5Y 6/1). It is dark gray (5Y 4/1) to pale olive (5Y 6/3) in the lower part. It is loam or clay loam 10 to 30 inches thick. The C horizon is loam or clay loam. It is gray (5Y 5/1), olive gray (5Y 5/2), and light olive gray (5Y 6/2) and has yellowish brown (10YR 5/8) mottles.

Canisteo, Webster and Harps soils formed in similar parent materials. Canisteo soils are moderately calcareous throughout, Webster soils are noncalcareous in the solum, and Harps soils are highly calcareous.

507—Canisteo silty clay loam, 0 to 2 percent slopes. Areas of this soil range from 2 acres to more than 100

acres in size. They are at lower elevations than most of the better drained adjoining soils.

Included with this soil in mapping are small areas in depressions which tend to pond.

The main management concern is wetness. Another management concern is the reduced availability of some plant nutrients caused by the high content of lime. This soil is well suited to cultivated crops if it is adequately drained. If the soil is inadequately drained, root growth is restricted during wet seasons and it is difficult to maintain good tilth. Tile is generally used to reduce wetness. Capability unit IIw–1.

Clarion series

The Clarion series consists of well drained, gently sloping to strongly sloping soils on uplands. Clarion soils formed in glacial till. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is about 16 inches thick. The upper part is black loam, and the lower part is dark brown loam. The subsoil is brown and dark yellowish brown loam about 16 inches thick. The underlying material is light olive brown loam.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content is generally moderate, depending on the extent of erosion.

Clarion soils are generally used for cultivated crops, but a few areas of the more sloping Clarion soils are in pasture.

Representative profile of Clarion loam, 2 to 5 percent slopes, in a cultivated field, 300 feet west and 300 feet north of the southeast corner of sec. 12, T. 86 N., R. 35 W.:

Ap—0 to 7 inches; black (10YR 2/1) heavy loam; weak fine granular structure; friable; slightly acid; abrupt smooth boundary.

A12—7 to 10 inches; black (10YR 2/1) heavy loam; weak very fine and fine subangular blocky structure; friable, neutral; clear smooth boundary.

A3—10 to 16 inches; dark brown (10YR 3/3) heavy loam; thick very dark gray (10YR 3/1) coats on peds; weak very fine and fine subangular blocky structure; friable; neutral; clear smooth boundary.

B21—16 to 24 inches; brown (10YR 4/3) heavy loam; thin very dark grayish brown (10YR 3/2) coats on peds; weak very fine and fine subangular blocky structure; friable; neutral; clear smooth boundary.

B22—24 to 32 inches; dark yellowish brown (10YR 4/4) heavy loam; weak fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

C—32 to 60 inches; light olive brown (2.5Y 5/6) loam; few fine distinct light olive gray (5Y 6/2) mottles; massive; friable; few reddish accumulations (oxides); few soft lime accumulations; strongly effervescent; moderately alkaline; clear smooth boundary.

The solum is slightly acid or neutral. The A1 horizon is black (10YR 2/1) or very dark brown (10YR 2/2) loam or light clay loam 6 to 12 inches thick. If cultivated, the Ap horizon is black (10YR 2/1) to very dark grayish brown (10YR 3/2) loam or light clay loam. The A3 horizon, if present, is generally very dark grayish brown (10YR 3/2) or dark brown (10YR 3/3) with darker coats on the peds. It is loam or light clay loam and is 4 to 8 inches thick. The B horizon is dark brown (10YR 3/3), brown (10YR 4/3), or dark yellowish brown (10YR 4/4) loam or light clay loam 10 to 30 inches thick. The C horizon is generally dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/4), or light olive brown (2.5Y 5/4) loam or light clay loam.

Because of erosion, mapping units 138C2 and 138D2 have a thinner dark colored surface layer than is defined in the range of the Clarion series.

The Clarion, Nicollet, and Lester soils formed in similar parent material. Clarion soils are better drained than Nicollet soils. They formed under prairie grasses, and they have a less clayey B horizon than the Lester soils that formed under trees and grasses.

138B—Clarion loam, 2 to 5 percent slopes. This soil is on convex knolls and on convex ridgetops that adjoin moderately sloping or strongly sloping soils on hillsides. Most areas are 2 to 10 acres in size and are surrounded by less well drained soils. This soil has the profile described as representative of the series. The surface layer has about 4 percent organic matter.

Included with this soil in mapping are spots of sandy or gravelly soils and ½- to 2-acre areas of Storden soils. These areas are shown on the map with special symbols.

This soil has a moderate erosion hazard. Soil blowing is a hazard if the soil is left bare during winter. This soil is well suited to cultivated crops if erosion is controlled. Slopes typically are short and irregular, especially where the soil is on knolls; these areas are generally farmed with the surrounding soils, which are mostly nearly level. Conservation practices that require contour tillage are difficult to establish. Good use of crop residue and manure is helpful in these areas. Terraces, contour tillage, and other conservation practices are generally suitable where the soil is on ridgetops upslope from more sloping soils. Capability unit IIe–1.

138C—Clarion loam, 5 to 9 percent slopes. This soil is on convex side slopes. Most areas are 5 to 10 acres in size. They generally adjoin areas of gently sloping soils that are upslope or strongly sloping soils that are downslope. Some areas are on knolls surrounded by less well drained soils. This soil has a profile similar to the one described as representative of the series, but the surface layer is typically very dark brown. The surface layer has 3 to 4 percent organic matter.

Included with this soil in mapping are spots of gravelly or sandy soils and ½- to 2-acre areas of Storden soils. These areas are shown on the map with special symbols. Also included are areas of moderately eroded Clarion soils.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. Conservation practices that require contour tillage are difficult to establish in some places because of short, irregular

slopes. Good use of crop residue and manure is helpful in these areas. Many areas are in pasture where it is not possible to establish adequate conservation practices. Maintaining good tilth is generally not a concern. Capability unit IIIe–1.

138C2—Clarion loam, 5 to 9 percent slopes, moderately eroded. This soil is on convex side slopes. Most areas are 5 to 10 acres in size. They generally adjoin areas of gently sloping soils that are upslope or strongly sloping soils that are downslope. Some areas are on knolls surrounded by less well drained soils. This soil has a profile similar to the one described as representative of the series, but the surface layer is typically a very dark grayish brown plow layer that is partly mixed with material from the dark brown subsoil and has 2 to 3 percent organic matter. Also, the depth to the calcareous substratum is less than in the representative profile.

Included with this soil in mapping are spots of sandy or gravelly soils, ½- to 2-acre areas of Storden soils, and spots of severely eroded soils. These areas are shown on the map with special symbols.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. Maintaining good tilth and establishing a good seedbed are more of a concern than on less eroded Clarion soils. Conservation practices that require contour tillage are difficult to establish in some places because of short, irregular slopes. Good use of crop residue and manure is helpful in these areas. Capability unit IIIe–1.

138D2—Clarion loam, 9 to 14 percent slopes, moderately eroded. This soil is on convex side slopes. Most areas are 2 to 5 acres in size. Typically they are downslope from areas of less sloping soils or upslope from more sloping soils. This soil has a profile similar to the one described as representative of the series, but combined thickness of the surface layer and subsoil is less, in cultivated areas the plow layer is very dark grayish brown and is mixed with material from the brown subsoil, and the plow layer has about 2 percent organic matter.

Included with this soil in mapping are spots of sandy or gravelly soils and ½- to 2-acre areas of Storden soils. These areas are shown on the map with special symbols. Some areas of uneroded soils are also included.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. However, many areas are used for pasture because of the erosion hazard and because conservation practices are difficult to establish on the short, irregular slopes. Capability unit IIIe–2.

Coland series

The Coland series consists of poorly drained, nearly level and gently sloping soils on bottom lands. Coland soils formed in alluvium. The native vegetation was grass.

In a representative profile the upper part of the surface layer is black clay loam about 21 inches thick, and the lower part is very dark gray clay loam about 21 inches thick. The underlying material is olive gray and olive sandy clay loam.

Permeability is moderately slow, and available water capacity is high. The rooting zone is deep where root growth is not restricted by a high water table. Organic matter content is high.

Coland soils are generally used for cultivated crops or pasture. Willows and other water-tolerant trees grow in a few places.

Representative profile of Coland clay loam, 0 to 2 percent slopes, in a cultivated field, 600 feet north and 400 feet west of the southeast corner of sec. 33, T. 87 N., R. 35 W.:

Ap—0 to 7 inches; black (5Y 2/1) light clay loam; cloddy; friable; neutral; abrupt smooth boundary.

A12—7 to 21 inches; black (5Y 2/1) medium clay loam; few medium distinct gray (5Y 5/1) mottles; weak fine granular and fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

A13—21 to 36 inches; very dark gray (5Y 3/1) medium clay loam; common distinct dark gray (5Y 4/1) mottles; weak very fine and fine subangular blocky structure; friable; neutral; gradual smooth boundary.

AC—36 to 42 inches; very dark gray (5Y 3/1) light clay loam; common fine distinct olive gray (5Y 4/2) mottles; weak fine prismatic structure parting to weak fine subangular blocky; friable; neutral; clear smooth boundary.

C1—42 to 53 inches; olive gray (5Y 4/2) sandy clay loam; massive; friable; neutral; clear smooth boundary.

C2—53 to 60 inches; olive gray (5Y 5/2) and olive (5Y 5/3) sandy clay loam; massive; very friable; neutral.

The solum is neutral or mildly alkaline and is 36 to 48 inches thick. The A horizon is black (N 2/0, 10YR 2/1, or 5Y 2/1) in the upper part and black (N 2/0, 10YR 2/1, or 5Y 2/1) or very dark gray (5Y 3/1) in the lower part. It is clay loam or silty clay loam in the upper part. In places, the A and C horizons are mixed, or there is a thin B horizon. The C horizon is very dark gray (5Y 3/1), dark gray (5Y 4/1), gray (5Y 5/1), olive gray (5Y 5/2), or olive (5Y 5/3, 5/4). It is generally stratified clay loam, sandy clay loam, or sandy loam. It is neutral to moderately alkaline.

Coland, Colo, and Spillville soils formed in alluvial material. Coland soils have more sand than Colo soils and more clay than Spillville soils.

135—Coland clay loam, 0 to 2 percent slopes. This soil is on bottom lands. Most areas are 2 to 20 acres in size and are long and narrow in shape. This soil has the profile described as representative of the series.

The main management concern is wetness. This soil is well suited to cultivated crops if it is adequately drained and if flooding is controlled. Undrained areas and unprotected areas are better suited to pasture. Many individual areas are in narrow valleys and are cut by a meandering stream. Parts of these areas are inaccessible to farm equipment so it is impractical to plant them to cultivated crops. Capability unit IIw–2.

135B—Coland clay loam, 2 to 4 percent slopes. This soil is along waterways and on alluvial fans. Typically, this soil adjoins gently sloping to strongly sloping soils

on hillsides. Most areas are 2 to 10 acres in size and are long and narrow in shape. In places, lighter colored overwash as much as 15 inches thick overlies the black surface layer.

The main management concern is wetness. Erosion is also a hazard. Water from the adjoining soils runs across areas of this soil and causes rilling. This soil is well suited to cultivated crops if it is adequately drained. Undrained areas are better suited to pasture. Many areas are in narrow valleys and are cut by a stream that is not crossable with farm equipment; thus, some of these areas are left in pasture. Capability unit IIw–1.

201B—Coland-Spillville complex, 2 to 5 percent slopes. This complex is in long, narrow drainageways. Most areas are 2 to 10 acres in size. This complex is about 60 percent Coland soils and 40 percent Spillville soils. Coland soils are in the middle of drainageways, and Spillville soils are on foot slopes next to the upland soils.

Included with this complex in mapping are some areas of Terril soils where this complex borders steep Storden soils.

The main management concerns are wetness and erosion caused mainly by runoff from upslope. These soils are well suited to cultivated crops if the soils are adequately drained, if vegetated waterways are maintained, and if flooding is controlled. Undrained areas are suited to pasture. A few areas are inaccessible to farm equipment because the stream meanders and is not crossable. These areas are in pasture. Capability unit IIw–1.

C201B—Coland-Spillville complex, channeled, 2 to 5 percent slopes. This complex is in long, narrow drainageways. Most areas are 2 to 20 acres in size. This complex is about 65 percent Coland soils and 35 percent Spillville soils. The Coland soils are in the middle of drainageways, and the Spillville soils are on the foot slopes next to the upland soils.

Included with this complex in mapping are some areas of Terril soils.

The main management concerns are wetness, sedimentation, and rilling caused by runoff from the adjoining upland soils. These soils are not commonly suited to cultivated crops, because the channel of the stream cuts the area into small sections. The soils are suited to pasture or hay if flooding is controlled. These soils are well suited to woodland and to wildlife habitat. Capability unit Vw–1.

Collinwood series

The Collinwood series consists of somewhat poorly drained, nearly level to gently sloping soils on uplands. Collinwood soils formed in glacial sediment. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is black silty clay loam about 23 inches thick. The subsoil is about 16 inches thick. The upper part is dark grayish brown silty clay, and the lower part is yellowish brown and olive gray silty clay loam. The underlying material is olive gray and yellowish brown silty clay loam that has distinct mottles.

Permeability is moderately slow to slow, and available water capacity is high. The rooting zone is deep. Organic matter content is high.

Collinwood soils are generally used for cultivated crops, although a few areas are in pasture.

Representative profile of Collinwood silty clay loam, 1 to 3 percent slopes, in a cultivated area, 500 feet east and 120 feet south of the northwest corner of sec. 17, T. 89 N., 36 W.:

Ap—0 to 9 inches; black (10YR 2/1) medium silty clay loam; weak fine granular and weak very fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

A12—9 to 14 inches; black (10YR 2/1) medium silty clay loam; weak fine granular and weak very fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

A3—14 to 23 inches; black (10YR 2/1) heavy silty clay loam; common fine distinct very dark grayish brown (2.5Y 3/2) peds; weak fine granular and weak very fine subangular blocky structure; friable; thin discontinuous shiny coatings on ped surfaces; few fine hard accumulations (oxides); neutral; clear smooth boundary.

B21—23 to 31 inches; dark grayish brown (2.5Y 4/2) light silty clay; common fine distinct olive brown (2/5Y 4/4) mottles; moderate very fine and fine subangular blocky structure; firm few fine dark accumulations (oxides); few fine reddish accumulations (oxides); old root channels filled with dark material from A3; horizon neutral; clear smooth boundary.

B22—31 to 39 inches; olive gray (5Y 5/2) and yellowish brown (10YR 5/6) heavy silty clay loam; weak fine prismatic structure parting to moderate very fine and fine subangular blocky; firm; few fine dark accumulations (oxides); common fine reddish accumulations (oxides); thin discontinuous shiny coatings on faces of peds and prisms; neutral; clear smooth boundary.

C1—39 to 43 inches; olive gray (5Y 5/2) and yellowish brown (10YR 5/6) medium silty clay loam; weak fine prismatic structure parting to weak fine subangular blocky; friable; few fine dark and reddish accumulations (oxides) weakly effervescent; mildly alkaline; abrupt smooth boundary.

C2—43 to 60 inches; olive gray (5Y 5/2) medium silty clay loam; common large distinct yellowish brown (10YR 5/6) mottles; massive but slightly stratified; friable; many large lime concretions; many medium reddish accumulations (oxides); few fine dark accumulations (oxides); strong effervescence; moderately alkaline.

The solum is slightly acid or neutral except in the lower part. The A1 horizon is medium or heavy silty

clay loam. The A3 horizon is black (10YR 2/1) or very dark gray (10YR 3/1) heavy silty clay loam or light silty clay. The A horizon is 14 to 24 inches thick. The B1 horizon, if present, is very dark grayish brown (10YR 3/2 or 2.5Y 3/2) or dark grayish brown (10YR 4/2). The B2 horizon is light silty clay or heavy silty clay loam. The B3 horizon is light silty clay to medium silty clay loam. The B horizon is 15 to 30 inches thick. The C horizon is dark grayish brown (2/5Y 5/2), grayish brown (2/5Y 5/2), or olive gray (5Y 4/2 or 5/2) and has distinct mottles. It is heavy to medium silty clay loam.

Collinwood soils in this county have less clay in the upper part of the A horizon and in the C horizon than in the defined range of the Collinwood series. Also, the 5Y hue in the lower part of the B horizon is not in the defined range. These differences do not significantly alter the use and behavior of the soils.

Collinwood and Waldorf soils formed in similar parent material. Collinwood soils are better drained than Waldorf soils. They formed in finer textured material than Nicollet soils, which have somewhat similar colors.

384—Collinwood silty clay loam, 1 to 3 percent slopes. Most areas of this soil are 5 to 20 acres in size and are irregular in shape. Included with this soil in mapping are soils that are similar to this Collinwood soil but that have clay loam or loam glacial till in the underlying material.

This soil has no major limitations, but the surface layer has a relatively high clay content and maintaining good tilth is a concern of management. This soil is well suited to cultivated crops. Slopes are such that surface drainage is generally good, but they are not steep enough to cause a severe hazard of erosion. Tile has been installed in a few areas for earlier completion of field operations. Capability unit I–1.

Colo series

The Colo series consists of poorly drained, nearly level and gently sloping soils on bottom lands. Colo soils formed in alluvium. The native vegetation was grass.

In a representative profile the surface layer is black silty clay loam about 47 inches thick. The underlying material is very dark gray light clay loam.

Permeability is moderately slow, and available water capacity is high. The rooting zone is deep if not restricted by a high water table. Organic matter content is high.

Colo soils are generally used for cultivated crops. Commonly flooded areas are used for pasture. Willows and other water-tolerant trees grow in a few places.

Representative profile of Colo silty clay loam, 0 to 2 percent slopes, in a pasture 280 feet north and 198 feet west of the southeast corner of SE¼NW¼ sec. 33, T. 88 N., R. 37 W.:

A11—0 to 7 inches; black (10YR 2/1) medium silty clay loam; about 10 percent mixing of very dark grayish brown (10YR 3/2) from recent deposition; weak very fine and fine granular and weak very fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

A12—7 to 24 inches; black (10YR 2/1) medium silty clay loam; weak fine granular and weak very fine subangular blocky structure; friable; neutral; gradual smooth boundary.

A13—24 to 34 inches; black (N 2/0) medium silty clay loam; moderate very fine subangular blocky structure; friable; neutral; gradual smooth boundary.

AC—34 to 47 inches; black (10YR 2/1) medium silty clay loam; moderate very fine and fine subangular blocky structure; friable; neutral; gradual smooth boundary.

C—47 to 62 inches; very dark gray (10YR 3/1) light clay loam; weak very fine prismatic structure parting to weak fine subangular blocky; friable; very fine distinct olive brown accumulations (oxides); neutral.

The solum is neutral or slightly acid. The A horizon is black (N 2/0, 10YR 2/1, or 5Y 2/1) in the upper part and black (N 2/0 or 10YR 2/1) or very dark gray (10YR 3/1) in the lower part. It is 36 to 54 inches thick. In places the A and C horizons are mixed or there is a thin B horizon. The C horizon is very dark gray (10YR 3/1 or 5Y 3/1) to gray (5Y 5/1) silty clay loam or clay loam and is stratified with loam and silt loam in places.

Colo, Calco, and Coland soils formed in alluvial material. Colo soils are noncalcareous, but Calco soils are calcareous throughout. Colo soils have less sand in the solum than Coland soils.

133—Colo silty clay loam, 0 to 2 percent slopes. This soil is generally in elongated areas along streams. Most areas are 5 to 40 acres in size. This soil has the profile described as representative of the series. In places, as much as 15 inches of very dark gray or very dark grayish brown silty clay loam overwash is on the surface or is mixed with the surface layer. The overwash is common in areas where the stream channel has been straightened, and where material has been spread over the original layer.

The main concern of management is wetness. This soil is well suited to cultivated crops if it is adequately drained and if flooding is controlled. Undrained areas are suited to pasture. Most areas are farmed with other nearly level soils on bottom lands or gently sloping soils on foot slopes. Capability unit IIw–2.

11B—Colo-Ely silty clay loams, 2 to 5 percent slopes. These soils typically are in long narrow drainageways at the base of gently sloping or moderately sloping soils on uplands. The Colo soil makes up about 60 percent of the complex, and the Ely soil makes up about 40 percent. The Colo soil is in the middle of the drainageways, and the Ely soil is on foot slopes next to the soils on uplands. Most areas are 2 to 20 acres in size. The Colo and Ely soils have profiles similar to the ones described as representative of their respective series, but in places 6 to 15 inches of very dark grayish brown overwash is over the original black surface layer.

The main management concerns are wetness and erosion caused by runoff from the adjoining soils on uplands. These soils are well suited to cultivated crops if the soils are adequately drained, if vegetated waterways are maintained, and if flooding is controlled. Un-

drained areas are suited to pasture. In places the waterways prevent the use of farm equipment. Because of this, it is impractical to plant cultivated crops in some of these areas, so they are in pasture. Capability unit IIw–1.

Cylinder series

The Cylinder series consists of somewhat poorly drained, nearly level soils on stream benches and on uplands. Cylinder soils formed in glacial sediment or alluvium. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is black loam about 14 inches thick. The upper part of the subsoil is very dark grayish brown and dark grayish brown loam and sandy clay loam about 20 inches thick. The lower part of the subsoil is dark yellowish brown loamy sand about 6 inches thick. The underlying material is dark yellowish brown sand and gravel.

Permeability is moderate in the upper part of the profile and rapid in the underlying sand and gravel. Available water capacity is moderate. The rooting zone is restricted by the underlying sand and gravel. Organic matter content is high.

Cylinder soils are generally used for cultivated crops, although a few areas are in pasture.

Representative profile of Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, in a cultivated area, 35 feet east and 300 feet south of the northwest corner of SW¼NW¼ sec. 30, T. 89 N., R. 35 W.:

Ap—0 to 9 inches; black (10YR 2/1) heavy loam; weak fine granular and weak very fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

A12—9 to 14 inches; black (10YR 2/1) heavy loam; common fine very dark grayish brown (10YR 3/2) mottles; weak very fine and fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B1—14 to 18 inches; very dark grayish brown (10YR 3/2) and very dark gray (10YR 3/1) heavy loam; (10YR 3/2) kneaded; fine and very fine subangular blocky structure; friable; few very fine dark and reddish accumulations (oxides); slightly acid; gradual smooth boundary.

B21—18 to 24 inches; dark grayish brown (2/5Y 4/2) and very dark grayish brown (10YR 3/2) heavy loam; weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B22—24 to 28 inches; dark grayish brown (2.5Y 4/2) heavy loam; weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B31—28 to 34 inches; dark grayish brown (2/5Y 4/2) to olive brown (2.5Y 4/4) sandy clay loam; few fine faint grayish brown (2.5Y 5/2) mottles; weak fine subangular blocky structure; friable; few dark concretions; few fine reddish accumulations (oxides); neutral; clear smooth boundary.

IIB32—34 to 40 inches; dark yellowish brown (10YR 4/4) loamy sand; few fine distinct grayish brown (10YR 5/2) mottles; weak medium subangular blocky structure; very friable; few medium reddish accumulations (oxides); few medium dark concretions; neutral; abrupt smooth boundary.

IIC1—40 to 58 inches; dark yellowish brown (10YR 3/4) sand and some gravel; single grained; loose; weakly effervescent; mildly alkaline; abrupt smooth boundary.

IIC2—58 to 64 inches; dark yellowish brown (10YR 4/4) sand and gravel; single grained; loose; weakly effervescent; mildly alkaline.

The solum is slightly acid or neutral. The A horizon is loam or light clay loam 10 to 24 inches thick. The medium textured part of the B horizon is typically dark grayish brown (2.5Y 4/2 or 10YR 4/2), but in places it is very dark grayish brown (10YR 3/2), dark brown (10YR 3/3), or brown (10YR 4/3) and has distinct grayish mottles. The B horizon is loam or light clay loam 14 to 32 inches thick. Most profiles have a sandy loam or sandy clay loam transition zone, less than 5 inches thick, between the medium textured part of the B horizon and the coarser textured material below. The IIB horizon is brown (10YR 4/3) or dark yellowish brown (10YR 4/4) and has distinct grayish brown (10YR 5/2 or 2.5Y 5/2) mottles or is dark grayish brown (10YR 4/2 or 2/5Y 4/2) and has dark yellowish brown (10YR 4/4) mottles or yellowish brown (10YR 5/4) mottles. It is loamy sand or sand with some gravel. The C horizon is generally stratified sand and gravel that is dark grayish brown (10YR 4/2) to light olive brown (2.5Y 5/6).

Cylinder and Biscay soils formed in similar parent material. Cylinder and Nicollet soils are somewhat poorly drained, and Biscay soils are poorly drained. Cylinder soils are underlain by sand and gravel at a depth of 24 to 40 inches. Nicollet soils are medium textured to moderately fine textured throughout.

203—Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This soil is at lower elevations than adjoining better drained soils and is slightly higher on the landscape than adjoining poorly drained soils. Most areas are 2 to 40 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of soils in Boyer River valley that are siltier and more stratified than Cylinder soils in other parts of the county. Also included are small areas of poorly drained soils.

This soil has no major limitations. However, runoff from adjoining slopes causes a slight hazard of wetness. This soil is well suited to cultivated crops, but droughtiness is a hazard in unusually dry years. The sand and gravel substratum limits the available water capacity. Capability unit I–1.

202—Cylinder loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes. This soil is at lower elevations than adjoining better drained soils and is slightly higher on the landscape than adjoining poorly drained

soils. Most areas are 2 to 20 acres in size. This soil has a profile similar to the one described as representative of the series, but the depth to sand and gravel is less.

Included with this soil in mapping are areas of soils in the Boyer River valley that are siltier and more stratified than Cylinder soils in other parts of the county. Also included are small areas of poorly drained soils.

This soil has a drought hazard. It is well suited to cultivated crops, but tillage practices that conserve moisture are required. Capability unit IIs–1.

Ely series

The Ely series consists of somewhat poorly drained, nearly level to gently sloping soils on foot slopes. Ely soils formed in moderately fine textured local alluvium. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is silty clay loam about 26 inches thick. The upper part is black, and the lower part is very dark grayish brown. The subsoil is very dark grayish brown and dark grayish brown to olive brown silty clay loam about 26 inches thick. The underlying material is dark grayish brown, olive gray, and yellowish brown silt loam.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content is high.

Ely soils are generally used for cultivated crops, although a few areas are in pasture.

Representative profile of Ely silty clay loam, 1 to 3 percent slopes, in a cultivated area, 300 feet south and 15 feet west of the northeast corner of SE¼NE¼ sec. 25, T. 88 N., R. 38 W.:

Ap—0 to 8 inches; black (10YR 2/1) medium silty clay loam; few fine faint very dark grayish brown (10YR 3/2) peds; cloddy; friable; neutral; abrupt smooth boundary.

A12—8 to 18 inches; black (10YR 2/1) medium silty clay loam; few fine faint very dark grayish brown (10YR 3/2) peds; weak fine prismatic and very fine subangular blocky structure; friable; neutral; gradual smooth boundary.

A3—18 to 26 inches; very dark grayish brown (10YR 3/2) heavy silty clay loam; black (10YR 2/1) coats on faces of peds; very dark brown (10YR 2/2) kneaded; moderate very fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B1—26 to 32 inches; very dark grayish brown (10YR 3/2) heavy silty clay loam; common very dark gray (10YR 3/1) coats on faces of peds; moderate fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B21—32 to 39 inches; dark grayish brown (10YR 4/2) medium silty clay loam; very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) coats on faces of peds; fine subangular blocky structure; friable; neutral; gradual, smooth boundary.

B22—39 to 52 inches; dark grayish brown (2.5Y 4/2) to olive brown (2.5 4/4) light silty clay loam; very dark gray (10YR 3/1) coats on faces of peds; weak fine prismatic structure parting to weak fine subangular blocky; friable; very dark gray (10YR 3/1) fills in wormholes; few fine dark and reddish accumulations (oxides); strongly effervescent; neutral; clear smooth boundary.

C1—52 to 76 inches; dark grayish brown (2.5Y 4/2), dark yellowish brown (10YR 4/4), and olive gray (5Y 5/2) silt loam; massive; friable; few fine dark and reddish accumulations (oxides); moderately alkaline; abrupt smooth boundary.

C2—76 to 84 inches; olive gray (5Y 5/2) silt loam; streaks of yellowish brown (10YR 5/8); massive, slight stratification; friable; dark accumulations (oxides) on cleavage faces; strong effervescence; moderately alkaline.

The A horizon is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2) in the lower part and is 20 to 32 inches thick. The B horizon is generally very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2) in the upper part and is 20 to 50 inches thick. The lower part ranges from dark grayish brown (10YR 4/2 or 2.5Y 4/2) to dark yellowish brown (10YR 4/4) and olive gray (5Y 5/2). The C horizon generally has mixed colors. It is light silty clay loam or heavy silt loam.

Ely, Marcus, and some of the Primghar soils are in similar landscape positions. Ely soils have a thicker A horizon than Primghar and Marcus soils. They are better drained and more sloping than Marcus soils.

428—Ely silty clay loam, 1 to 3 percent slopes. This soil is on foot slopes below areas of gently sloping to strongly sloping soils. Most areas are 2 to 10 acres in size and are long and narrow in shape. This soil has the profile described as representative of the series. Many areas have some lighter colored overwash overlying the original black surface layer.

This soil has no major limitations. However, runoff from adjoining slopes causes rilling or sedimentation if it is not controlled. This soil is well suited to cultivated crops. It is generally farmed with areas of adjoining upland soils. Capability unit I–1.

Everly series

The Everly series consists of well drained, gently sloping to strongly sloping soils on uplands. These soils formed in less than 20 inches of loess and in the underlying loamy glacial till. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is very dark brown clay loam about 6 inches thick. The subsoil is about 28 inches thick. The upper part is dark brown and brown clay loam, and the lower part is yellowish brown loam. The underlying material is yellowish brown loam.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic mat-

ter content is moderate to low, depending on the extent of erosion.

Everly soils are used for cultivated crops and pasture.

Representative profile of Everly clay loam, 4 to 9 percent slopes, moderately eroded, in a cultivated area, 500 feet east and 75 feet north of the southwest corner of sec. 1, T. 89 N., R. 37 W.:

Ap—0 to 6 inches; very dark brown (10YR 2/2) light clay loam; weak fine granular and weak very fine and fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

B1—6 to 11 inches; dark brown (10YR 3/3) light clay loam; thin very dark grayish brown (10YR 3/2) coats on peds; weak fine granular and weak very fine and fine subangular blocky structure; friable; neutral; clear smooth boundary.

B21—11 to 17 inches; brown (10YR 4/3) light clay loam; weak fine and very fine subangular blocky structure; friable; neutral; clear smooth boundary.

IIB22—17 to 22 inches; yellowish brown (10YR 5/4) and dark yellowish brown (10YR 4/4) heavy loam; weak fine subangular blocky structure; friable; few fine reddish accumulations (oxides); slightly effervescent; moderately alkaline; clear smooth boundary.

IIB31—22 to 28 inches; yellowish brown (10YR 5/4) heavy loam; weak fine prismatic structure parting to weak fine subangular blocky; friable; common medium soft lime accumulations; common lime threads; few fine reddish accumulations (oxides); strongly effervescent; moderately alkaline; gradual smooth boundary.

IIB32—28 to 34 inches; yellowish brown (10YR 5/4) heavy loam; weak fine prismatic structure; friable; few fine reddish accumulations (oxides); common lime threads; strongly effervescent; moderately alkaline; gradual smooth boundary.

IIC—34 to 60 inches; yellowish brown (10YR 5/4) heavy loam; massive; friable; few fine dark accumulations (oxides); common fine reddish accumulations (oxides); few fine lime threads; strongly effervescent; moderately alkaline.

The solum is slightly acid or neutral in the upper part and mildly alkaline or moderately alkaline in the lower part. The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2). It is heavy loam or light clay loam and has a high silt content. It is 10 to 16 inches thick where uneroded. The B horizon is brown (10YR 4/3), dark yellowish brown (10YR 4/4), yellowish brown (10YR 5/4 or 5/6), olive brown (2.5Y 4/4), or light olive brown (2.5Y 5/4 or 5/6). It is 4 to 30 inches thick. In most places it is very dark grayish brown (10YR 3/2) or dark brown (10YR 3/3) in the upper part and has olive gray (5Y 5/2) mottles in the lower part. The C horizon is loam or light clay loam.

Everly and Sac soils formed in similar parent material. Everly soils formed in less than 20 inches of loess over glacial till, and Sac soils formed in 20 to 40 inches of loess over glacial till.

577C2—Everly clay loam, 4 to 9 percent slopes, moderately eroded. This soil is on ridgetops and side slopes. Areas range from 2 acres to more than 50 acres in size and are irregular in shape. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of slightly eroded soils. Also included are spots of sandy or gravelly soils and ½- to 2-acre areas of Storden soils, both of which are shown on the map with special symbols.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. Most areas are farmed with areas of gently sloping or moderately sloping Galva or Sac soils. All of these soils are generally well suited to contour tillage because of their smooth, relatively long slopes. Capability unit IIIe–1.

577D2—Everly clay loam, 9 to 14 percent slopes, moderately eroded. This soil is on side slopes. Most areas are 2 to 10 acres in size and are irregular in shape. This soil has a profile similar to the one described as representative of the series, but the surface layer typically is very dark grayish brown.

Included with this soil in mapping are areas of Sac soils. Also included are small spots of sandy and gravelly soils and some ½- to 2-acre areas of Storden soils.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. However, many areas are used for pasture because of the erosion hazard. Most areas that are used for cultivated crops are farmed with areas of moderately sloping Galva and Sac soils. This soil is suited to contour tillage and terracing because slopes are generally long and smooth. Capability unit IIIe–2.

Flagler variant

The Flagler variant consists of somewhat excessively drained, gently sloping to moderately sloping soils on benches and on uplands. These soils formed in glacial sediment and alluvium. The native vegetation was prairie grasses.

In a representative profile the surface layer is very dark brown sandy loam about 13 inches thick. The subsoil is brown and dark yellowish brown and is about 23 inches thick. It is sandy loam in the upper part and loamy sand in the lower part. The underlying material is dark brown sand and some gravel.

Permeability is moderately rapid in the surface layer and subsoil and rapid in the underlying material. Available water capacity is moderate to low. The rooting zone is deep, but root growth often is restricted by droughty conditions. Organic matter content is moderate to low.

Flagler variant soils are used for cultivated crops or pasture.

Representative profile of Flagler sandy loam, calcareous subsoil variant, 2 to 5 percent slopes, in a cultivated field, 300 feet west and 20 feet north of the southeast corner of SW¼ of sec. 23, T. 87 N., R. 36 W.:

Ap—0 to 8 inches; very dark brown (10YR 2/2) heavy sandy loam; weak fine granular and weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

A3—8 to 13 inches; very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) sandy loam; weak fine granular and weak very fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B1—13 to 19 inches; brown (10YR 4/3) light sandy loam; very dark grayish brown (10YR 3/2) coats on ped surfaces; weak fine subangular blocky structure; friable; neutral; clear smooth boundary.

B2—19 to 28 inches; dark yellowish brown (10YR 4/4) light sandy loam; weak medium subangular blocky structure; very friable; neutral; gradual wavy boundary.

IIB3—28 to 36 inches; dark yellowish brown (10YR 4/4) loamy sand; weak medium subangular blocky structure; very friable; neutral; abrupt wavy boundary.

IIC—36 to 63 inches; brown (10YR 4/3) sand, some gravel; single grained; loose; strongly effervescent; moderately alkaline.

The solum ranges from medium acid to neutral. The A horizon is black (10YR 2/1) to very dark grayish brown (10YR 3/2) and is 12 to 24 inches thick unless eroded. The B horizon is dark brown (10YR 3/3) to strong brown (7.5YR 5/6) and is 8 to 30 inches thick. The C horizon is dark yellowish brown (10YR 4/4), brown (10YR 4/3), or yellowish brown (10YR 5/4 and 5/6) loamy sand or sand. It ranges from 0 to more than 20 percent gravel.

The Flagler variant and Sparta soils formed in similar parent material. Flagler variant soils are deeper to loamy sand or sand than Sparta soils and are calcareous at a shallower depth than Sparta soils.

823B—Flagler sandy loam, calcareous subsoil variant, 2 to 5 percent slopes. Most areas are on elongated knolls and are 2 to 10 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are a few areas of soils that have a loam surface layer and some nearly level Flagler variant soils.

This soil has moderate erosion and drought hazards. It is suited to cultivated crops if erosion is controlled and practices are used to conserve moisture. Contour tillage and practices that leave crop residue on the surface are also helpful. Capability unit IIIe–3.

823C2—Flagler sandy loam, calcareous subsoil variant, 5 to 9 percent slopes, moderately eroded. This soil is on knolls. Most areas are 2 to 10 acres in size and are elongated in shape.

This soil has a profile similar to the one described as representative of the series, but the surface layer is thinner and lighter colored and in cultivated areas the plow layer is very dark grayish brown and commonly is mixed with the brown subsoil.

Included with this soil in mapping are areas of soils that have a loam surface layer, areas of soils that have coarse gravel and sand in the underlying material, and areas of soils that are deeply leached. Also included are some areas of soils that are calcareous throughout.

This soil has severe erosion and drought hazards. It is suited to cultivated crops if erosion is controlled and if practices to conserve moisture are used. Contour tillage and mulch tillage are suitable practices on this soil. Capability unit IIIe–3.

Galva series

The Galva series consists of well drained, nearly level to moderately sloping soils on uplands and on stream benches. These soils formed in 40 inches or more of loess over glacial till. The native vegetation was tall prairie grass.

In a representative profile the surface layer is silty clay loam about 16 inches thick. The upper part is black, and the lower part is very dark grayish brown. The subsoil is about 31 inches thick. It is brown silty clay loam in the upper 24 inches and dark yellowish brown silt loam in the lower 7 inches. The underlying material, to a depth of 53 inches, is dark yellowish brown silty clay loam that has distinct grayish brown mottles. Beneath this is dark yellowish brown clay loam that has distinct olive gray mottles.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content typically is moderate.

Galva soils are mostly used for cultivated crops, but a few areas are used for pasture.

Representative profile of Galva silty clay loam, 2 to 5 percent slopes, in a cultivated field, 45 feet north and 1,125 feet east of the southwest corner of sec. 19, T. 89 N., R. 37 W.:

Ap—0 to 8 inches; black (10YR 2/1) silty clay loam; cloddy; friable; slightly acid; abrupt smooth boundary.

A12—8 to 12 inches; black (10YR 2/1) light silty clay loam; moderate fine granular structure; friable; neutral; gradual smooth boundary.

A3—12 to 16 inches; very dark grayish brown (10YR 3/2) heavy silty clay loam; moderate fine granular and very fine subangular blocky structure; friable; neutral; clear smooth boundary.

B21—16 to 23 inches; brown (10YR 4/3) heavy silty clay loam; very dark grayish brown (10YR 3/2) coatings on peds; moderate fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B22—23 to 32 inches; brown (10YR 4/3) medium silty clay loam; weak medium prismatic structure parting to weak fine and medium subangular blocky; friable; neutral; gradual smooth boundary.

B31—32 to 40 inches; brown (10YR 4/3) light silty clay loam; few fine faint grayish brown (2.5Y 5/2) mottles; weak medium prismatic structure parting to weak fine and medium subangular blocky; few patchy coatings on peds; friable; neutral; gradual smooth boundary.

B32—40 to 47 inches; dark yellowish brown

(10YR 4/4) heavy silt loam; common fine distinct olive gray (5Y 5/2) and few fine distinct strong brown (7/5YR 5/6) mottles; moderate medium prismatic structure parting to weak medium subangular blocky; friable; few soft dark accumulations (oxides); neutral; gradual smooth boundary.

C1—47 to 53 inches; dark yellowish brown (10YR 4/4) silt loam; common medium distinct grayish brown (2.5Y 5/2) mottles; massive; friable; few fine dark and red accumulations (oxides); common fine threads of lime; strongly effervescent; moderately alkaline; gradual smooth boundary.

IIC2—53 to 60 inches; dark yellowish brown (10YR 4/4) light clay loam; few medium distinct olive gray (5Y 5/2) mottles; massive; firm; few fine dark accumulations (oxides); few medium red accumulations (oxides), common fine threads of lime; common stones and pebbles at loess-till contact; strongly effervescent; moderately alkaline.

The A1 horizon is black (10YR 2/1) or very dark brown (10YR 2/2) and is 10 to 16 inches thick where uneroded. Because of erosion, mapping units 310B2 and 310C2 have a dark colored surface layer that is thinner than the defined range of the Galva series. The B horizon is 20 to 36 inches thick. The upper part is dark brown (10YR 3/3) or brown (10YR 4/3). The upper part of the C horizon is brown (10YR 4/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4). In most places it is light silty clay loam or silt loam. The clay loam glacial till directly underlies the solum in places. In units T310 and T310B, the underlying material is sand and gravel and is at a depth of 4 to 6 feet.

Galva, Sac, and Primghar soils formed in similar parent material. Galva and Primghar soils formed in loess. Sac soils formed in 20 to 40 inches of loess and in the underlying glacial till. Galva soils are better drained than Primghar soils.

310—Galva silty clay loam, 0 to 2 percent slopes. This soil is on ridgetops. Most areas are 2 to 10 acres in size. The surface layer of this soil has about 4 percent organic matter.

This soil has no major limitations to use. It is well suited to cultivated crops. Practices that conserve moisture, such as tillage methods that leave crop residue on the surface, are beneficial. This soil is commonly farmed with areas of gently sloping Galva or Sac soils. Capability unit I–1.

310B—Galva silty clay loam, 2 to 5 percent slopes. Areas of this soil extend for a mile or more on convex upland positions. This soil has the profile described as representative of the series. The surface layer has about 3 to 4 percent organic matter, and the total content is about 90 tons per acre.

Included with this soil in mapping are narrow areas of Primghar soils.

This soil has a moderate erosion hazard. It is well suited to cultivated crops if erosion is controlled. Good tilth is easy to maintain, but timely field operations are important because of the clay content of the surface layer. Capability unit IIe–1.

310B2—Galva silty clay loam, 2 to 5 percent slopes, moderately eroded. This soil is on very slightly convex knobs. Most areas are 5 to 10 acres in size and are irregular in shape. The surface layer is a very dark grayish brown plow layer and is partly mixed with material from the brown subsoil in many places. This soil has 2 to 3 percent organic matter and the total content of the profile is about 45 tons per acre, most of which is in the plow layer.

This soil has a moderate erosion hazard. It is well suited to cultivated crops if erosion is controlled. This soil is farmed with areas of adjoining soils. Since the slopes are generally slightly steeper and more convex than those of adjoining soils, this soil tends to erode more easily. The loss of organic matter and the mixing of material from the subsoil with that in the plow layer adversely affects tilth. Capability unit IIe–1.

310C—Galva silty clay loam, 5 to 9 percent slopes. This soil is on side slopes. Most areas range from about 5 to 20 acres in size and are irregular in shape. This soil typically has a very dark brown to very dark grayish brown surface layer about 10 inches thick. The surface layer has 3 to 4 percent organic matter, and the total content of the profile is about 85 tons per acre.

Included with this soil in mapping are areas of Primghar soils in narrow hillside drainageways.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. Good tilth is easy to maintain, but timely field operations are important because of the clay content of the surface layer. Capability unit IIIe–1.

310C2—Galva silty clay loam, 5 to 9 percent slopes, moderately eroded. This soil is on side slopes. It lies between areas of gently sloping Galva and Sac soils that are upslope and areas of somewhat poorly drained and poorly drained soils that are in valleys. Most areas are about 5 to 20 acres in size and are irregular in shape. This soil typically has a very dark grayish brown plow layer that is mixed with some material from the brown subsoil. It has about 2 to 3 percent organic matter, and the total content is about 40 tons per acre, most of which is in the plow layer.

Included with this soil in mapping are areas of Primghar soils in narrow hillside drainageways.

This soil has a severe erosion hazard. It tends to erode more readily than other moderately sloping Galva soils because its slopes are generally slightly steeper and more convex. Also, the rate of infiltration is lower in this soil because of the loss of organic matter and the mixing of material from the subsoil with that in the plow layer. These factors make it difficult to establish a good seedbed. Capability unit IIIe–1.

T310—Galva silty clay loam, benches, 0 to 2 percent slopes. This nearly level soil is on benches. Most areas are 2 to 40 acres in size. This soil has a profile similar to that described as representative of the series, but it is underlain by gravel and sand at a depth of about 4 to 6 feet.

This soil has no serious limitations for farming. It is well suited to cultivated crops, but it is severely limited for livestock ponds and many other uses be-

cause of the underlying sand and gravel. Capability unit I–1.

T310B—Galva silty clay loam, benches, 2 to 5 percent slopes. This gently sloping soil typically is in thin bands along the edges of benches. It is between areas of nearly level soils on benches and nearly level soils on bottom lands. Most areas are 2 to 5 acres in size. This soil has a profile similar to that described as representative of the series, but it is underlain by gravel and sand at a depth of about 4 to 6 feet.

This soil has a moderate erosion hazard. It is suited to cultivated crops if erosion is controlled, but it is severely limited for livestock ponds and some other uses because of the underlying gravel and sand. Capability unit IIe–1.

Harps series

The Harps series consists of poorly drained, nearly level soils on uplands. Harps soils formed in medium textured and moderately fine textured glacial sediment. Native vegetation was tall grasses and sedges.

In a representative profile the surface layer is black loam and light clay loam about 21 inches thick. The subsoil is dark gray and gray clay loam about 21 inches thick. The underlying material is light gray loam that has strong brown mottles.

Permeability is moderate, and available water capacity is high. The rooting zone is deep but in wet seasons is restricted by a high water table. Organic matter content is high. Harps soils are mainly used for cultivated crops.

Representative profile of Harps loam, 0 to 2 percent slopes, in a cultivated area, 100 feet south of the northwest corner of the NE¼NE¼ of sec. 4, T. 87 N., R. 35 W.:

Apca—0 to 8 inches; black (5Y 2/1) loam, very dark brown (10YR 2/2) dry; weak fine granular and weak very fine subangular blocky structure; friable; violently effervescent; moderately alkaline; abrupt smooth boundary.

A12ca—8 to 15 inches; black (5Y 2/1) loam, dark gray (10YR 4/1) dry; weak very fine subangular blocky structure; friable; violently effervescent; moderately alkaline; clear smooth boundary.

A3ca—15 to 21 inches; black (5Y 2/1) light clay loam, gray (5Y 3/1) dry; weak very fine subangular blocky structure; friable; violently effervescent; moderately alkaline; clear smooth boundary.

B1gca—21 to 30 inches; dark gray (5Y 4/1) and very dark gray (5Y 3/1) light clay loam; weak very fine subangular blocky structure; friable; strongly effervescent; moderately alkaline; clear smooth boundary.

B2g—30 to 42 inches; dark gray (5Y 4/1) and gray (5Y 5/1) light clay loam; few fine distinct light gray (5Y 7/1) mottles; weak very fine subangular blocky structure; friable; strongly effervescent; moderately alkaline; gradual smooth boundary.

C1g—42 to 52 inches; light gray (5Y 6/1) loam; few fine distinct strong brown (7.5YR 5/6) mottles; massive; friable; few fine dark and reddish accumulations (oxides); common light gray lime concretions; strongly effervescent; moderately alkaline; gradual smooth boundary.

C2g—52 to 70 inches; light gray (5Y 6/1) loam; many medium prominent strong brown (7.5YR 5/8) mottles; massive; friable; common fine dark accumulations (oxides); few light gray lime concretions; strongly effervescent; moderately alkaline.

The A horizon is black (10YR 2/1 or 5Y 2/1) or very dark gray (10YR 3/1 or 5Y 3/1) loam or light clay loam. It is 12 to 22 inches thick. The B horizon is dark gray (5Y 4/1), gray (5Y 5/1), or light gray (5Y 6/1) loam or light clay loam and has distinct brownish mottles in some places. It is 18 to 30 inches thick. The C horizon generally is dark gray (5Y 4/1), gray (5Y 5/1), olive gray (5Y 5/2), or light gray (5Y 6/1) and has distinct yellowish brown or strong brown mottles. In places it has thin strata of coarser textured material.

Harps and Canisteo soils formed in similar parent material. Harps soils are highly calcareous; Canisteo soils are moderately calcareous.

95—Harps loam, 0 to 2 percent slopes. This soil is on narrow rims along the edge of depressions. Areas of this soil are at a lower elevation than the adjoining better drained soils. They have a high lime content and appear as whitish bands around the depressions when the soil is dry. Most areas are 2 to 10 acres in size.

The main management concern is wetness. This soil is well suited to cultivated crops, but the high content of lime reduces the availability of some plant nutrients and affects the reaction of herbicides. If this soil is not adequately drained, root growth is restricted during wet seasons. Tile drains work well if satisfactory outlets are available. Capability unit IIw–1.

Ida series

The Ida series consists of well drained, strongly sloping to very steep soils on uplands. These soils formed in medium textured loess. The native vegetation was prairie grasses.

In a representative profile the surface layer is brown silt loam about 7 inches thick. The underlying material is brown, yellowish brown, and light olive brown silt loam and extends to a depth of more than 60 inches.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content is generally low.

Ida soils are used for cultivated crops and pasture.

Representative profile of Ida silt loam, 14 to 20 percent slopes, severely eroded, in a pasture, 100 feet east and 300 feet north of the southwest corner of NE¼NW¼ of sec. 21, T. 86 N., R. 37 W.:

Ap—0 to 7 inches; brown (10YR 4/3) silt loam; weak fine subangular blocky structure; friable; strongly effervescent; moderately alkaline; abrupt smooth boundary.

C1—7 to 22 inches; brown (10YR 4/3) silt loam; weak fine subangular blocky structure; friable; common fine lime concretions; few medium dark reddish brown accumulations (oxides); strongly effervescent; moderately alkaline; gradual smooth boundary.

C2—22 to 36 inches; yellowish brown (10YR 5/4) silt loam; few fine distinct grayish brown (2.5Y 5/2) mottles and few fine faint yellowish brown (10YR 5/6) mottles; massive; friable; few medium dark accumulations (oxides); few fine lime threads; strongly effervescent; moderately alkaline; gradual smooth boundary.

C3—36 to 50 inches; yellowish brown (10YR 5/4) silt loam; few fine faint yellowish brown (10YR 5/6) mottles; friable; many fine dark accumulations (oxides); few fine lime threads; strongly effervescent; moderately alkaline; clear smooth boundary.

C4—50 to 60 inches; light olive brown (2/5Y 5/4) silt loam; few fine faint grayish brown (2.5Y 5/2) mottles; massive; friable; few medium dark accumulations (oxides); strongly effervescent; moderately alkaline.

The A horizon is very dark grayish brown (10YR 3/2) to brown (10YR 4/3) and is about 6 inches thick. The Ap horizon typically is dark grayish brown (10YR 4/2) or brown (10YR 4/3) and is 6 to 10 inches thick. The upper part of the C horizon is brown (10YR 4/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4 or 5/6). The lower part ranges from brown (10YR 4/3) to olive brown (2.5Y 5/4).

Ida, Monona, and Marshall soils formed in loess. Ida soils are coarser textured than Marshall soils. Ida soils are moderately alkaline, and Monona and Marshall soils are slightly acid to neutral and are noncalcareous.

1D3—Ida silt loam, 9 to 14 percent slopes, severely eroded. This soil is on convex hillsides. Areas are generally 2 to 10 acres in size and are irregular in shape.

Included with this soil in mapping are areas of Ida soils that have a darker colored surface layer than that described as representative of the series. Also included are areas of Ida soils that are moderately sloping and areas of Ida soils that have many lime concretions on the surface.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. This soil has a high lime content that reduces the availability of phosphorus and other plant nutrients. It is farmed with areas of Marshall and Monona soils but has a lower level of available nutrients. Because runoff is more rapid on this soil, it has less available water than those soils. It responds well to management that reduces runoff, increases fertility, and controls erosion. Capability unit IIIe–2.

1E3—Ida silt loam, 14 to 20 percent slopes, severely eroded. This soil is on convex hillsides. Most areas are 2 to 10 acres in size and are irregular in shape. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of soil that have a darker colored surface layer than the one described as representative of the series. Also included are areas of Ida soils that have numerous lime concretions on the surface.

This soil has a severe erosion hazard. It is suited to hay or pasture. It can be planted to cultivated crops part of the time if erosion is controlled. This soil has a high lime content that reduces the availability of phosphorus and other plant nutrients. Much of the precipitation is lost unless runoff is controlled by using practices such as terraces, contour tillage, and adequate plant cover. This soil responds well to management that reduces runoff and erosion and increases fertility. Capability unit IVe–1.

1F3—Ida silt loam, 20 to 30 percent slopes, severely eroded. This soil is at or near the base of hillsides. Most areas are 2 to 10 acres in size and are irregular in shape.

Included with this soil in mapping are areas of soils that have a darker colored surface layer than the one described as representative of the series. Also included are areas of very steep Ida soils and areas of Ida soils that have numerous lime concretions on the surface.

This soil has a severe erosion hazard. It is suited to hay, although in places the steepness of the slope makes it hazardous to use farm machinery. Capability unit VIe–1.

Judson series

The Judson series consists of well drained and moderately well drained, gently sloping to moderately sloping soils on foot slopes. These soils formed in moderately fine textured local alluvium. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is silty clay loam about 25 inches thick. The upper part is black, and the lower part is very dark grayish brown. The subsoil is dark brown silty clay loam about 53 inches thick. The underlying material is olive brown silty clay loam.

Permeability is moderate and available water capacity is high. The rooting zone is deep. Organic matter content is high.

Judson soils are used for cultivated crops.

Representative profile of Judson silty clay loam, 3 to 8 percent slopes, in a cultivated area, 400 feet west and 100 feet north of the southeast corner of NE¼ of sec. 20, T. 87 N., R. 38 W.:

Ap—0 to 7 inches; black (10YR 2/1) light silty clay loam; cloddy; friable; slightly acid; abrupt smooth boundary.

A12—7 to 10 inches; black (10YR 2/1) light silty clay loam; weak coarse platy structure parting to weak fine granular and weak fine subangular blocky; friable; neutral; gradual smooth boundary.

A3—10 to 25 inches; very dark grayish brown (10YR 3/2) light silty clay loam; black (10YR 2/1) coatings on peds; common medium distinct brown (10YR 4/3)

mottles; weak fine granular and weak very fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B21—25 to 45 inches; dark brown (10YR 3/3) medium silty clay loam; very dark grayish brown (10YR 3/2) coatings on peds; weak fine prismatic structure parting to weak fine subangular blocky; friable; neutral; gradual smooth boundary.

B22—45 to 54 inches; dark brown (10YR 3/3) medium silty clay loam; very dark grayish brown (10YR 3/2) coatings on peds; weak medium prismatic structure parting to weak fine subangular blocky; few fine dark accumulations (oxides); neutral; gradual; smooth boundary.

B31—54 to 69 inches; dark brown (10YR 3/3) medium silty clay loam; very dark grayish brown (10YR 3/2) coatings on peds; weak medium prismatic structure parting to weak fine subangular blocky; friable; common fine dark accumulations (oxides); very few fine reddish accumulations (oxides); slightly acid; gradual smooth boundary.

B32—69 to 78 inches; dark brown (10YR 3/3) medium silty clay loam; very dark grayish brown (10YR 3/2) coatings on peds; few fine faint brown (10YR 4/3) mottles; weak medium prismatic structure; friable; common dark accumulations (oxides); few fine reddish accumulations (oxides); neutral; clear smooth boundary.

C—78 to 93 inches; olive brown (2.5Y 4/4) light silty clay loam; weak medium prismatic structure; friable; common dark reddish accumulations (oxides); neutral.

The solum is medium acid to neutral in the most acid part. The A horizon is 24 to 36 inches thick. The upper part is very dark brown (10YR 2/2) in some places. The B horizon is dark brown (10YR 3/3) or brown (10YR 4/3) and has grayish mottles below a depth of 30 inches in some places. It is 10 inches to several feet thick. The C horizon is moderately alkaline and calcareous in some places.

Judson soils in Sac County have value of 3 that extends to a depth of 40 inches or more, which is not within the defined range of the Judson series. This difference does not have a significant effect on the use or behavior of the soils.

Judson, Ely, and Kennebec soils formed in similar parent material. Judson soils are generally more sloping, are finer textured, and have a thinner surface layer than Kennebec soils. Judson soils are generally more sloping and better drained than Ely soils.

8C—Judson silty clay loam, 3 to 8 percent slopes. This soil is on foot slopes or alluvial fans. Most areas are 2 to 5 acres in size and are long and narrow in shape.

Included with this soil in mapping are bands of Ely soils along the downslope edge of areas of some Judson soils.

This soil has a moderate to severe erosion hazard. It is suited to cultivated crops if erosion is controlled. Most areas are farmed with areas of adjoining upland soils. This soil receives runoff from adjoining soils that are upslope, which causes rilling and, in places, sedimentation. Capability unit IIIe–1.

Kennebec series

The Kennebec series consists of moderately well drained, gently sloping soils on foot slopes. These soils formed in moderately fine textured local alluvium. The native vegetation was tall prairie grasses.

In a representative profile this soil is black silty clay loam to a depth of 20 inches and very dark grayish brown silty clay loam between depths of 20 and 46 inches. The underlying material is silty clay loam that extends to a depth of 72 inches or more. It is very dark grayish brown in the upper part and dark brown in the lower part.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content is high.

Kennebec soils are generally used for cultivated crops.

Representative profile of Kennebec silty clay loam, 2 to 5 percent slopes, in a cultivated area, 50 feet west and 200 feet south of the northeast corner of NW¼ SE¼ of sec. 22, T. 86 N., R. 38 W.:

Ap—0 to 9 inches; black (10YR 2/1) light silty clay loam; weak fine granular and weak very fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

A12—9 to 20 inches; black (10YR 2/1) light silty clay loam; weak very fine and fine subangular blocky structure; friable; stratified with few thin grayish brown (2.5Y 5/2) lenses; neutral; gradual smooth boundary.

A13—20 to 36 inches; very dark grayish brown (10YR 3/2) light silty clay loam; black (10YR 2/1) ped surfaces; weak very fine and fine subangular blocky structure; friable; stratified with few thin grayish brown (2.5Y 5/2) lenses; neutral; gradual smooth boundary.

A14—36 to 46 inches; very dark grayish brown (10YR 3/2) light silty clay loam; black (10YR 2/1) ped surfaces; weak fine subangular blocky structure; friable; neutral; gradual smooth boundary.

C1—46 to 54 inches; very dark grayish brown (10YR 3/2) light silty clay loam; very dark gray (10YR 3/1) ped surfaces; weak fine granular and weak very fine subangular blocky structure; friable; neutral; clear smooth boundary.

C2—54 to 72 inches; dark brown (10YR 3/3) light silty clay loam; very dark gray (10YR 3/1) ped surfaces; weak fine prismatic structure parting to weak fine subangular blocky; friable; few fine reddish accumulations (oxides); neutral.

The A horizon is neutral or slightly acid light silty clay loam or heavy silt loam. It is 36 to 54 inches thick.

The upper part is black (10YR 2/1) or very dark brown (10YR 2/2), and the lower part is black (10YR 2/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2). The C horizon is black (10YR 2/1), very dark gray (10YR 3/1), very dark grayish brown (10YR 3/2), or dark brown (10YR 3/3) light silty clay loam or heavy silt loam.

The Kennebec soils in this county have a thin, light colored stratum in the A horizon that is not within the defined range of the Kennebec series. This difference does not have a significant effect on the use or behavior of the soils.

Kennebec and Judson soils formed in similar parent material. Kennebec soils have a thicker dark colored surface layer than Judson soils.

26B—Kennebec silty clay loam, 2 to 5 percent slopes. Most areas of this soil are on foot slopes downslope from soils that formed in loess. Most areas are 2 to 10 acres in size and are long and narrow in shape. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of soils that have as much as 15 inches of very dark grayish brown overwash on the surface. Also included are areas that are dissected by a gully.

This soil has a moderate erosion hazard. It received runoff from the soils that are upslope, which causes rilling and sedimentation. There is a hazard of gullies cutting into waterways. This soil is well suited to cultivated crops if runoff from upslope is intercepted and if erosion is controlled. Grassed waterways help control gully erosion. Capability unit IIe–1.

5B—Kennebec-Ackmore complex, 2 to 5 percent slopes. This complex is generally in long narrow drainageways. Most areas are 2 to 40 acres in size. This complex is about 60 percent Kennebec soils, 30 percent Ackmore soils, and 10 percent Colo, Judson, and other soils. The Kennebec soils are on foot slopes or at the head of drainageways, and the Ackmore soils are in the central part of the complex.

The main management problems are wetness, sedimentation, and erosion caused by runoff from soils that are upslope. Gullying is a hazard. These soils are well suited to cultivated crops if wetness is controlled. Capability unit IIw–1.

C5B—Kennebec-Ackmore complex, channeled, 2 to 5 percent slopes. This complex is in long, narrow drainageways. Most areas are 2 to 20 acres in size. This complex is about 60 percent Kennebec soils, 30 percent Ackmore soils, and 10 percent Colo, Judson, and other soils. The Kennebec soils are on foot slopes or at the head of drainageways, and the Ackmore soils are in the central part of the complex. Areas of the Ackmore soils have gullies or channels that are not crossable with farm machinery.

Gullies or stream channels cut the areas of this complex into small sections, making it generally unsuitable for cultivated crops. Excess water from upslope causes wetness, sedimentation, and erosion. These soils are suited to pasture or woodland. Capability unit Vw–1.

Lanyon series

The Lanyon series consists of very poorly drained soils in depressions on uplands. These soils formed in moderately fine textured and fine textured glacial sediment. The native vegetation was marshgrasses, sedges, and other water-tolerant grasses.

In a representative profile the surface layer is black silty clay loam about 15 inches thick. The underlying material is gray silty clay loam, silty clay, and clay loam.

Permeability is moderately slow to slow, and available water capacity is high. The rooting zone is deep, but in wet seasons it is restricted by a high water table. Organic matter content is high.

Lanyon soils are generally used for cultivated crops. Undrained areas are commonly used for pasture.

Representative profile of Lanyon silty clay loam, 0 to 1 percent slopes, in pasture, 145 feet north and 400 feet west of the southeast corner of NE¼NW¼ of sec. 8, T. 86 N., R. 35 W.:

Ap—0 to 7 inches; black (N 2/0) medium silty clay loam; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A12—7 to 11 inches; black (N 2/0) medium silty clay loam; weak fine granular and moderate fine and very fine subangular and angular blocky structure; friable; neutral; abrupt smooth boundary.

A13—11 to 15 inches; black (N 2/0) heavy silty clay loam; common medium distinct olive gray (5Y 4/2) mottles; moderate very fine and fine angular blocky structure; friable; few thin brown coats on root channels; neutral; abrupt smooth boundary.

C1g—15 to 21 inches; gray (5Y 5/1) heavy silty clay loam; very dark gray (5Y 3/1) coats on peds in the upper part; few fine prominent strong brown (7.5YR 5/6) mottles; weak fine subangular blocky structure; firm; many thin brown coats on root channels; few fine dark accumulations (oxides); few very fine lime concretions; few pale olive streaks; weakly effervescent; mildly alkaline; abrupt smooth boundary.

C2g—21 to 31 inches; gray (5Y 5/1) heavy silty clay loam; many fine distinct light olive brown (2.5Y 5/4) mottles; moderate fine prismatic structure parting to weak fine subangular blocky; firm; common very fine dark accumulations (oxides); thin brown coats in root channels; thin discontinuous shiny coatings on ped surfaces; few fine lime concretions and snail shells; strongly effervescent; moderately alkaline; gradual smooth boundary.

C3g—31 to 44 inches; gray (5Y 5/1) light silty clay; light olive brown (2.5Y 5/4) mottles; moderate fine prismatic structure parting to weak very fine angular and subangular blocky; firm; common medium brown coats in root channels; common dark and reddish accumulations (oxides); strongly effervescent; moder-

ately alkaline; gradual smooth boundary.

C4g—44 to 56 inches; gray (5Y 5/1) light silty clay, common fine distinct light olive brown (2.5Y 5/4) mottles; weak fine prismatic structure parting to weak very fine angular blocky; firm; common dark reddish accumulations (oxides); strongly effervescent; moderately alkaline; abrupt smooth boundary.

C5g—56 to 66 inches; gray (5Y 5/1) light clay loam; common fine distinct light olive brown (2.5Y 5/4) mottles and few medium distinct yellowish brown (10YR 5/6) mottles; massive; friable; strongly effervescent; moderately alkaline.

The A horizon is medium or heavy silty clay loam or light silty clay 10 to 16 inches thick. The B horizon, if present, is heavy silty clay loam or light silty clay 0 to 8 inches thick. It is very dark gray (N 3/0 or 5Y 3/1) to olive gray (5Y 5/2). The C horizon is dark gray (5Y 4/1), gray (5Y 5/1), or olive gray (5Y 5/2).

Lanyon, Okoboji, and Wacousta soils formed in similar parent material in depressions. Lanyon soils are finer textured than Wacousta soils and have a solum that is thinner than that of Okoboji soils and, in places, is finer textured.

606—Lanyon silty clay loam, 0 to 1 percent slopes. This soil is in depressions surrounded by soils that are better drained. Most areas are 20 to 60 acres in size and are irregular in shape.

The main management concern is wetness. Maintaining good tilth is difficult. This soil is suited to cultivated crops if it is adequately drained and if flooding or ponding is controlled. Artificial drainage generally requires deep cuts to establish suitable outlets. Capability unit IIIw–1.

Lester series

The Lester series consists of well drained, gently sloping to moderately sloping soils on uplands. These soils formed in glacial till. The native vegetation was trees and grasses.

In a representative profile the surface layer is very dark gray loam about 6 inches thick. The subsurface layer is very dark grayish brown and dark brown loam about 3 inches thick. The subsoil is about 39 inches thick. The upper part is brown and dark yellowish brown clay loam, and the lower part is brown and light olive brown clay loam. The underlying material is light olive brown loam.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content is moderate to low.

Lester soils are generally used for cultivated crops. A few areas are in native vegetation.

Representative profile of Lester loam, 2 to 7 percent slopes, in a wooded pasture, 175 feet south and 350 feet west of the northeast corner of sec. 2, T. 87 N., R. 36 W.:

A1—0 to 6 inches; very dark gray (10YR 3/1) loam; weak very fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

A2—6 to 9 inches; very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) loam; weak thin platy structure; friable; many grayish (dry) coats on ped surfaces; medium acid; abrupt smooth boundary.

B1t—9 to 14 inches; brown (10YR 4/3) light clay loam; thin discontinuous dark grayish brown (10YR 4/2) coats on peds; weak very fine subangular blocky structure; friable; many grayish (dry) coats on ped surfaces; medium acid; clear smooth boundary.

B21t—14 to 21 inches; brown (10YR 4/3) light clay loam; thin discontinuous dark grayish brown (10YR 4/2) coats on peds; moderate fine subangular blocky structure; friable; many grayish (dry) coats on ped surfaces; medium acid; clear smooth boundary.

B22t—21 to 25 inches; brown (10YR 4/3) medium clay loam; thin discontinuous dark brown (10YR 3/3) coats on ped surfaces; moderate fine subangular blocky structure; firm; medium acid; gradual smooth boundary.

B23t—25 to 30 inches; dark yellowish brown (10YR 4/4) medium clay loam; thin discontinuous dark brown (10YR 3/3) coats on peds; common fine distinct yellowish brown (10YR 5/4) mottles; moderate fine subangular blocky structure; firm; few fine dark organic coats in pores; medium acid; gradual smooth boundary.

B31t—30 to 43 inches; dark yellowish brown (10YR 4/4) medium clay loam; thin discontinuous dark brown (10YR 3/3) coats on peds; common fine distinct light olive brown (2.5Y 5/4) mottles; weak fine prismatic structure parting to moderate fine subangular blocky; firm; few dark and reddish accumulations (oxides); few thin patchy organic coats on ped surfaces and in pores; neutral; gradual smooth boundary.

B32t—43 to 48 inches; brown (10YR 4/3) and light olive brown (2.5Y 5/4) light clay loam; thin discontinuous dark brown (10YR 3/3) coats on peds; few fine distinct olive gray (5Y 5/2) mottles; weak fine prismatic structure parting to weak fine subangular blocky; friable; dark patchy organic coats on peds and in pores; few fine dark and reddish accumulations (oxides); neutral; clear smooth boundary.

C—48 to 72 inches; light olive brown (2.5Y 5/4) loam; common fine distinct olive gray (5Y 5/2) mottles; massive; friable; few organic coats in small root channels; common fine lime threads; common very fine dark and reddish accumulations (oxides); strongly effervescent; moderately alkaline.

The solum is mainly medium acid or slightly acid, but the lower part ranges to neutral. The A1 or Ap horizon is black (10YR 2/1), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2) loam or light clay loam and is 6 to 10 inches thick. The A2 horizon is very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2) loam or light clay loam and is 1 to 4 inches thick. The B horizon is 10 to 39 inches thick. The C horizon is yellowish brown (10YR 5/4 or 5/6) or light olive brown (2.5Y 5/4).

Lester, Le Sueur, and Clarion soils formed in similar parent material. Lester soils are better drained than Le Sueur soils, and have a more clayey B horizon than Clarion soils.

236B—Lester loam, 2 to 7 percent slopes. Most areas of this soil are on knolls and are 2 to 5 acres in size. They are generally surrounded by less well drained soils. Some areas are on ridgetops.

Included with this soil in mapping are spots of sandy or gravelly soils.

This soil has a moderate erosion hazard. It is well suited to cultivated crops if erosion is controlled. The use of contour tillage and terraces is limited in many places by short, irregular slopes. Good use of crop residue and manure is especially helpful in these places. Capability unit IIe–1.

Le Sueur series

The Le Sueur series consists of somewhat poorly drained to moderately well drained, nearly level to gently sloping soils on uplands. These soils formed in moderately fine textured and medium textured glacial till. The native vegetation was trees and grasses.

In a representative profile the surface layer is very dark grayish brown loam about 8 inches thick. The subsurface layer is dark grayish brown loam about 6 inches thick. The subsoil is dark grayish brown, very dark grayish brown, and grayish brown clay loam about 30 inches thick. The underlying material is yellowish brown and light olive brown or olive gray clay loam.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content is moderate.

Le Sueur soils are used for cultivated crops or are in native vegetation.

Representative profile of Le Sueur loam, 1 to 3 percent slopes, in a cultivated area, 150 feet east and 200 feet south of the northwest corner of SW¼NE¼ of sec. 11, T. 86 N., R. 35 W.:

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) loam; gray (10YR 5/1) dry; cloddy; friable; neutral; abrupt smooth boundary.

A21—8 to 11 inches; dark grayish brown (10YR 4/2) loam; light gray (10YR 6/1) dry; light gray (10YR 7/1) coats on plates; weak medium platy structure parting to weak very fine subangular blocky; friable; many fine dark accumulations (oxides); neutral; abrupt smooth boundary.

A22—11 to 14 inches; dark grayish brown (10YR 4/2) loam; gray (10YR 5/1) dry; light gray (10YR 6/1 and 7/1) coats on peds; moderate very fine subangular blocky structure; friable; many very fine dark accumulations (oxides); few very fine reddish accumulations (oxides); slightly acid; abrupt smooth boundary.

B21t—14 to 23 inches; dark grayish brown (2.5Y 4/2) and very dark grayish brown (10YR 3/2) heavy clay loam; common fine distinct olive brown (2.5Y 4/4) mottles; thick very dark gray (10YR 3/1) coats on peds; moderately very fine subangular structure; firm; common very fine dark accumulations (oxides); few very fine reddish accumulations (oxides); medium acid; clear smooth boundary.

B22t—23 to 32 inches; dark grayish brown (2.5Y 4/2) and grayish brown (2.5Y 5/2) medium clay loam; common fine distinct gray (10YR 5/1) mottles; weak fine prismatic structure parting to moderate fine subangular blocky; firm; common medium dark accumulations (oxides); common fine reddish accumulations (oxides); dark clay fills in root channels and pores; thick clay films on faces of prisms and peds; mildly alkaline; clear smooth boundary.

B31t—32 to 38 inches; grayish brown (2/5Y 5/2) medium clay loam; common fine distinct yellowish brown (10YR 5/6) mottles; weak fine prismatic structure parting to weak medium subangular blocky; firm; thick clay films in pores and root channels; few medium soft lime accumulations; many fine distinct reddish accumulations (oxides); thick clay films on faces of prisms and peds; strongly effervescent; moderately alkaline; clear smooth boundary.

B32t—38 to 44 inches; grayish brown (2.5Y 5/2) medium clay loam; few fine distinct yellowish brown (10YR 5/6) mottles; weak fine prismatic structure parting to weak medium subangular blocky; firm; thick dark clay films in root channels and pores and on faces of prisms and peds; common fine dark accumulations (oxides); common fine reddish accumulations (oxides); common fine soft lime accumulations; strongly effervescent; moderately alkaline; clear smooth boundary.

C1—44 to 51 inches; yellowish brown (10YR 5/6) and light olive gray (5Y 6/2) loam; friable; common fine dark accumulations (oxides); few fine reddish accumulations (oxides); many clay films in pores; many fine soft lime accumulations; strongly effervescent; moderately alkaline; gradual smooth boundary.

C2—51 to 60 inches; yellowish brown (10YR 5/6) and olive gray (5Y 5/2) loam; friable; common fine dark accumulations (oxides); few medium reddish accumulations (oxides); few clay films in pores;

few soft lime accumulations; strongly effervescent; moderately alkaline.

The A1 or Ap horizon is black (10YR 2/1) to very dark grayish brown (10YR 3/2) loam or light clay loam 6 to 12 inches thick. The A2 horizon, if present, is very dark gray (10YR 3/1) to grayish brown (2.5Y 5/2) and is 2 to 8 inches thick. The B horizon is 18 to 40 inches thick. The C horizon has mixed colors but is commonly light olive brown (2.5Y 5/4 or 5/6), yellowish brown (10YR 5/4 or 5/6), olive gray (5Y 5/2), or light olive gray (5Y 6/2) in a combination of dominant colors and mottles. The C horizon is calcareous.

The Le Sueur soils in this county have dark colors that extend to a shallower depth than is defined in the range of the Le Sueur series. Also, the reaction is higher. These differences do not have a significant effect on the use and behavior of these soils.

Le Sueur, Lester, and Nicollet soils formed in similar parent material. Le Sueur soils are less well drained than Lester soils. They have a thinner, less clayey surface layer and a slightly more clayey B horizon than Nicollet soils.

325—Le Sueur loam, 1 to 3 percent slopes. Most areas of this soil are 2 to 10 acres in size and are irregular in shape.

Included with this soil in mapping are areas of Lester soils.

This soil has no major limitations. It is well suited to cultivated crops. Wetness is a slight limitation at times. This soil dries out more slowly than some soils with which it is farmed. Tiles are used in places. Capability unit I–1.

Letri series

The Letri series consists of poorly drained, nearly level to gently sloping soils on uplands and on benches. These soils formed in a thin layer of erosional sediment and are underlain by calcareous, firm clay loam glacial till. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is black silty clay loam and clay loam about 14 inches thick. The subsoil is clay loam and is about 20 inches thick. The upper part is dark olive gray and olive, the middle part is olive gray and olive, and the lower part is light olive gray. The underlying material is light olive gray, strong brown, yellowish brown, and olive gray clay loam.

Permeability is moderate in the upper part of the profile and moderately slow in the lower part. Available water capacity is high. The rooting zone is deep but in wet seasons is restricted by a high water table. Organic matter content is high.

Letri soils are used for crops and pasture.

Representative profile of Letri silty clay loam, 1 to 4 percent slopes, in a cultivated area, 450 feet north and 20 feet east of the southwest corner of NE¼NE¼ of sec. 29, T. 88 N., R. 38 W.:

Ap—0 to 8 inches; black (10YR 2/1) silty clay loam; high content of sand; weak fine granular to very fine weak subangular blocky structure; friable; neutral; abrupt smooth boundary.

A3—8 to 14 inches; black (10YR 2/1) medium clay loam; common medium distinct dark grayish brown (2.5Y 4/2) mottles; weak fine granular to very fine weak subangular blocky structure; friable; neutral; clear smooth boundary.

B1—14 to 18 inches; mixed dark olive gray (5Y 3/2) and olive (5Y 4/3) medium clay loam; weak fine and very fine subangular blocky structure; friable; mildly alkaline; clear smooth boundary.

B21—18 to 23 inches; mixed olive gray (5Y 5/2) and olive (5Y 5/3) medium clay loam; few fine faint light olive brown (2.5Y 5/4) mottles; weak fine subangular blocky structure; friable; few fine dark accumulations (oxides); slightly effervescent; mildly alkaline; gradual smooth boundary.

B22—23 to 27 inches; light olive gray (5Y 6/2) light clay loam; distinct light olive brown (2.5Y 5/6) mottles; weak medium subangular blocky structure; friable; few fine dark accumulations (oxides); mildly alkaline; gradual smooth boundary.

IIB3—27 to 34 inches; light olive gray (5Y 6/2) clay loam; few fine distinct light olive brown (2.5Y 5/6) mottles; weak medium subangular blocky structure; friable; very few dark accumulations (oxides); neutral; abrupt smooth boundary.

IIC1—34 to 38 inches; mixed light olive gray (5Y 6/2) and strong brown (7.5YR 5/8) medium clay loam; weak medium subangular blocky structure; firm; few fine and medium dark accumulations (oxides); strongly effervescent; moderately alkaline; clear smooth boundary.

IIC2—38 to 65 inches; mixed yellowish brown (10YR 5/6) and olive gray (5Y 5/2) heavy clay loam; massive; firm; few small pebbles; few fine dark accumulations (oxides); strongly effervescent; moderately alkaline.

The A horizon is black (10YR 2/1) or very dark gray (10YR 3/1) heavy loam, light to medium clay loam, or light silty clay loam that has a high content of sand. It is 14 to 24 inches thick. Mottles are not present in some pedons. The B horizon is commonly dark olive gray (5Y 3/2), olive (5Y 4/3 or 5Y 5/3), olive gray (5Y 5/2), light olive gray (5Y 6/2), or gray (5Y 4/1). It is heavy loam or light to medium clay loam that formed in material derived from erosional sediments. In places the lower part of this horizon is in matter that formed in glacial till and is medium to heavy clay loam. The B horizon is 10 to 24 inches thick. The C horizon is light olive gray (5Y 6/2), strong brown (7.5YR 5/8), yellowish brown (10YR 5/4 or 5/6), or olive gray (5Y 4/2 or 5/2) heavy loam to medium clay loam.

The upper part of the profile is thicker than is defined in the range of the Letri series, and carbonates are leached deeper. These differences do not have a

significant effect on the use and behavior of these soils.

Letri and Sac soils formed in similar parent material. Letri soils have more sand in the upper part of the profile than Sac soils and are poorly drained. Sac soils are well drained.

397B—Letri silty clay loam, 1 to 4 percent slopes. This soil typically is at lower elevations than adjoining soils. Most areas are 2 to 10 acres in size and are irregular in shape.

Included with this soil in mapping are areas of somewhat poorly drained soils.

The main management concern is wetness, but maintaining good tilth is also a concern. This soil is well suited to cultivated crops if the soil is adequately drained. It is generally farmed with areas of soils that are better drained. Undrained areas are better suited to pasture. Capability unit IIw–1.

Marcus series

The Marcus series consists of poorly drained, nearly level soils in drainageways. These soils formed in moderately fine textured loess. The native vegetation was tall grasses and some sedges.

In a representative profile the surface layer is black silty clay loam about 15 inches thick. The subsoil is silty clay loam about 25 inches thick; the upper part is very dark gray, the middle part is dark gray, and the lower part is olive gray. The underlying material is olive gray silt loam that has distinct mottles.

Permeability is moderately slow, and available water capacity is high. The rooting zone is deep, but in wet seasons it is restricted by a high water table. Organic matter content is high.

Marcus soils are generally used for cultivated crops. Inadequately drained areas are used for pasture.

Representative profile of Marcus silty clay loam, 0 to 2 percent slopes, in a cultivated field, 430 feet east and 775 feet north of the southwest corner of SE¼ of sec. 2, T. 88 N., R. 38 W.:

Ap—0 to 8 inches; black (N 2/0) heavy silty clay loam; cloddy; firm; neutral; abrupt smooth boundary.

A12—8 to 11 inches; black (5Y 2/1) heavy silty clay loam; moderate fine granular and very fine subangular blocky structure; firm; neutral; gradual smooth boundary.

A3—11 to 15 inches; black (5Y 2/1) heavy silty clay loam; few fine faint olive brown (2.5Y 4/4) mottles; moderate fine granular and very fine subangular smooth boundary.

B1—15 to 18 inches; very dark gray (5Y 3/1) heavy silty clay loam, common fine distinct olive gray (5Y 5/2) mottles; weak fine to medium prismatic structure parting to moderate very fine subangular blocky; friable; mildly alkaline; clear smooth boundary.

B21—18 to 24 inches; dark gray (5Y 4/1) medium silty clay loam; few fine distinct olive brown (2.5Y 4/4) mottles and olive gray (5Y 5/2) mottles; weak fine prismatic structure parting to moderate very fine subangular blocky; friable; mildly alkaline; gradual smooth boundary.

B22—24 to 32 inches; olive gray (5Y 5/2) light to medium silty clay loam; many fine distinct light olive brown (2/5Y 5/4) mottles and few fine distinct yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to weak fine subangular blocky; friable; mildly alkaline; gradual smooth boundary.

B3—32 to 40 inches; olive gray (5Y 5/2) light silty clay loam; common medium distinct yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to weak medium and fine subangular blocky; friable; few soft dark accumulations (oxides); mildly alkaline; gradual smooth boundary.

C—40 to 60 inches; olive gray (5Y 5/2) heavy silt loam; few medium distinct yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure; friable; few fine lime concretions; large dark and reddish accumulations (oxides); strongly effervescent; moderately alkaline.

The A horizon is slightly acid or neutral and is 14 to 24 inches thick. The B horizon is neutral or mildly alkaline and is 16 to 30 inches thick. It is dominantly very dark gray (5Y 3/1) or dark gray (5Y 4/1) in the upper part and gray (5Y 5/1) or olive gray (5Y 5/2) in the lower part. The C horizon commonly is silt loam or light silty clay loam, but in a few places it is loam or clay loam. It is dominantly gray (5Y 5/1) or olive gray (5Y 5/2) and generally has higher chroma mottles.

Marcus, Primghar, and Afton soils formed in similar parent material. Marcus soils are more poorly drained than Primghar soils and have a thinner A horizon than Afton soils.

92—Marcus silty clay loam, 0 to 2 percent slopes. This soil commonly is in drainageways. Most areas are 2 to 10 acres in size and are long and narrow in shape. In places very dark gray overwash overlies the original black surface layer.

The main management concern is wetness. Excess water from adjoining soils runs onto this soil. Maintaining good tilth is a concern. This soil is well suited to cultivated crops if drainage is adequate. Tile drainage normally is used. Undrained areas are better suited to pasture than to cultivated crops. Capability unit IIw–1.

Marsh

354—Marsh is covered by water most of the time. Typically, the soil material is moderately fine textured. In Marsh near Blackhawk Lake, the upper few feet is generally moderately fine textured, but the underlying material is stratified with moderately coarse textured and coarse textured material.

Most areas of Marsh are designated as game refuges or public grounds for aquatic wildlife. These areas are suited to aquatic wildlife. Capability unit VIIw–1.

Marshall series

The Marshall series consists of well drained, gently sloping to strongly sloping soils on uplands. These soils formed in loess. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is very dark brown and very dark grayish brown silty clay loam about 12 inches thick. The subsoil is silty clay loam about 55 inches thick. The upper part is dark brown, the middle part is brown, and the lower part is dark yellowish brown. The underlying material is yellowish brown silt loam.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content is moderate to low depending on the extent of erosion.

Marshall soils are used mainly for cultivated crops.

Representative profile of Marshall silty clay loam, 2 to 5 percent slopes, in a cultivated field, 390 feet north and 110 feet west of the southwest corner of NW¼NE¼ of sec. 36, T. 86 N., R. 37 W.:

Ap—0 to 7 inches; very dark brown (10YR 2/2) light silty clay loam; weak fine granular and very fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

A12—7 to 12 inches; very dark grayish brown (10YR 3/2) light silty clay loam; very dark brown (10YR 2/2) coats on peds; weak fine granular and very fine subangular blocky structure; friable; medium acid; gradual smooth boundary.

B1—12 to 23 inches; dark brown (10YR 3/3); very dark grayish brown (10YR 3/2) coats on peds; light silty clay loam; weak fine subangular blocky structure; friable; medium acid; gradual smooth boundary.

B21—23 to 29 inches; brown (10YR 4/3) medium silty clay loam; dark brown (10YR 3/3) coats on peds; weak fine and very fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

B22—29 to 36 inches; brown (10YR 4/3) medium silty clay loam; weak fine and very fine subangular blocky structure; friable; thin discontinuous coats on peds; neutral; gradual smooth boundary.

B23—36 to 45 inches; dark yellowish brown (10YR 4/4) light silty clay loam; weak fine subangular blocky structure; friable; few soft dark accumulations (oxides); in pores; neutral; gradual smooth boundary.

B31—45 to 56 inches; dark yellowish brown (10YR 4/4) light silty clay loam; few fine olive gray (5Y 5/2) mottles; weak fine prismatic structure; friable; many very fine dark accumulations (oxides); few fine red accumulations (oxides); neutral; gradual smooth boundary.

B32—56 to 67 inches; dark yellowish brown (10YR 4/4) light silty clay loam; common medium olive gray (5Y 5/2) mottles; weak fine prismatic structure; friable; many fine dark accumulations (oxides); common very fine red accumulations (oxides); neutral; gradual smooth boundary.

C—67 to 85 inches; yellowish brown (10YR 5/4) heavy silt loam; few medium olive gray (5Y 5/2) mottles; massive; friable common fine dark accumulations (oxides); few fine red accumulations (oxides); neutral.

The A horizon is black (10YR 2/1) to very dark grayish brown (10YR 3/2) and is 10 to 20 inches thick unless eroded. The B horizon is 25 to 60 inches thick. The C horizon is brown (10YR 4/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4) light silty clay loam or silt loam.

Because of erosion, mapping unit 9D3 has a thinner dark colored surface layer than is defined in the range of the Marshall series.

Marshall and Monona soils formed in similar parent material. Marshall soils have a thicker, slightly finer textured solum than Monona soils.

9B—Marshall silty clay loam, 2 to 5 percent slopes. This soil is typically on ridgetops. Areas of this soil are 100 to 600 feet wide and ¼ to ½ mile long. This soil has the profile described as representative of the series. The surface layer has 3 to 4 percent organic matter, and the total content of the profile is about 80 tons per acre.

Included with this soil in mapping are areas of moderately eroded Marshall soils.

This soil has a moderate erosion hazard. It is well suited to cultivated crops if erosion is controlled. Maintaining good tilth is not a major management concern. However, timely field operations are important because of the high clay content in the surface layer. Capability unit IIe–1.

9B2—Marshall silty clay loam, 2 to 5 percent slopes, moderately eroded. Most areas of this soil are on ridgetops. Areas are about 100 to 400 feet wide and ⅛ to ½ mile long. This soil has a very dark grayish brown plow layer that is mixed with some material from the dark brown subsoil in most places. It has 2 to 3 percent organic matter, and the total content is about 45 tons per acre, most of which is in the plow layer.

This soil has a moderate erosion hazard. It is well suited to cultivated crops if erosion is controlled. Because this soil mainly is on narrower, slightly more convex ridgetops than other gently sloping Marshall soils, it tends to erode more readily. The low content of organic matter and the presence of subsoil material in the plow layer reduce infiltration, thus increasing the amount of runoff and increasing the hazard of erosion. Capability unit IIe–1.

9C—Marshall silty clay loam, 5 to 9 percent slopes. Most areas of this soil are on side slopes. They are irregular in shape and are about 5 to 40 acres in size. Some areas are in bowl-shaped positions around the heads of drainageways where slopes are straight or slightly concave. The surface layer is very dark grayish brown and is 8 to 10 inches thick. It has 3 to 4 percent organic matter, and the total content of the profile is about 80 tons per acre.

Included with this soil in mapping are areas of somewhat poorly drained and poorly drained soils in narrow hillside drainageways.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. Maintaining good tilth is not a major management concern. However, timely field operations are important because of the high clay content in the surface layer. Capability unit IIIe–1.

9C2—Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded. Most areas of this soil are on side slopes. Areas are 500 to 1,000 feet wide. Many areas extend for several miles along the contour of the landscape. The surface layer is a very dark grayish brown plow layer that is partly mixed with material from the dark brown subsoil in many places. It has 2 to 3 percent organic matter, and the total content of the profile is about 40 tons per acre, most of which is in the plow layer.

Included with this soil in mapping are areas of severely eroded Marshall soils and small areas of Ida soils, which are shown on the map with special symbols.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. This soil has slopes that are mainly slightly steeper and more convex than those of less eroded Marshall soils; therefore, runoff and the erosion hazard are increased. Also, the loss of organic matter and the mixing of the subsoil and the plow layer tend to reduce infiltration and increase runoff. It is more difficult to maintain good tilth on this soil than on the less eroded Marshall soils. Capability unit IIIe–1.

9D2—Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded. Most areas of this soil are about 5 to 20 acres in size and are irregular in shape. The surface layer is a very dark grayish brown plow layer that is partly mixed with material from the dark brown subsoil in many places. It has 2 to 3 percent organic matter, and the total amount is about 35 tons per acre, most of which is in the plow layer.

Included with this soil in mapping are small areas of Ida soils, which are shown on the map with a special symbol.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. This soil is generally farmed with less sloping Marshall soils, and management is often suited to those soils. This increases the problem of controlling erosion. Capability unit IIIe–2.

9D3—Marshall silty clay loam, 9 to 14 percent slopes, severely eroded. Areas of this soil are about 5 to 20 acres in size and are irregular in shape. The surface layer is a plow layer that is dark brown and very dark grayish brown and has been mixed with material from the subsoil. It has 1 to 2 percent organic matter, and the total content of the profile is about 25 tons per acre, most of which is in the plow layer.

Included with this soil in mapping are small areas of Ida soils, which are shown on the map with a special symbol.

This soil has a severe erosion hazard, which has been increased by the loss of organic matter by prior erosion. It is more difficult to establish a good seedbed on this soil than on less eroded Marshall soils. Thus, plant cover is generally relatively sparse, infiltration is less, and runoff and erosion are greater. This soil is suited to cultivated crops if erosion is controlled, but some areas are used for pasture. Capability unit IIIe–2.

Monona series

The Monona series consists of well drained, strongly sloping and moderately steep soils on uplands. These soils formed in loess. Native vegetation was prairie grasses.

In a representative profile the surface layer is mixed very dark grayish brown, dark brown, and brown silt loam about 4 inches thick. The subsoil is about 31 inches thick. The upper part is brown silty clay loam, and the lower part is dark yellowish brown silty clay loam and silt loam. The underlying material is dark yellowish brown and yellowish brown silt loam.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content is moderate to low, depending on the extent of erosion.

Monona soils are used mainly for cultivated crops.

Representative profile of Monona silt loam, 9 to 14 percent slopes, severely eroded, in a cultivated field, 300 feet west and 100 feet north of the southeast corner of sec. 16, T. 86 N., R. 37 W.:

Ap—0 to 4 inches; very dark grayish brown (10YR 3/2); dark brown (10YR 3/3), and brown (10YR 4/3) silt loam; weak fine granular and very fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

B1—4 to 9 inches; brown (10YR 4/3) light silty clay loam; weak fine and very fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B2—9 to 22 inches; dark yellowish brown (10YR 4/4) light silty clay loam; weak fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B3—22 to 35 inches; dark yellowish brown (10YR 4/4) heavy silt loam; few fine distinct olive gray (5Y 5/2) mottles; weak medium subangular blocky structure; friable; few fine reddish accumulations (oxides); few fine dark accumulations (oxides); neutral; gradual smooth boundary.

C1—35 to 50 inches; dark yellowish brown (10YR 4/4) heavy silt loam; common medium distinct olive gray (5Y 5/2) mottles; massive; friable; many fine dark accumulations (oxides); few small lime concretions; common fine reddish accumulations (oxides); strongly effervescent; moderately alkaline; diffuse smooth boundary.

C2—50 to 72 inches; yellowish brown (10YR 5/4) silt loam; common medium distinct olive gray (5Y 5/2) mottles and few fine distinct light gray (5Y 6/1) mottles; massive; few small soft lime accumulations; common fine reddish

accumulations (oxides); many fine dark accumulations (oxides); strongly effervescent; moderately alkaline; diffuse smooth boundary.

The solum is neutral or mildly alkaline. The A horizon is black (10YR 2/1) to very dark grayish brown (10YR 3/2) and is 10 to 18 inches thick unless eroded. It is generally silt loam but in places is light silty clay loam. The B horizon is brown (10YR 4/3) to yellowish brown (10YR 5/6) and is 6 to 30 inches thick. The C horizon is brown (10YR 4/3) to yellowish brown (10YR 5/6) and in most places has grayish mottles.

The Monona soils in this county are eroded, and the dark colored surface layer is thinner than is defined in the range of the series. In places, the content of grayish mottles is higher in the profile than is defined in the range of the series. These differences do not have a significant effect on the use or behavior of the soils.

Monona, Ida, and Marshall soils formed in similar parent material. Monona soils have a B horizon, which Ida soils do not have, and they are coarser textured than Marshall soils.

10D3—Monona silt loam, 9 to 14 percent slopes, severely eroded. Most areas of this soil are 2 to 10 acres in size and are irregular in shape. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of soils that have a thicker dark colored surface layer than this Monona soil.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. Sparse plant growth and degree of slope, however, make it difficult to control further erosion. Some areas are used for pasture to reduce the erosion hazard. Capability unit IIIe-2.

10E3—Monona silt loam, 14 to 20 percent slopes, severely eroded. Most areas of this soil are 2 to 10 acres in size and are irregular in shape.

Included with this soil in mapping are areas of soils that have a thicker dark colored surface layer than this soil.

This soil has a severe erosion hazard. It is suited to hay and pasture. It can be planted to cultivated crops part of the time if erosion is controlled. Sparse plant growth and steep slopes, however, make it difficult to control further erosion. Capability unit IVe-1.

Nicollet series

The Nicollet series consists of somewhat poorly drained to moderately well drained, nearly level to gently sloping soils on uplands. These soils formed in medium textured or moderately fine textured glacial till. The native vegetation was prairie grasses.

In a representative profile the surface layer is black loam about 14 inches thick. The subsoil is clay loam or loam about 31 inches thick. The upper part is very dark grayish brown, the middle part is dark grayish brown, and the lower part is olive and olive brown. The underlying material is olive gray and yellowish brown loam.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content is high.

Nicollet soils are used for cultivated crops.

Representative profile of Nicollet loam, 1 to 3 percent slopes, in a cultivated area, 260 feet north and 60 feet east of the southwest corner of SE¼SW¼ of sec. 8, R. 88 N., R. 35 W.:

Ap—0 to 9 inches; black (10YR 2/1) heavy loam; weak fine granular and very fine subangular blocky structure; friable; neutral; clear smooth boundary.

A3—9 to 14 inches; black (10YR 2/1) heavy loam; some peds of grayish brown (10YR 3/2); weak very fine subangular blocky structure; friable; neutral; clear smooth boundary.

B1—14 to 20 inches; very dark grayish brown (10YR 3/2) light clay loam; some very dark gray (10YR 3/1) coats on peds; very dark grayish brown (10YR 3/2 to 2.5Y 3/2) kneaded; weak very fine and fine subangular blocky structure; friable; neutral; clear smooth boundary.

B21—20 to 27 inches; dark grayish brown (2.5Y 4/2) clay loam; weak fine prismatic structure parting to weak fine subangular blocky; friable; some dark fills on worm channels; thin discontinuous coats on faces of prisms; few very fine reddish accumulations (oxides); neutral; clear smooth boundary.

B22—27 to 37 inches; dark grayish brown (2.5Y 4/2) and olive brown (2.5Y 4/4) heavy loam; weak fine prismatic structure parting to weak fine subangular blocky; friable; thin discontinuous clay films on faces of prisms; few very fine dark and reddish accumulations (oxides); mildly alkaline; clear smooth boundary.

B3—37 to 45 inches; olive (5Y 5/3) and olive brown (2.5Y 5/4) heavy loam; many fine distinct olive (2.5Y 5/6) mottles; weak fine prismatic structure parting to weak fine subangular blocky; friable; few fine dark and reddish accumulations (oxides); mildly alkaline; abrupt smooth boundary.

C—45 to 69 inches; olive gray (5Y 5/2) and yellowish brown (10YR 5/6) heavy loam; massive; friable; common fine dark and reddish accumulations (oxides); strongly effervescent; moderately alkaline; gradual smooth boundary.

The solum is dominantly medium acid to neutral, but it ranges to mildly alkaline in the lower part of some pedons. The A horizon is light clay loam or loam 10 to 18 inches thick. The B horizon is loam or clay loam. The C horizon is commonly dark grayish brown (2.5Y 4/2), light olive brown (2.5Y 5/4), olive gray (5Y 5/2), or yellowish brown (10YR 5/6). Typically, colors are mixed or stratified.

Nicollet, Webster, and Clarion soils formed in similar parent material. Nicollet soils are better drained than Webster soils. They are not so well drained and in places are finer textured than Clarion soils.

55—Nicollet loam, 1 to 3 percent slopes. Areas of

this soil are 2 to 40 acres or more in size and are irregular in shape.

This soil has no major limitations, but runoff from the gently sloping areas can cause rilling. This soil is well suited to cultivated crops. Tile drainage is used in places to speed drying, especially where this soil is adjacent to poorly drained soils. Capability unit I–1.

Nishna series

The Nishna series consists of poorly drained, nearly level soils on bottom lands. These soils formed in moderately fine textured and fine textured alluvium. The native vegetation was sedges and swamp grasses.

In a representative profile this soil is black silty clay loam and silty clay to a depth of about 48 inches. The underlying material is very dark gray silty clay loam. The soil is calcareous throughout.

Permeability is slow, and available water capacity is moderate. The rooting zone is somewhat restricted by the clayey texture and by a high water table. Organic matter content is high.

Nishna soils are used mostly for pasture, but adequately drained areas are used for cultivated crops.

Representative profile of Nishna silty clay loam, 0 to 2 percent slopes, in a pasture, 520 feet west and 360 feet south of the northeast corner of the NW¼NW¼ of sec. 23, T. 86 N., R. 37 W.:

Ap—0 to 7 inches; black (N 2/0) heavy silty clay loam; cloddy; friable; few dark very fine accumulations (oxides); weakly effervescent; mildly alkaline; abrupt smooth boundary.

A12—7 to 18 inches; black (N 2/0) light silty clay; moderate fine granular and moderate very fine subangular blocky structure; firm; few very fine dark accumulations (oxides); strongly effervescent; moderately alkaline; gradual smooth boundary.

A13—18 to 32 inches; black (5Y 2/1) light silty clay; moderate very fine subangular blocky structure; firm; few fine dark accumulations (oxides); weakly effervescent; mildly alkaline; gradual smooth boundary.

Bg—32 to 48 inches; black (5Y 2/1) light silty clay; weak fine prismatic structure parting to moderate very fine subangular blocky; firm; few very fine dark accumulations (oxides); weakly effervescent; mildly alkaline; gradual smooth boundary.

Cg—48 to 60 inches; very dark gray (5Y 3/1) silty clay loam; weak fine prismatic structure parting to weak very fine subangular blocky; firm; few very fine dark accumulations (oxides); weakly effervescent; mildly alkaline.

The A horizon is heavy silty clay loam or light silty clay 24 to 36 inches thick. The B horizon, if present, is black (N 2/0 or 5Y 2/1) or very dark gray (N 3/0 or 5Y 3/1) silty clay 4 to 16 inches thick. The C horizon is medium to heavy silty clay loam or silty clay.

Nishna, Zook, and Calco soils formed in similar parent material. Nishna soils are calcareous throughout; Zook soils are noncalcarous in the solum. Nishna soils are more clayey than Calco soils.

234—Nishna silty clay loam, 0 to 2 percent slopes. This soil is next to a sluggish stream or in slack water areas of other streams. Areas are generally long and narrow and adjoin areas of other nearly level soils on bottom lands. Most areas are 2 to 20 acres in size, but a few are much larger.

Included with this soil in mapping are areas of soils that are calcareous only in the surface layer.

The main management concern is wetness. This soil is well suited to cultivated crops if drainage is adequate and if flooding is controlled. Maintaining good tilth is difficult because of the high clay content and wetness. A high content of lime reduces the availability of phosphorus and some other plant nutrients. Undrained and unprotected areas are better suited to pasture than to cultivated crops. Capability unit IIw–2.

Okoboji series

The Okoboji series consists of very poorly drained soils in depressions on uplands. These soils formed in moderately fine textured and fine textured glacial sediment. The native vegetation was marshgrasses, sedges, and other water-tolerant grasses.

In a representative profile the surface layer is about 31 inches thick. It is black silty clay loam in the upper 24 inches and black silty clay in the lower 7 inches. The subsoil is very dark gray, dark gray, and olive gray silty clay loam 29 inches thick.

Permeability is moderately slow, and available water capacity is high. The rooting zone is deep, but in wet seasons it is restricted by a high water table. Organic matter content is high.

Okoboji soils are generally used for cultivated crops, but undrained areas are better suited to pasture or wildlife habitat.

Representative profile of Okoboji silty clay loam, 0 to 1 percent slopes, in a cultivated area, 200 feet east and 250 feet north of the southwest corner of the NW¼SW¼ of sec. 8, T. 86 N., R. 35 W.:

Ap—0 to 10 inches; black (N 2/0) heavy silty clay loam; cloddy; friable; mildly alkaline; abrupt smooth boundary.

A12—10 to 16 inches; black (N 2/0) heavy silty clay loam; weak very fine and fine subangular blocky structure; firm; mildly alkaline; gradual smooth boundary.

A13—16 to 24 inches; black (5Y 2/1) heavy silty clay loam; moderate fine and weak very fine subangular blocky structure; friable; mildly alkaline; gradual smooth boundary.

A3—24 to 31 inches; black (5Y 2/1) light silty clay; weak fine prismatic structure parting to moderate fine subangular blocky; friable; thin continuous shiny surfaces on faces of peds; mildly alkaline; gradual smooth boundary.

B1g—31 to 39 inches; very dark gray (5Y 3/1) heavy silty clay loam; weak fine prismatic structure parting to weak fine sub-

angular blocky; friable; thin continuous shiny surfaces on faces of peds; mildly alkaline; gradual smooth boundary.

B2g—39 to 49 inches; very dark gray (5Y 3/1) heavy silty clay loam; weak fine prismatic structure parting to weak fine subangular blocky; friable; thin continuous shiny surface on faces of prism; mildly alkaline; gradual smooth boundary.

B3g—49 to 60 inches; dark gray (5Y 5/4) olive gray (5Y 5/2) heavy silty clay loam; common fine faint olive (5Y 5/4) mottles and light olive brown (2.5Y 5/4) mottles; weak fine prismatic structure; friable; mildly alkaline.

The solum is slightly acid to mildly alkaline. The A horizon is generally heavy silty clay loam, but in places it is light silty clay. It is more than 25 inches thick. The B horizon is black (5Y 2/1) to olive gray (5Y 5/2) and is generally heavy silty clay loam, but in places it is silty clay. It ranges from a few inches thick to several feet in thickness.

Okoboji, Lanyon, and Wacousta soils formed in similar parent material. Okoboji soils have a thicker solum than Lanyon and Wacousta soils. In places, Okoboji soils are not so fine textured as Lanyon soils. They are finer textured than Wacousta soils.

6—Okoboji silty clay loam, 0 to 1 percent slopes. This soil is in depressions. Most areas are 2 to 20 acres in size and are irregular in shape.

Included with this soil in mapping are areas of soils that are similar to this Okoboji soil but are calcareous. Also included are areas of soils that have a surface layer of mucky silt loam.

The main management concern is wetness. This soil is suited to cultivated crops if drainage is adequate and if flooding or ponding is controlled. Maintaining good tilth is difficult. This soil is cultivated with areas of surrounding soils, and it often is inadequately dried when cultivated. Areas with no artificial drainage are generally better suited to wildlife habitat than to cultivated crops. This soil can also be used for pasture if ponding is controlled. Capability unit IIIw–1.

Palms series

The Palms series consists of very poorly drained soils in depressions on uplands. These soils formed in decayed organic matter and in the underlying moderately fine textured glacial sediment. The native vegetation was marshgrasses, reeds, and sedges.

In a representative profile the organic layer is black or very dark gray muck about 24 inches thick. The subsoil is a black or very dark gray silty clay loam about 13 inches thick. The underlying material is olive gray, gray, and light olive brown silty clay loam.

Permeability is moderate in the organic layer and moderately slow to slow in the subsoil and underlying material. Available water capacity is high. The rooting zone is deep but in wet seasons is restricted by a high water table.

Palms soils are generally used for cultivated crops or pasture, but undrained areas are better suited to pasture or wildlife habitat.

Representative profile of Palms muck, 0 to 1 percent slopes, in a pasture, 400 feet south and 75 feet east of the northwest corner of the SW¼SW¼ of sec. 16, T. 87 N., R. 36 W.:

Oap—0 to 6 inches; black (N 2/0) muck (sapric material); very dark gray (10YR 3/1) dry; common medium faint dark reddish brown (5YR 3/3) mottles; weak fine subangular blocky structure; friable; mildly alkaline; abrupt smooth boundary.

Oa1—6 to 12 inches; black (5Y 2/1) muck (sapric material); very dark gray (10YR 3/1) rubbed moist; dark brown (7.5YR 3/2) rubbed dry; common medium distinct dark brown (7.5YR 3/2) mottles; weak medium platy structure; friable; 1 inch strata of black (10YR 2/1) moist; many white lime flecks; strongly effervescent; moderately alkaline; abrupt smooth boundary.

Oa2—12 to 16 inches; very dark gray (10YR 3/1) muck (sapric material); very dark grayish brown (2.5Y 3/2) dry; moderate thin platy structure; friable; few fine reddish accumulations (oxides) on plates; common fragments of snail shells; strongly effervescent except some strata do not effervesce; mildly alkaline to moderately alkaline; abrupt smooth boundary.

Oa3—16 to 19 inches; very dark gray (10YR 3/1) and light brownish gray (2.5Y 6/2) muck (sapric material); weak thin platy structure; friable; common fine reddish accumulations (oxides) on plates; common fragments of snail shells; strongly effervescent; moderately alkaline; abrupt smooth boundary.

Oa4—19 to 24 inches; black (10YR 2/1) muck (sapric material); black (N 2/0) rubbed moist; dark gray (5Y 4/1) dry; white grains on plates; weak medium platy structure; friable; thin reddish coats in root channels; noncalcareous; mildly alkaline; abrupt smooth boundary.

IIB1g—24 to 31 inches; black (N 2/0) medium silty clay loam; weak fine prismatic structure parting to weak fine subangular and angular blocky; firm; many thin reddish coats in root channels; strongly effervescent; moderately alkaline; clear smooth boundary.

IIB2g—31 to 37 inches; very dark gray (5Y 3/1) medium silty clay loam; weak fine prismatic structure parting to weak fine subangular and angular blocky; firm; many thin olive brown (2.5Y 4/4) coats in root channels; thin discontinuous coats on ped surfaces; strongly effervescent; moderately alkaline; clear smooth boundary.

IIC1g—37 to 48 inches; olive gray (5Y 5/2) and light olive brown (2.5Y 5/4) medium silty clay loam; common fine distinct

dark yellowish brown (10YR 4/4) mottles; weak medium prismatic structure; firm; dark streaks of krotovinas and organic matter in cracks; few undecomposed roots; few dark brown (7.5Y 3/2) coats in root channels and on faces of prisms; strongly effervescent; moderately alkaline; gradual smooth boundary.

IIC2g—48 to 66 inches; gray (5Y 5/1) medium silty clay loam; common medium distinct strong brown (7.5YR 4/4) mottles; massive; friable; dark brown (10YR 3/3) coats in root channels in upper part; strongly effervescent; moderately alkaline.

The organic layer is 20 to 42 inches thick. The underlying material is typically silty clay loam, but in places it is silt loam or clay loam. Lenses of sand are common.

Palms and Blue Earth soils formed in similar parent material. They are very poorly drained and are in depressions. Palms soils have a higher organic matter content than Blue Earth soils.

221—Palms muck, 0 to 1 percent slopes. This soil is in depressions. Most areas are 2 to 40 acres in size and are irregular in shape.

Included with this soil in mapping are areas of soils that have a thinner organic layer than is typical for Palms soils. Also included are areas of soils that are noncalcareous in the organic layer.

The main management concern is wetness. This soil is suited to cultivated crops if drainage is adequate and if flooding and ponding are controlled. Areas that are not adequately drained can be used for pasture. This soil is generally better suited to wildlife habitat if no artificial drainage is used. Capability unit IIIw–1.

Primghar series

The Primghar series consists of somewhat poorly drained, nearly level to gently sloping soils on uplands, on benches, and in drainageways. Primghar soils formed in 40 inches or more of loess over glacial till. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is silty clay loam about 20 inches thick. It is black in the upper part and very dark gray in the lower part. The subsoil is dark grayish brown and olive brown silty clay loam about 24 inches thick. The underlying material is grayish brown, light olive brown, and olive gray silt loam that has yellowish brown mottles.

Permeability is moderate to moderately slow, and available water capacity is high. The rooting zone is deep. Organic matter content is high.

Primghar soils are mostly used for cultivated crops. A few areas are in pasture.

Representative profile of Primghar silty clay loam, 0 to 3 percent slopes, 500 feet east of the northwest corner of SE¼ of sec. 2, T. 89 N., R. 38 W.:

Ap—0 to 8 inches; black (10YR 2/1) medium to heavy silty clay loam; cloddy; moderate medium angular blocky structure in the lower inch; friable; neutral; abrupt smooth boundary.

A12—8 to 15 inches; black (10YR 2/1) heavy silty clay loam; moderate very fine granular and subangular blocky structure; firm; neutral; gradual smooth boundary.

A3—15 to 20 inches; very dark gray (10YR 3/1) heavy silty clay loam; many peds of very dark grayish brown (10YR 3/2); moderate very fine subangular blocky structure; firm; neutral; clear smooth boundary.

B1—20 to 24 inches; dark grayish brown (2.5Y 4/2) heavy silty clay loam; very dark grayish brown (10YR 3/2) and very dark gray (10YR 3/1) coatings on peds; moderate fine subangular blocky structure; friable; neutral; clear smooth boundary.

B21—24 to 31 inches; olive brown (2.5Y 4/4) medium silty clay loam; few fine distinct yellowish brown (10YR 5/6 and 5/8) mottles; very dark grayish brown (2.5Y 3/2) and very dark gray (2.5Y 3/1) coatings on peds; weak medium prismatic structure parting to weak fine subangular blocky; friable; neutral; gradual smooth boundary.

B22—31 to 38 inches; olive brown (2.5Y 4/4) medium silty clay loam; few fine distinct yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to weak medium subangular blocky; friable; few fine dark accumulations (oxides); neutral; gradual smooth boundary.

B3—38 to 44 inches; olive brown (2.5Y 4/4) light silty clay loam; few fine distinct yellowish brown (10YR 5/6) mottles and few fine distinct gray (5Y 5/1) mottles; weak medium prismatic structure parting to weak medium subangular blocky; friable; mildly alkaline; abrupt smooth boundary.

C1—44 to 50 inches; grayish brown (2.5Y 5/2) and light olive brown (2.5Y 5/4) silt loam; many fine distinct yellowish brown (10YR 5/6) mottles; weak coarse prismatic structure; friable; strongly effervescent; moderately alkaline; diffuse smooth boundary.

C2—50 to 64 inches; olive gray (5Y 5/2), grayish brown (2.5Y 5/2), yellowish brown (10YR 5/6), and light olive brown (2.5Y 5/4) silt loam; massive; friable; strongly effervescent; moderately alkaline.

The A horizon is 16 to 22 inches thick. The B horizon is 14 to 30 inches thick. Grayish mottles are in the B2 horizon in places. The C horizon generally is light silty clay loam or silt loam, but in places it is loam or clay loam. Areas on low benches have sand and some gravel in the C horizon.

Primghar, Galva, and Marcus soils formed in similar parent material. Primghar soils are less well drained than Galva soils and are better drained than Marcus soils.

91—Primghar silty clay loam, 0 to 3 percent slopes.

This nearly level soil is in convex or plane, irregularly shaped areas on uplands and benches and in nearly level to gently sloping, concave, narrow and elongated areas in drainageways. Normally, the areas in the drainageways are adjacent to areas of sloping, well drained soils. Most areas of this soil are 2 to 20 acres in size.

Included with this soil in mapping are areas of poorly drained soils in the center of the drainageways.

This soil has no major limitations to use, but runoff from the more sloping adjoining soils can cause rilling and wetness in the drainageways and on the benches. This soil is well suited to cultivated crops. The sand and gravel that underlie areas of this soil on benches are a limitation for the development of dwellings, landfills, or other such uses. Capability unit I–1.

Rolfe series

The Rolfe series consists of very poorly drained, nearly level soils on uplands and on benches. These soils formed in glacial sediment and glacial till. The native vegetation was prairie grasses, marshgrasses, and water-tolerant sedges.

In a representative profile the surface layer is black loam about 10 inches thick. The subsurface layer is very dark gray, dark gray, and gray silt loam about 7 inches thick. The subsoil is 48 inches thick. It is dark gray clay in the upper 10 inches and olive gray clay and clay loam in the lower 38 inches.

Permeability is slow, and available water capacity is high. The rooting zone is somewhat restricted by the clay subsoil, and during wet seasons it is restricted by a high water table. The organic matter content is moderate.

Rolfe soils are used for cultivated crops if the soil is adequately drained. Undrained areas are used for pasture or for aquatic wildlife habitat.

Representative profile of Rolfe loam, 0 to 1 percent slopes, in a cultivated area, 100 feet south and 125 feet west of the northeast corner of NW¼NE¼ of sec. 11, T. 88 N., R. 36 W.:

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

A21—10 to 13 inches; very dark gray (10YR 3/1) silt loam; common fine distinct yellowish brown (10YR 5/6) mottles; weak thin platy structure parting to weak very fine subangular blocky; friable; slightly acid; clear smooth boundary.

A22—13 to 17 inches; dark gray (10YR 4/1) and gray (10YR 5/1) silt loam; common fine distinct light olive brown (2.5Y 5/4) mottles; weak medium platy structure; friable; slightly acid; abrupt smooth boundary.

B21gt—17 to 27 inches; dark gray (5Y 4/1) light clay; many very dark gray (5Y 3/1) and few black (5Y 2/1) coatings on peds; moderate very fine and fine subangular blocky structure; thick clay films on peds; firm; common fine reddish accumulations (oxides); slightly acid; clear smooth boundary.

B22—27 to 37 inches; olive gray (5Y 4/2 and 5/2) light clay; moderate fine subangular blocky structure; firm; thin discontinuous clay films; common fine reddish accumulations (oxides); slightly acid; clear smooth boundary.

B31—37 to 47 inches; olive gray (5Y 4/2 and 5/2) heavy clay loam; few fine distinct olive (5Y 5/4) mottles; weak fine subangular blocky structure; firm; black (10YR 2/1) coats in root channels; few fine reddish and dark accumulations (oxides); slightly acid; clear smooth boundary.

B32—47 to 65 inches; olive gray (5Y 5/2) light clay loam; many medium prominent strong brown (7.5YR 5/8) mottles; weak fine subangular blocky structure; friable; common fine reddish and dark accumulations (oxides); dark coats in root channels; slightly acid; clear smooth boundary.

The solum is medium acid or slightly acid in the most acid part. The A horizon is black (10YR 2/1) or very dark gray (10YR 3/1) loam, silt loam, or light silty clay loam 6 to 10 inches thick. The A2 horizon is very dark gray (10YR 3/1), dark gray (10YR 4/1), or gray (10YR 5/1) loam or silt loam 4 to 8 inches thick. The B horizon is generally 20 to 36 inches thick but in places is as thick as 54 inches. The upper part of the B horizon is very dark gray (10YR 3/1 or 5Y 3/1) to olive gray (5Y 5/2) clay or silty clay. The lower part is dark gray (5Y 4/1), gray (5Y 5/1), or olive gray (5Y 4/2 or 5/2) clay loam or loam.

Rolfe and Webster soils formed from similar parent material. Rolfe soils have an A2 horizon, which Webster soils do not have, and they have a more clayey B horizon than Webster soils.

274—Rolfe loam, 0 to 1 percent slopes. This soil is in depressions and is surrounded by areas of soils that are better drained. Most areas of this soil are 2 to 5 acres in size and are irregular in shape.

Included with this soil in mapping are areas of soils that do not have the distinct subsurface layer typical of this Rolfe soil.

The main management concern is wetness. This soil is suited to cultivated crops if drainage is adequate and if flooding or ponding is controlled. Deep cuts are commonly needed for outlets for tile or open ditches. If the soil is inadequately drained, cultivated crops drown out or are stunted during wet seasons. Capability unit IIIw–1.

Sac series

The Sac series consists of well drained, gently sloping to moderately sloping soils on uplands. These soils formed in 20 to 40 inches of loess and in the underlying glacial till. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is black, very dark gray, and very dark grayish brown silty clay loam about 14 inches thick. The subsoil is about

19 inches thick. It is brown silty clay loam in the upper part and yellowish brown clay loam in the lower part. The underlying material is yellowish brown clay loam.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content is moderate to low, depending on the extent of erosion.

Sac soils are generally used for cultivated crops.

Representative profile of Sac silty clay loam, clay loam substratum, 2 to 5 percent slopes, in a cultivated field, 350 feet west and 350 feet north of the southeast corner of SW¼SE¼ of sec. 14, T. 88 N., R. 38 W.:

Ap—0 to 8 inches; black (10YR 2/1) to very dark gray (10YR 3/1) silty clay loam; weak fine granular and weak fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

A3—8 to 14 inches; very dark grayish brown (10YR 3/2) silty clay loam; dark brown (10YR 3/3) ped faces; few fine distinct brown (10YR 4/3) peds; moderate fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B1—14 to 21 inches; brown (10YR 4/3) silty clay loam; few discontinuous dark brown (10YR 3/3) coatings on peds; fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B2—21 to 28 inches; brown (10YR 4/3) silty clay loam; weak fine subangular blocky structure; friable; few thin discontinuous very dark grayish brown (10YR 3/2) coatings on peds; neutral; abrupt smooth boundary.

IIB3—28 to 36 inches; yellowish brown (10YR 5/4) clay loam; brown (10YR 4/3) coatings on peds; weak fine subangular blocky structure; firm; few reddish accumulations (oxides); few small pebbles; thin discontinuous clay films on vertical faces; neutral; abrupt smooth boundary.

IIC1—36 to 49 inches; yellowish brown (10YR 5/4) clay loam; few fine distinct gray (5Y 5/1) and many distinct yellowish brown (10YR 5/6) mottles and strong brown (7.5YR 5/8) mottles; thin nearly continuous brown (10YR 4/3) coatings on vertical faces; massive; firm; common medium lime concretions; strongly effervescent; moderately alkaline; diffuse smooth boundary.

IIC2—49 to 76 inches; yellowish brown (10YR 5/6) clay loam; common to many strong brown (7.5YR 5/6 and 5/8) mottles and common fine distinct gray (5Y 5/1) mottles; massive; firm; few fine strong brown accumulations (oxides); common to many lime concretions; strongly effervescent; moderately alkaline.

The solum is medium acid or slightly acid in the most acid part. The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark gray (10YR 3/1) in the upper part and is black (10YR 2/1) to very dark grayish brown (10YR 3/2) in the lower part. The B horizon is brown (10YR 4/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4 or 5/6) and is 12 to 30 inches thick. The IIB horizon is firm clay loam or friable loam. The lower part has grayish mottles in places. The C horizon is dark yellowish brown (10YR 4/4) or yellowish brown (10YR 5/4 or 5/6) loam or clay loam. It generally has grayish mottles.

Sac and Galva soils formed in similar parent material and are on similar landscape positions. Sac soils have 20 to 40 inches of loess over glacial till, but Galva soils have more than 40 inches.

77B—Sac silty clay loam, loam substratum, 2 to 5 percent slopes. This soil is on ridgetops and side slopes. Areas are about 5 to 40 acres in size and are irregular in shape. This soil has a friable loam substratum. The surface layer has 3 to 4 percent organic matter, and the total content of the profile is about 90 tons per acre.

Included with this soil in mapping are small areas of gravelly or sandy soils and soils that formed in glacial till. These areas are shown on the map with special symbols.

This soil has a moderate erosion hazard. It is well suited to cultivated crops if erosion is controlled (fig. 5). Maintaining good tilth is not a major management concern. However, timely field operations are important because of the high clay content in the surface layer. Capability unit IIe–1.

77B2—Sac silty clay loam, loam substratum, 2 to 5 percent slopes, moderately eroded. This soil is on ridgetops and side slopes. Areas are about 5 to 30 acres in size and are irregular in shape. This soil has a friable loam substratum. The surface layer is a very dark grayish brown plow layer, and in many places it is mixed with material from the brown subsoil. The surface layer has about 2 to 3 percent organic matter, and the total content of the profile is about 45 tons per acre, much of which is in the plow layer.

Included with this soil in mapping are small areas of gravelly or sandy soils and soils that formed in glacial till. These areas are shown on the map with special symbols.

This soil has a moderate erosion hazard. It tends to erode more readily than the adjoining soils with which it is farmed, because its slopes are generally slightly steeper and more convex. This soil is well suited to cultivated crops if erosion is controlled. Loss of organic matter and mixing of the subsoil and the plow layer lower the tilth of this soil. It is more difficult to establish a good seedbed on this soil than on less eroded soils. Capability unit IIe–1.

77C—Sac silty clay loam, loam substratum, 5 to 9 percent slopes. Typically this soil is on side slopes. Most areas are about 5 to 20 acres in size and are irregular in shape. This soil has a friable loam substratum. The surface layer is very dark brown to very dark grayish brown and is about 10 inches thick. It has about 3 to 4 percent organic matter, and the total content of the profile is about 85 tons per acre.

Included with this soil in mapping are small areas of gravelly or sandy soils and soils that formed in glacial till. These areas are shown on the map with special symbols.

This soil has a severe erosion hazard. It is suited to

Figure 5.—Grassed backslope of terrace on Sac silty clay loam, loam substratum, 2 to 5 percent slopes.

cultivated crops if erosion is controlled. Maintaining good tilth is not a major management concern, but timely field operations are important because of the high clay content in the surface layer. Capability unit IIIe–1.

77C2—Sac silty clay loam, loam substratum, 5 to 9 percent slopes, moderately eroded. This soil is on side slopes. Areas are 5 to 100 acres or more in size. Some of the larger areas are a half mile or more in length. This soil has a friable loam substratum. The surface layer is a very dark grayish brown plow layer and is commonly partly mixed with the brown subsoil. The surface layer has 2 to 3 percent organic matter, and the total content of the profile is about 40 tons per acre.

Included with this soil in mapping are small areas of gravelly or sandy soils and soils that formed in glacial till. These areas are shown on the map with special symbols.

This soil has a severe erosion hazard. It erodes more readily than the adjoining soils with which it is farmed, because its slopes are generally steeper and more convex. It is suited to cultivated crops if erosion is controlled. Loss of organic matter and mixing of material from the subsoil and the plow layer lower the tilth of this soil. Capability unit IIIe–1.

78B—Sac silty clay loam, clay loam substratum, 2 to 5 percent slopes. Typically this soil is on slightly elevated knolls. Most areas are 5 to 10 acres in size, but some are 20 to 30 acres. This soil has the profile described as representative of the series. The surface layer has 3 to 4 percent organic matter, and the total content of the profile is about 90 tons per acre.

Included with this soil in mapping are small areas of sandy or gravelly soils and soils that formed in glacial till. These soils are shown on the map with special symbols.

This soil has a moderate erosion hazard. It is well suited to cultivated crops if erosion is controlled. Care is needed in the construction of terraces or other structures that require the moving of soil. The firm clay loam substratum is poorly suited to plant growth. Capability unit IIe–1.

78B2—Sac silty clay loam, clay loam substratum, 2 to 5 percent slopes, moderately eroded. Typically this soil is on slightly elevated knolls. Most areas are 5 to 10 acres in size, but some are larger. The surface layer is a very dark grayish brown plow layer. In many places it is mixed with material from the brown subsoil. Erosion has reduced the depth to the substratum. The surface layer has 2 to 3 percent organic matter, and the total content of the profile is about

45 tons per acre, much of which is in the plow layer.

Included with this soil in mapping are small areas of gravelly or sandy soils and soils that formed in glacial till. These areas are shown on the map with special symbols.

This soil has a moderate erosion hazard. It tends to erode more readily than the adjoining soils with which it is farmed, because its slopes are generally slightly steeper and more convex. It is well suited to cultivated crops if erosion is controlled. Loss of organic matter and mixing of material from the subsoil and the plow layer reduce the tilth of this soil. It is more difficult to establish a good seedbed on this soil than on less eroded soils. Care is needed in the construction of terraces or other structures that require the moving of soil. The firm clay loam substratum is poorly suited to plant growth. Capability unit IIe–1.

78C—Sac silty clay loam, clay loam substratum, 5 to 9 percent slopes. This soil is mainly on side slopes, but some areas are on convex knolls. Areas are about 5 to 30 acres in size. The surface layer is about 10 inches thick and is very dark brown to very dark grayish brown. It has 3 to 4 percent organic matter, and the total content of the profile is about 85 tons per acre.

Included with this soil in mapping are small areas of gravelly or sandy soils and soils that formed in glacial till. These areas are shown on the map with special symbols.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. Maintaining good tilth is not a major management concern, but timely field operations are important because of the high clay content in the surface layer. Care is needed in the construction of terraces or other structures that require earthmoving. The firm clay loam substratum is poorly suited to plant growth. Capability unit IIIe–1.

78C2—Sac silty clay loam, clay loam substratum, 5 to 9 percent slopes, moderately eroded. Most areas of this soil are on side slopes, but some areas are on knolls. Many areas are 500 to 1,000 feet wide and are a mile or more long. The areas on knolls typically are 5 to 20 acres in size. The surface layer is a very dark grayish brown plow layer and is commonly partly mixed with material from the brown subsoil. It has 2 to 3 percent organic matter, and the total content of the profile is about 40 tons per acre.

Included with this soil in mapping are small areas of gravelly or sandy soils and soils that formed in glacial till. These areas are shown on the map with special symbols.

This soil has a severe erosion hazard. It erodes more readily than the adjoining soils with which it is farmed, because its slopes are generally steeper and more convex. This soil is suited to cultivated crops if erosion is controlled. Loss of organic matter and mixing of material from the subsoil in the plow layer reduce the tilth of this soil. It is more difficult to establish a good seedbed on this soil than on less eroded soils. Care is needed in the construction of terraces or other structures that require the moving of soil. The firm clay loam substratum is poorly suited to plant growth. Capability unit IIIe–1.

Salida series

The Salida series consists of excessively drained, moderately sloping to strongly sloping soils on uplands and on stream benches. These soils formed in coarse textured glacial drift. The native vegetation was prairie grasses.

In a representative profile the surface layer is black and very dark gray gravelly loamy sand about 10 inches thick. The next layer is dark grayish brown gravelly loamy sand about 8 inches thick. The underlying material is yellowish brown, light olive brown, light brownish gray, and brown gravelly sand.

Permeability is very rapid, and available water capacity is low. The rooting zone is restricted by depth to sand and gravel. Organic matter content is low.

Salida soils are mainly used for pasture. A few areas of the less sloping soils are planted to cultivated crops.

Representative profile of Salida gravelly loamy sand, 9 to 14 percent slopes, in an idle area, 150 feet west and 500 feet north of the southeast corner of NE¼ of sec. 34, T. 86 N., R. 38 W.:

Ap—0 to 5 inches; very dark gray (10YR 3/1) gravelly loamy sand; fine subangular blocky structure; very friable; strongly effervescent; moderately alkaline; abrupt smooth boundary.

A12—5 to 10 inches; mixed black (10YR 2/1) and very dark gray (10YR 3/1) gravelly loamy sand; very weak fine subangular blocky structure; very friable to loose; strongly effervescent; moderately alkaline; abrupt smooth boundary.

AC—10 to 18 inches; dark grayish brown (10YR 4/2) gravelly loamy sand; some very dark grayish brown (10YR 3/2) peds; very weak fine subangular blocky structure; very friable to loose; strongly effervescent; moderately alkaline; abrupt smooth boundary.

C1—18 to 27 inches; yellowish brown (10YR 5/4) gravelly medium and coarse sand; single grained; loose; strongly effervescent; moderately alkaline; clear smooth boundary.

C2—27 to 34 inches; light olive brown (2.5Y 5/4) gravelly coarse and medium sand; single grained; loose; yellowish brown accumulations (oxides) at a depth of 32 to 34 inches; strongly effervescent; moderately alkaline; abrupt smooth boundary.

C3—34 to 60 inches; light brownish gray (2.5Y 6/2) and brown (10YR 5/3) gravelly medium and coarse sand; yellowish brown (10YR 5/6) mottles; single grained; loose; strongly effervescent; moderately alkaline.

The solum is moderately alkaline and calcareous in most places but is neutral to mildly alkaline and noncalcareous in a few places. The A horizon is black (10YR 2/1) to very dark grayish brown (10YR 3/2) gravelly sandy loam or gravelly loamy sand 7 to 12

inches thick. The B horizon, if present, is dark brown (10YR 3/3) or brown (10YR 4/3) and is less than 10 inches thick. The C horizon is gravelly loamy sand or gravel and has mixed colors. It is commonly brown (10YR 5/3), yellowish brown (10YR 5/4), pale brown (10YR 5/3), light olive brown (2/5Y 5/4), and light brownish gray (2.5Y 6/2).

Salida and Flagler soils formed in similar parent material. The underlying sand and gravel are shallower in Salida soils than in Flagler soils.

73C—Salida gravelly loamy sand, 5 to 9 percent slopes. Most areas of this soil are 2 to 5 acres in size and are irregular in shape. In these areas the Salida soil is intermingled with soils that are better suited to row crops. Included with this soil in mapping are areas of gently sloping Salida soils.

This soil is suited to hay or pasture. Many areas are farmed with areas of adjoining soils. This soil can be planted to cultivated crops part of the time if erosion is controlled. Practices that conserve moisture are needed. Stones and boulders hinder farm operations. It is a common practice to leave areas of this soil in meadow when the rest of the field is planted to row crops. Capability unit IVe–2.

73D—Salida gravelly loamy sand, 9 to 14 percent slopes. Most areas of this soil are 2 to 5 acres in size and are irregular in shape. In these areas the Salida soil is intermingled with soils that are better suited to row crops. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of moderately steep Salida soils.

This soil is suited to hay or pasture, and it can be planted to cultivated crops part of the time if erosion is controlled. Practices that conserve moisture are needed. Stones and boulders hinder cultivation in many places. Capability unit IVe–2.

Shelby series

The Shelby series consists of moderately well drained, moderately sloping to moderately steep soils on uplands. These soils formed in moderately fine textured glacial till. The native vegetation was tall prairie grasses.

In a representative profile most of the surface layer is very dark brown loam and very dark grayish brown and brown clay loam about 14 inches thick. The subsoil is clay loam about 22 inches thick. It is brown in the upper 5 inches and yellowish brown and dark yellowish brown in the lower 17 inches. The underlying material is dark yellowish brown, yellowish brown, olive gray, and strong brown clay loam.

Permeability is moderately slow, and available water capacity is high. The rooting zone is deep. Organic matter content is moderate to low, depending on the extent of erosion.

Shelby soils are used for cultivated crops and pasture.

Representative profile of Shelby loam, in an area of Shelby loam, 9 to 14 percent slopes, moderately eroded, in a pasture, 300 feet east and 340 feet north of the southwest corner of NE¼NE¼ of sec. 28, T. 87 N., R. 37 W.:

A11—0 to 4 inches; very dark brown (10YR 2/2) heavy loam; weak very fine and fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

A12—4 to 9 inches; very dark grayish brown (10YR 3/2) light clay loam; continuous very dark brown (10YR 2/2) coatings on ped surfaces; weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

AB—9 to 14 inches; brown (10YR 4/3) light clay loam; continuous very dark grayish brown (10YR 3/2) coatings on ped surfaces; weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B21t—14 to 19 inches; brown (10YR 4/3) medium clay loam; discontinuous very dark grayish brown (10YR 3/2) coatings on ped surfaces; weak fine subangular blocky structure; friable; thin clay films; slightly acid; clear smooth boundary.

B22t—19 to 29 inches; yellowish brown (10YR 5/4) medium clay loam; discontinuous olive brown (2.5Y 4/4) coatings on ped surfaces; weak fine prismatic structure parting to moderate fine subangular blocky; firm; thin continuous clay films; few fine dark accumulations (oxides); neutral; gradual smooth boundary.

B3t—29 to 36 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6) heavy clay loam; medium distinct olive gray (5Y 5/2) mottles; weak medium prismatic structure parting to weak fine subangular blocky; firm; thin discontinuous clay films; few fine dark and reddish accumulations (oxides); few dark grayish brown (10YR 4/2) coatings on ped surfaces; mildly alkaline; gradual smooth boundary.

C1—36 to 43 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6) medium clay loam; medium common distinct olive gray (5Y 5/2) mottles; massive; firm; dark grayish brown (2.5Y 4/2) coatings on ped surfaces; few fine dark and reddish accumulations (oxides); many lime concretions; strongly effervescent; moderately alkaline; abrupt smooth boundary.

C2—43 to 76 inches; strong brown (7.5YR 5/6), olive gray (5Y 5/2), and yellowish brown (10YR 5/6) medium clay loam; massive; firm; few fine dark and reddish accumulations (oxides); common lime concretions and threads; strongly effervescent; moderately alkaline.

The A horizon is black (10YR 2/1) to very dark grayish brown (10YR 3/2), depending on the extent of erosion. It is 10 to 18 inches thick if not eroded. The B horizon is dark brown (10YR 3/3) or dark yellowish brown (10YR 4/4) in the upper part; the middle and lower parts are dark yellowish brown (10YR 4/4),

brown (10YR 4/3), or yellowish brown (10YR 5/4 or 5/6) and generally have grayish mottles. The B horizon is 20 to 36 inches thick. The C horizon is mottled with various shades of brown and includes olive gray (5YR 5/2) and grayish brown (2.5Y 5/2).

Because of erosion, Shelby soils in this county have a thinner dark colored surface layer than is defined in the range of the series.

Shelby and Steinauer soils formed in similar parent material. Shelby soils are leached and noncalcareous in the solum; Steinauer soils are generally calcareous throughout.

24C2—Shelby loam, 5 to 9 percent slopes, moderately eroded. This soil is on side slopes. Most areas are 2 to 4 acres in size.

Included with this soil in mapping are a few areas that are less sloping than this Shelby soil and some areas that have a siltier surface layer. Also included are a few areas of Steinauer soils.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. Stones and boulders hinder cultivation in places. Capability unit IIIe–1.

24D2—Shelby loam, 9 to 14 percent slopes, moderately eroded. This soil is on side slopes. Most areas are 2 to 5 acres in size and are irregular in shape. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of severely eroded soils and areas of soils that have a siltier surface layer than this Shelby soil. Small areas of Steinauer soils are also included.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. However, many areas are used for pasture because of the erosion hazard. Stones and boulders hinder cultivation in places. Capability unit IIIe–2.

24E2—Shelby loam, 14 to 18 percent slopes, moderately eroded. This soil is on side slopes. Most areas are 2 to 10 acres in size and are irregular in shape.

Included with this soil in mapping are areas of severely eroded soils and areas of Steinauer soils.

This soil is suited to pasture and woodland and is moderately suited to hay. Capability unit VIe–1.

Sparta series

The Sparta series consists of excessively drained, moderately sloping and strongly sloping soils on uplands. These soils formed in eolian sand. The native vegetation was prairie grasses.

In a representative profile the surface layer is loamy fine sand about 21 inches thick. The upper part is very dark brown, and the lower part is very dark grayish brown. The subsoil is yellowish brown sand about 34 inches thick. The underlying material is light yellowish brown loamy sand.

Permeability is very rapid, and available water capacity is low. The rooting zone is mainly deep, but root growth is severely restricted during periods of drought. Organic matter content is moderately low to low.

Sparta soils are used mainly for pasture.

Representative profile of Sparta loamy fine sand, 5 to 14 percent slopes, in a wildlife area, 600 feet north of the southeast corner of sec. 31, T. 87 N., R. 38 W.:

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

A3—10 to 21 inches; very dark grayish brown (10YR 3/2) loamy fine sand; brown (10YR 5/2) dry; weak fine subangular blocky structure; very friable; medium acid; abrupt smooth boundary.

B2—21 to 55 inches; yellowish brown (10YR 5/4) sand; pale brown (10YR 6/3) dry; weak fine subangular blocky structure; loose; slightly acid; diffuse smooth boundary.

C—55 to 87 inches; light yellowish brown (2.5Y 6/4) loamy sand; single grained; loose; yellowish brown (10YR 5/6) iron bands a few inches thick; slightly acid.

The A horizon is black (10YR 2/1) to very dark grayish brown (10YR 3/2) loamy fine sand or fine sand 10 to 24 inches thick. The B horizon is dark yellowish brown (10YR 4/4) or yellowish brown (10YR 5/4 or 5/6) loamy sand or sand 14 to 40 inches thick. The C horizon is yellowish brown (10YR 5/4 or 5/6), pale brown (10YR 6/3), or light yellowish brown (10YR 6/4 or 2.5Y 6/4) sand or loamy sand.

Sparta and Bolan soils formed in eolian soil material. Sparta soils formed in loamy sand or sand, but Bolan soils formed partly in loam or sandy loam.

41D—Sparta loamy fine sand, 5 to 14 percent slopes. Typically, this soil is on hillsides. Most areas are 2 to 5 acres in size and are irregular in shape.

This soil has a severe drought hazard and is subject to soil blowing if the vegetative cover is sparse. It is suited to pasture or woodland. Capability unit VIs–1.

Spillville series

The Spillville series consists of moderately well drained to somewhat poorly drained, nearly level and gently sloping soils on foot slopes and bottom lands. These soils formed in medium textured alluvial sediment. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is black loam 25 inches thick. The subsoil is very dark grayish brown and dark brown loam to a depth of 47 inches. It is brown, dark brown and dark gray sandy clay loam to a depth of 56 inches. The underlying material is yellowish brown and olive gray coarse sandy loam or sand and gravel.

Permeability is moderate, and available water capacity is high. The rooting zone is deep, but in wet seasons it is restricted by a high water table. Organic matter content is high.

Spillville soils are used mostly for crops and pasture.

Representative profile of Spillville loam, 2 to 5 percent slopes, in a cultivated area, 200 feet west and 150 feet south of the northeast corner of SE¼SE¼ of sec. 12, T. 88 N., R. 36 W.:

Ap—0 to 8 inches; black (10YR 2/1) loam; few fine faint very dark grayish brown (10YR 3/2) coatings on peds; weak fine

granular and very fine and fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

A12—8 to 19 inches; black (10YR 2/1) loam; few very dark grayish brown (10YR 3/2) peds; weak thin platy structure parting to fine granular and weak very fine and fine subangular blocky; friable; neutral; gradual smooth boundary.

A13—19 to 25 inches; black (10YR 2/1) loam; weak fine granular and weak very fine and fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B1—25 to 32 inches; very dark grayish brown (10YR 3/2) loam; black (10YR 2/1) coatings on peds; very dark brown (10YR 2/2) kneaded; weak very fine and fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B21—32 to 43 inches; very dark grayish brown (10YR 3/2) loam; black (10YR 2/1) coatings on peds; very dark grayish brown (10YR 3/2) kneaded; weak fine and medium subangular blocky structure; friable; neutral; gradual smooth boundary.

B22—43 to 47 inches; dark brown (10YR 3/3) loam; very dark gray (10YR 3/1) coatings on peds; very dark grayish brown (10YR 3/2) kneaded; weak medium subangular blocky structure; friable; neutral; clear smooth boundary.

B3—47 to 56 inches; brown (7.5YR 4/4) dark brown (7.5YR 3/2) and dark gray (5Y 4/1) sandy clay loam; brown (7.5YR 4/2) kneaded; weak medium subangular blocky structure; few fine dark and reddish accumulations (oxides); friable; neutral; clear smooth boundary.

C—56 to 66 inches; yellowish brown (10YR 5/4) and olive gray (5Y 5/2) sandy loam; light olive brown (2.5Y 5/4) kneaded; weak medium prismatic structure; friable; common fine dark and reddish accumulations (oxides); mildly alkaline.

The solum is neutral to slightly acid. The A horizon is 24 to 56 inches thick. The lower part of the A horizon ranges from black (10YR 2/1) to very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). The B horizon, if present, is dominantly very dark grayish brown (10YR 3/2) but commonly has a mixed matrix of very dark gray (10YR 3/1), light olive brown (2.5Y 5/4), brown (7.5YR 4/4) or olive gray (5Y 4/1). It is loam, sandy clay loam, or sandy loam 4 to 50 inches thick. The C horizon is generally very dark grayish brown (10YR 3/2) to olive gray (5Y 5/2). It is loam, sandy loam, or sand and gravel and is stratified.

Spillville and Coland soils formed in similar parent material. Spillville soils are mainly loam and Coland soils are silty clay loam and clay loam. Spillville soils are better drained than Coland soils.

485—Spillville loam, 0 to 2 percent slopes. This soil is on bottom lands, and areas are generally long and narrow. Most areas are 2 to 20 acres in size. They commonly are intermingled with other nearly level soils on bottom lands.

Included with this soil in mapping are areas of soils that are mildly alkaline.

The main management concern is wetness. This soil is well suited to cultivated crops if drainage is adequate and if flooding is controlled. It usually is farmed with the adjoining nearly level soils, most of which are more poorly drained. Undrained areas and unprotected areas are better suited to pasture than to cultivated crops. Capability unit IIw–2.

485B—Spillville loam, 2 to 5 percent slopes. This soil is on foot slopes and areas are generally long and narrow. Typically it is downslope from areas of Clarion or Storden soils. Most areas are 2 to 10 acres in size. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of soils that are similar to this Spillville soil but are light clay loam throughout.

This soil has a moderate erosion hazard. It receives runoff from adjoining upslope soils, which causes rilling and, in places, sedimentation. This soil is well suited to cultivated crops if erosion is controlled. It is commonly farmed with adjacent upland soils. Capability unit IIe–1.

Steinauer series

The Steinauer series consists of well drained, strongly sloping to very steep soils on uplands. These soils formed in moderately fine textured glacial till. The native vegetation was prairie grasses and a few scattered trees.

In a representative profile the surface layer is dark grayish brown loam about 5 inches thick. The underlying material is yellowish brown clay loam.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content is moderate to low.

Steinauer soils are used mainly for pasture.

Representative profile of Steinauer loam, 9 to 18 percent slopes, in pasture, 300 feet west and 25 feet north of the southeast corner of NW¼SE¼ of sec. 29, T. 86 N., R. 37 W.:

Ap—0 to 5 inches; dark grayish brown (10YR 4/2) loam; weak fine subangular blocky structure; friable; strongly effervescent; moderately alkaline; abrupt smooth boundary.

C1—5 to 24 inches; yellowish brown (10YR 5/4) clay loam; thin discontinuous dark grayish brown (10YR 4/2) coatings on peds; few medium prominent light gray (10YR 6/1) mottles; weak fine prismatic structure and weak fine subangular blocky; firm; few fine black and red concretions; strongly effervescent; moderately alkaline; clear smooth boundary.

C2—24 to 48 inches; yellowish brown (10YR 5/4) medium clay loam; few medium prominent light gray mottles; massive; firm; few fine black accumulations; strongly

effervescent; moderately alkaline; clear smooth boundary.

C3—48 to 73 inches; yellowish brown (10YR 5/4) medium clay loam; few medium prominent light gray (10YR 6/1) mottles; massive; firm; few fine black and brown concretions; few lime concretions; few small pebbles; strongly effervescent; moderately alkaline.

The solum generally is calcareous throughout, but the A horizon is noncalcareous in places. The A horizon commonly is dark grayish brown (10YR 4/2) or grayish brown (10YR 5/2) loam or clay loam. It is 8 to 14 inches thick if uneroded. Some pedons have a very dark grayish brown (10YR 3/2) A horizon that is less than 6 inches thick. The C horizon is yellowish brown (10YR 5/4), brown (10YR 5/3), pale brown (10YR 6/3), or light yellowish brown (10YR 6/4).

Steinauer and Shelby soils formed in similar parent material. Steinauer soils do not have the B horizon typical of Shelby soils and are generally calcareous throughout. Shelby soils are noncalcareous in the A and B horizons.

33E—Steinauer loam, 9 to 18 percent slopes. This soil is on convex side slopes. Most areas are 2 to 5 acres in size and are irregular in shape. This soil has the profile described as representative of the series.

This soil is suited to pasture and woodland and is moderately suited to hay. Surface stones and boulders hinder farm operations in places. Capability unit VIe–1.

33F—Steinauer loam, 18 to 40 percent slopes. This soil is on side slopes. Most areas are 2 to 10 acres in size and are irregular in shape.

This soil is suited to pasture and woodland. Some areas are moderately suited to hay, but the steepness of the slopes in many other areas prevents the use of farm machinery. Capability unit VIe–1.

Storden series

The Storden series consists of somewhat excessively drained, moderately sloping to very steep soils on uplands. These soils formed in medium textured glacial till. The native vegetation was prairie grasses.

In a representative profile the surface layer is dark grayish brown loam about 5 inches thick. The underlying material is light olive brown or yellowish brown loam.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content is moderate to low.

Storden soils are used for pasture and cultivated crops.

Representative profile of Storden loam, 9 to 14 percent slopes, in a pasture, 400 feet north and 600 feet west of the southeast corner of SW¼ of sec. 12, T. 88 N., R. 37 W.:

A1—0 to 5 inches; dark grayish brown (10YR 4/2) loam; weak fine subangular blocky structure; friable; few small pebbles; strongly effervescent; moderately alkaline; abrupt smooth boundary.

C1—5 to 15 inches; light olive brown (2.5Y 5/4) loam; moderate fine subangular blocky structure; friable; many light gray concretions; strongly effervescent; moderately alkaline; clear smooth boundary.

C2—15 to 28 inches; light olive brown (2.5Y 5/6) loam; weak fine subangular blocky structure; friable; vertical lime streaks; strongly effervescent; moderately alkaline; gradual smooth boundary.

C3—28 to 38 inches; yellowish brown (10YR 5/8) loam; weak fine and medium subangular blocky structure; few fine distinct light olive gray (5Y 6/2) mottles; friable; few fine dark accumulations (oxides); very few medium reddish accumulations (oxides); strongly effervescent; moderately alkaline; gradual smooth boundary.

C4—38 to 49 inches; yellowish brown (10YR 5/4) loam; few coarse distinct yellowish brown (10YR 4/2) mottles; weak medium subangular blocky structure; friable; strongly effervescent; moderately alkaline; gradual smooth boundary.

C5—49 to 70 inches; yellowish brown (10YR 5/4) loam; massive; friable; thin discontinuous dark coatings (oxides) on cleavage faces; strongly effervescent; moderately alkaline; gradual smooth boundary.

The A horizon is dark grayish brown (10YR 4/2) or grayish brown (10YR 5/2). It is as much as 10 inches thick if uneroded. The C horizon is yellowish brown (10YR 5/6 or 5/8), light olive brown (2.5Y 5/4 or 5/6), or brown (10YR 5/3).

Storden and Clarion soils formed in similar parent material. Storden soils have a thinner solum and lack the B horizon typical of Clarion soils. Storden soils are calcareous throughout, and Clarion soils are noncalcareous in the solum.

62C—Storden loam, 5 to 9 percent slopes. This soil is on side slopes or knolls. Most areas are irregular in shape and are 2 to 5 acres in size.

Included with this soil in mapping are areas of severely eroded soils, spots of sandy or gravelly soils, and small areas of Clarion soils.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. Capability unit IIIe–1.

62D—Storden loam, 9 to 14 percent slopes. This soil is on side slopes. Most areas are 2 to 5 acres in size and are irregular in shape. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of severely eroded soils, spots of sandy or gravelly soils, and small areas of Clarion soils.

This soil has a severe erosion hazard. It is suited to cultivated crops if erosion is controlled. However, many areas are used for pasture because of the erosion hazard. Capability unit IIIe–2.

62E—Storden loam, 14 to 18 percent slopes. This soil is on side slopes. Most areas are 2 to 10 acres in size and are irregular in shape.

Included with this soil in mapping are spots of severely eroded soils and areas of sand and gravel.

This soil is suited to hay or pasture. It can be planted

to cultivated crops part of the time if erosion is controlled. Capability unit IVe–1.

62F—Storden loam, 18 to 25 percent slopes. This soil is on side slopes. Most areas are 2 to 10 acres in size and are irregular in shape.

Included with this soil in mapping are small areas of sand and gravel. Also included are areas of shale outcrop near Grant City.

This soil is suited to pasture and woodland and is moderately suited to hay. The steepness of the slopes makes the use of farm machinery hazardous in places. Capability unit VIe–1.

62G—Storden loam, 25 to 40 percent slopes. This soil is on side slopes. Areas range from 2 acres to more than 50 acres in size and are irregular in shape.

Included with this soil in mapping are a few areas of gravelly soils. Also included are areas of shale outcrop near Grant City.

This soil is suited to pasture and woodland. The steepness of the slopes makes the use of farm machinery impractical or extremely hazardous. Capability unit VIIe–1.

Talcot series

The Talcot series consists of very poorly drained, nearly level soils on uplands and benches. These soils formed in moderately fine textured glacial outwash over coarse textured outwash. The native vegetation was grasses and sedges.

In a representative profile the surface layer is black clay loam about 18 inches thick. The subsoil is clay loam about 19 inches thick. The upper part is black, and the middle and lower parts are gray and light gray. The underlying material is light gray sand.

Permeability is moderate in the upper part and rapid in the underlying sand. Available water capacity is moderate. The rooting zone is restricted by depth to sand and gravel. Organic matter content is high.

Talcot soils are used for cultivated crops and pasture.

Representative profile of Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, in a cultivated field, 35 feet north and 725 feet east of the southwest corner of NE¼ of sec. 7, T. 89 N., R. 35 W.:

Ap—0 to 8 inches; black (N 2/0) light clay loam; weak fine granular and weak very fine subangular blocky structure; friable; strongly effervescent; moderately alkaline; abrupt smooth boundary.

A12—8 to 12 inches; black (N 2/0) light clay loam; weak fine granular and weak very fine subangular blocky structure; friable; strongly effervescent; moderately alkaline; clear smooth boundary.

A3—12 to 18 inches; black (5Y 2/1) light clay loam; weak fine granular and weak very fine subangular blocky structure; friable; strongly effervescent; moderately alkaline; clear smooth boundary.

B1g—18 to 23 inches; black (5Y 2/1) light clay loam; common medium distinct dark gray (4Y 4/1) mottles; very dark gray (5Y 3/1) kneaded; weak very fine subangular blocky structure; friable; strongly effervescent; moderately alkaline; clear smooth boundary.

B2g—23 to 29 inches; gray (5Y 5/1) light clay loam; weak fine prismatic structure parting to very fine subangular blocky; friable; very dark gray fills in worm or root channels; few very fine reddish and dark accumulations (oxides); strongly effervescent; moderately alkaline; gradual smooth boundary.

B3g—29 to 37 inches; light gray (5Y 6/1) light clay loam; very few coarse distinct light olive brown (2.5Y 5/6) mottles; weak fine prismatic structure parting to weak fine subangular blocky; friable; very dark gray (5Y 3/1) fills in worm and root channels; common very fine reddish accumulations (oxides); few fine dark accumulations (oxides); strongly effervescent; moderately alkaline; abrupt smooth boundary.

IIC—37 to 60 inches; light gray (5Y 6/1) medium sand; few stones; common large distinct strong brown (7.5YR 5/6) mottles and iron bands; structureless; loose; common large reddish accumulations (oxides); strongly effervescent; moderately alkaline.

The A horizon is 14 to 24 inches thick. The B horizon is 10 to 20 inches thick. It is black (5Y 2/1) to very dark gray (5Y 4/1) in the upper part and mottled, very dark gray (5Y 4/1) to light olive gray (5Y 6/2) in the lower part. The C horizon is very dark gray (5Y 4/1) to light olive gray (5Y 6/2). The amount of gravel ranges from almost none to almost 100 percent but is mainly less than 50 percent.

Talcot and Biscay soils formed in similar parent material. Talcot soils are calcareous throughout, but Biscay soils are noncalcareous in the solum.

559—Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. Typically, this soil is at lower elevations than most of the adjoining soils. Most areas are 2 to 20 acres in size and are irregular in shape.

Included with this soil in mapping are areas of soils that are similar to this Talcot soil but that have sand and gravel at a depth of less than 32 inches. Also included are areas of soils in the upper Boyer River Valley that are siltier in the upper part than this Talcot soil.

The main management concern is wetness. Excess water from adjoining areas runs onto this soil. The low available water capacity of the underlying sand and gravel makes this soil droughty during dry seasons.

This soil is well suited to cultivated crops if drainage is adequate. If this soil is inadequately drained, root growth is restricted during wet seasons. Capability unit IIw–1.

Terril series

The Terril series consists of moderately well drained, gently sloping and moderately sloping soils

on foot slopes and benches. These soils formed in medium textured local alluvium. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is loam about 31 inches thick. The upper part is black and the lower part is very dark grayish brown. The subsoil is dark brown, brown, and very dark grayish brown clay loam that extends to a depth of 73 inches or more.

Permeability is moderate, and available water capacity is high. The rooting zone is deep. Organic matter content is high.

Terril soils are used for cultivated crops and for pasture.

Representative profile of Terril loam, 3 to 8 percent slopes, in a cultivated area, 400 feet south and 300 feet east of the northwest corner of SW¼NW¼ of sec. 36, T. 88 N., R. 36 W.:

Ap—0 to 8 inches; black (10YR 2/1) medium loam; weak fine granular and weak very fine subangular blocky structure; friable; neutral abrupt smooth boundary.

A12—8 to 17 inches; black (10YR 2/1) and very dark grayish brown (10YR 3/2) heavy loam; weak fine granular and weak very fine subangular blocky structure; friable; neutral; gradual smooth boundary.

A13—17 to 24 inches; very dark grayish brown (10YR 3/2) heavy loam; very dark gray (10YR 3/1) coatings on peds; weak very fine and fine subangular blocky structure; friable; neutral; gradual smooth boundary.

A3—24 to 31 inches; very dark grayish brown (10YR 3/2) heavy loam; weak fine subangular blocky structure; friable; neutral; gradual smooth boundary.

B2—31 to 54 inches; dark brown (10YR 3/3) and brown (10YR 4/3) light clay loam; few very dark grayish brown (10YR 3/2) coatings on peds; weak fine and medium subangular blocky structure; friable; slightly acid; gradual smooth boundary.

B3—54 to 73 inches; very dark grayish brown (10YR 3/2), dark grayish brown (2.5Y 4/3), and brown (7.5YR 4/4) light clay loam; weak prismatic structure parting to weak medium subangular blocky; friable; slightly acid; gradual smooth boundary.

The solum is slightly acid or neutral. The A horizon is loam or light clay loam 24 to 36 inches thick. The B horizon is loam or light clay loam 24 inches to several feet thick. The C horizon, where present, is commonly brown (10YR 4/3), dark yellowish brown (10YR 4/4), olive brown (2.5Y 4/4), or yellowish brown (10YR 5/4) and, in places, has grayish mottles. In mapping unit 323B, the C horizon is loamy sand or sand.

Terril and Spillville soils formed in similar parent material. Terril soils are browner in the B horizon than Spillville soils.

27C—Terril loam, 3 to 8 percent slopes. This soil is on foot slopes. Most areas of this soil are 2 to 5 acres in size and are generally narrow and elongated. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of soils that have a sandy loam surface layer.

This soil has a moderate to severe erosion hazard. It is suited to cultivated crops if erosion is controlled. Runoff from adjoining soils on the hillsides causes rilling and, in places, sedimentation. Capability unit IIIe–1.

323B—Terril loam, sandy substratum, 2 to 5 percent slopes. This soil is on benches. Most areas are 2 to 20 acres in size. They are irregular in shape but are generally slightly elongated.

Included with this soil in mapping are areas of soils that have a sandy loam surface layer.

This soil has a moderate erosion hazard. It is well suited to cultivated crops if erosion is controlled. Runoff from adjoining soils on the hillsides causes rilling and, in places, sedimentation. This soil has lower available water capacity than Terril soils that do not have a sandy substratum. Capability unit IIe–1.

Wacousta series

The Wacousta series consists of very poorly drained, nearly level soils in depressions on uplands. These soils formed in moderately fine textured glacial sediment. The native vegetation was water-tolerant grasses.

In a representative profile the surface layer is black silty clay loam about 15 inches thick. The subsoil is very dark gray and dark gray silty clay loam about 4 inches thick. The underlying material is olive gray and light olive gray silty clay loam.

Permeability is moderate to moderately slow, and available water capacity is high. The rooting zone is restricted in wet seasons by a high water table. Organic matter content is high.

Wacousta soils are used for cultivated crops and pasture.

Representative profile of Wacousta silty clay loam, 0 to 1 percent slopes, in a cultivated area, 100 feet west and 100 feet south of the northeast corner of NW¼ of sec. 20, T. 88 N., R. 36 W.:

Ap—0 to 9 inches; black (N 2/0) light silty clay loam; cloddy; friable; neutral; abrupt smooth boundary.

A1—9 to 15 inches; black (5Y 2/1) medium silty clay loam; weak very fine subangular blocky structure; friable; few gray fills in root and worm channels; neutral; abrupt smooth boundary.

Bg—15 to 19 inches; very dark gray (5Y 3/1) and dark gray (5Y 4/1) medium silty clay loam; massive; friable; very dark gray streaks and fills in crayfish holes; many fine light gray lime accumulations and fragments of snail shells; strongly effervescent; moderately alkaline; abrupt smooth boundary.

C1g—19 to 30 inches; light olive gray (5Y 6/2) light silty clay loam; many medium distinct light olive brown (2.5Y 5/4) mottles; olive gray (5Y 5/2) kneaded; massive; friable; few fine dark and reddish accumulations (oxides); few fine

soft lime accumulations; darks fills in root and worm channels; strongly effervescent; moderately alkaline; abrupt smooth boundary.

C2g—30 to 60 inches; olive gray (5Y 5/2) light silty clay loam; many medium distinct yellowish brown (10YR 5/6) mottles; massive; friable; few large lime accumulations; few fine dark and reddish accumulations (oxides); strongly effervescent; moderately alkaline.

The A horizon is slightly acid or neutral. It is 8 to 16 inches thick. The B horizon, if present, is neutral to moderately alkaline. It is black (5Y 2/1) to light olive gray (5Y 6/2) and is as much as 6 inches thick. The C horizon is dark gray (5Y 4/1) to light olive gray (5Y 6/2). It is generally silty clay loam but is silt loam in places.

Wacousta and Okoboji soils formed in similar parent material in depressions. Wacousta soils have a thinner solum than Okoboji soils and are generally slightly coarser textured. They are coarser textured than Lanyon soils, which also formed in depressions.

506—Wacousta silty clay loam, 0 to 1 percent slopes. This soil is in depressions. Most areas are 5 to 50 acres in size and are irregular in shape.

Included with this soil in mapping are areas of a soil similar to this Wacousta soil, but it is calcareous throughout the profile.

The main management concern is wetness. This soil is subject to runoff from adjoining areas. This soil is suited to cultivated crops if drainage is adequate and if flooding or ponding is controlled. If this soil is inadequately drained, crops drown out or are stunted during flooding or ponding. Capability unit IIIw–1.

Wadena series

The Wadena series consists of well drained, nearly level to moderately sloping soils on benches and on uplands. These soils formed in medium textured glacial outwash and in the underlying sand and gravel. The native vegetation was tall prairie grasses.

In a representative profile the surface layer is very dark brown loam about 13 inches thick. The subsoil is 21 inches thick. The upper part is very dark brown and very dark grayish brown loam, the middle part is brown loam and dark yellowish brown sandy clay loam, and the lower part is dark yellowish brown sand and gravel. The underlying material is brown sand and gravel.

Permeability is moderately rapid in the upper part of the profile and very rapid in the underlying sand and gravel. Available water capacity is moderate. The rooting zone is restricted by depth to sand and gravel. Organic matter content is moderate to moderately low, depending on the thickness of the surface layer.

Wadena soils are used mostly for cultivated crops.

Representative profile of Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes, in a cultivated area, 350 feet north and 800 feet west of the southeast corner of sec. 24, T. 87 N., R. 36 W.:

Ap—0 to 6 inches; very dark brown (10YR 2/2) loam; cloddy; friable; neutral; abrupt smooth boundary.

A12—6 to 9 inches; very dark brown (10YR 2/2) loam; weak very fine and fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

A3—9 to 13 inches; very dark brown (10YR 2/2) loam; common very dark grayish brown (10YR 3/2) peds; weak very fine and fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B1—13 to 17 inches; very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) loam; weak very fine and fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B21—17 to 23 inches; brown (10YR 4/3) loam; dark brown (10YR 3/3) coatings on peds; weak very fine and fine subangular blocky structure; friable; neutral; clear smooth boundary.

B22—23 to 27 inches; dark yellowish brown (10YR 4/4) sandy clay loam; weak fine subangular blocky structure; friable; common gravel; neutral; abrupt smooth boundary.

IIB3—27 to 34 inches; dark yellowish brown (10YR 4/4) sand and gravel; single grained; loose; slightly acid; abrupt wavy boundary.

IIC—34 to 60 inches; brown (10YR 4/3) sand and gravel; single grained; loose; strongly effervescent; moderately alkaline.

The solum is neutral or slightly acid. The A horizon is black (10YR 2/1), very dark gray (10YR 3/1), or very dark brown (10YR 2/2) and is 10 to 20 inches thick if uneroded. The B horizon is generally brown (10YR 4/3) or dark yellowish brown (10YR 4/4), but in places it is very dark brown (10YR 2/2), very dark grayish brown (10YR 3/2), or dark brown (10YR 3/3) in the upper part. The B horizon is loam or sandy clay loam, but the B3 horizon is sand and gravel in places. The B horizon is 12 to 24 inches thick.

Wadena and Cylinder soils formed in similar parent material. Wadena soils are better drained than Cylinder soils.

308—Wadena loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This soil is generally on benches. A few areas formed in outwash on uplands. Most areas are 2 to 10 acres in size and are irregular in shape.

Included with this soil in mapping are areas of soils in the Boyer River valley that are siltier and more stratified in the underlying material than this Wadena soil.

This soil is well suited to cultivated crops. Potential productivity is reduced by prolonged dry periods because of limited available water capacity. Moisture conservation practices such as tillage that leaves crop residue on the surface are beneficial to this soil. Capability unit I–1.

308B—Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes. This soil is generally on

benches. Most areas are 2 to 10 acres in size and are irregular in shape.

This soil has a moderate erosion hazard and is slightly droughty. It is well suited to cultivated crops if erosion is controlled and if moisture conservation practices are used. Capability unit IIe–1.

108—Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes. This soil is generally on benches, but some areas are in outwash areas on uplands. Most areas are 2 to 50 acres in size. They are irregular in shape but generally are somewhat elongated. This soil has the profile described as representative of the series.

Included with this soil in mapping are areas of soils in the Boyer River valley that are siltier and more stratified than this Wadena soil.

This soil has a drought hazard. It is well suited to cultivated crops if moisture conservation practices are used. Capability unit IIs–1.

108B—Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes. This soil is generally on benches in valleys, but some areas formed in outwash on uplands. Most areas are 2 to 50 acres in size. They are irregular in shape but generally are somewhat elongated.

Included with this soil in mapping are areas of soils in the Boyer River valley that are siltier and more stratified than this Wadena soil.

This soil has moderate erosion and drought hazards. It is well suited to cultivated crops if erosion is controlled and if moisture conservation practices are used. Capability unit IIe–2.

108C2—Wadena loam, 24 to 32 inches to sand and gravel, 5 to 9 percent slopes, moderately eroded. This soil is generally on benches. It forms escarpments between areas of less sloping Wadena soils and bottom lands. Most areas are 2 to 10 acres in size and are long and narrow in shape.

Included with this soil in mapping are areas of soils that have a slightly thicker surface layer than this Wadena soil.

This soil has severe erosion and drought hazards. It is suited to cultivated crops if erosion is controlled and if moisture conservation practices are used. Capability unit IIIe–3.

Waldorf series

The Waldorf series consists of poorly drained, nearly level soils on uplands. These soils formed in moderately fine textured and fine textured glacial sediment. The native vegetation was water-tolerant tall prairie grasses.

In a representative profile the surface layer is black and is about 24 inches thick. The upper 10 inches is silty clay loam, and the lower 14 inches is silty clay. The subsoil is olive gray to dark gray silty clay about 23 inches thick. The underlying material is olive gray silty clay loam.

Permeability is moderately slow, and available water capacity is high. The rooting zone is deep, but in wet seasons it is restricted by a high water table. The organic matter content is high.

Waldorf soils are used mostly for cultivated crops.

Representative profile of Waldorf silty clay loam, 0 to 2 percent slopes, in a cultivated area, 150 feet east and 5 feet south of the northwest corner of NE¼NE¼ of sec. 14, T. 86 N., R. 36 W.:

Ap—0 to 10 inches; black (N 2/0) medium silty clay loam; weak fine granular and weak very fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

A12—10 to 18 inches; black (N 2/0) light silty clay; moderate fine granular and moderate very fine subangular blocky structure; friable; few dark accumulations (oxides); neutral; gradual smooth boundary.

A3—18 to 24 inches; black (N 2/0) silty clay; weak fine prismatic structure parting to moderate very fine subangular blocky; firm; many fine reddish accumulations (oxides); neutral; gradual smooth boundary.

B21tg—24 to 29 inches; olive gray (5Y 4/2) and olive brown (2.5Y 4/4) silty clay; very dark gray (5Y 3/1) coatings on ped surfaces; dark gray (5Y 4/1) kneaded; weak fine prismatic structure parting to moderate very fine and fine subangular blocky; firm; thin continuous clay films; many fine red and dark accumulations (oxides); neutral; gradual smooth boundary.

B22tg—29 to 36 inches; dark gray (5Y 4/1) silty clay; olive gray (5Y 4/2) kneaded; many medium distinct olive brown (2.5Y 4/4) mottles; weak fine prismatic structure parting to moderate very fine and fine subangular blocky; firm; black (5Y 2/1) thick continuous clay films; many fine red accumulations (oxides); neutral; gradual smooth boundary.

B3tg—36 to 47 inches; dark gray (5Y 4/1) light silty clay; many distinct olive brown (2.5Y 4/4) mottles; weak fine subangular blocky structure; firm; thick continuous clay films; few fine reddish accumulations (oxides); thick continuous organic stains on faces of prisms; neutral; abrupt smooth boundary.

C—47 to 64 inches; olive gray (5Y 5/2) heavy silty clay loam; many distinct yellowish brown (10YR 5/6) mottles; firm; thin discontinuous clay films on cleavage faces; strongly effervescent; moderately alkaline.

The solum is slightly acid to mildly alkaline. The A horizon is medium to heavy silty clay loam or light silty clay 16 to 24 inches thick. The A3 horizon is black (N 2/0) to very dark gray (5Y 3/1). The B horizon is dark gray (5Y 4/1) to olive brown (2.5Y 4/4) and is 16 to 30 inches thick. The C horizon is silty clay to medium silty clay loam. In places it is neutral or mildly alkaline in the upper part but with depth becomes moderately alkaline and calcareous.

Waldorf and Collinwood soils formed in similar material, and their profile is similar to that of Webster soils. Waldorf soils are in less sloping positions and

are more poorly drained than Collinwood soils. They are finer textured and less permeable than Webster soils.

390—Waldorf silty clay loam, 0 to 2 percent slopes. Most areas of this soil are 2 to 10 acres in size and are irregular in shape.

Included with this soil in mapping are areas of soils that are similar to this Waldorf soil but that have clay loam or loam glacial till in the underlying material.

The main management concern is wetness. This soil is suited to cultivated crops. If the soil is inadequately drained, root growth is restricted during wet seasons. The soil becomes cloddy if worked when it is too wet. Capability unit IIw–1.

Webster series

The Webster series consists of poorly drained, nearly level soils on uplands. These soils formed in moderately fine textured glacial till and glacial sediment. The native vegetation was tall prairie grasses and marsh grasses.

In a representative profile the surface layer is black silty clay loam and clay loam about 12 inches thick. The subsoil is clay loam about 21 inches thick. The upper part is very dark gray and olive gray and the lower part is olive gray, light olive gray, and dark gray. The underlying material is olive gray and yellowish brown clay loam.

Permeability is moderate to moderately slow, and available water capacity is high. The rooting zone is deep, but in wet seasons it is restricted by a high water table. Organic matter content is high.

Webster soils are used mainly for cultivated crops.

Representative profile of Webster silty clay loam, 0 to 2 percent slopes, in a pasture, 400 feet south and 80 feet east of the northwest corner of SW¼ of sec. 29, T. 88 N., R. 35 W.:

A1—0 to 9 inches; black (N 2/0) silty clay loam that has a high content of sand; weak fine granular and very fine subangular blocky structure; friable; neutral; clear smooth boundary.

A3—9 to 12 inches; black (N 2/0) light clay loam; few fine distinct olive gray (5Y 4/2) mottles; weak very fine and fine subangular blocky structure; friable; neutral; clear smooth boundary.

B1g—12 to 16 inches; very dark gray (5Y 3/1) medium clay loam; common fine distinct olive gray (5Y 4/2) mottles; weak very fine and fine subangular blocky structure; friable; mildly alkaline; clear smooth boundary.

B21g—16 to 21 inches; olive gray (5Y 4/2) and very dark gray (5Y 3/1) medium clay loam; weak fine prismatic structure parting to weak very fine and fine subangular blocky; friable; few fine reddish accumulations (oxides); mildly alkaline; clear smooth boundary.

B22g—21 to 25 inches; olive gray (5Y 4/2) and dark gray (5Y 4/1) light clay loam; weak fine prismatic structure parting to weak fine subangular blocky; friable; few fine dark and reddish accumulations (oxides); mildly alkaline; abrupt smooth boundary.

B3g—25 to 33 inches; olive gray (5Y 5/2), light olive gray (5Y 6/2), and dark gray (5Y 4/1) light clay loam; weak medium prismatic structure parting to weak medium subangular blocky; friable; few fine dark and reddish accumulations (oxides); common soft lime accumulations; strongly effervescent; moderately alkaline; gradual smooth boundary.

C1g—33 to 42 inches; olive gray (5Y 5/2) light clay loam; common prominent yellowish brown (10YR 5/6) mottles; massive; friable; few fine dark and reddish accumulations (oxides); strongly effervescent; moderately alkaline; clear smooth boundary.

C2g—42 to 76 inches; olive gray (5Y 5/2), yellowish brown (10YR 5/6), and olive gray (5Y 5/2) light clay loam; many medium prominent yellowish brown (10YR 5/6) mottles; massive; friable; few medium dark and reddish accumulations (oxides); strongly effervescent; moderately alkaline.

The solum is mainly slightly acid to mildly alkaline, but the lower part is typically moderately alkaline and calcareous. The A horizon is 12 to 22 inches thick. The B horizon is very dark gray (10YR 3/1 or 5Y 3/1) to olive gray (5Y 4/2 or 5Y 5/2) in the upper part and dark gray (5Y 4/1) to light olive gray (5Y 6/1) in the lower part. It is light to medium silty clay loam or clay loam 10 to 24 inches thick. The C horizon is silty clay loam, clay loam, or heavy loam and in places is stratified.

Webster, Nicollet, and Canisteo soils formed in similar parent material. Webster soils are more poorly drained than Nicollet soils and in places are finer textured. They are noncalcareous in the upper part of the solum, but Canisteo soils are calcareous throughout the profile.

107—Webster silty clay loam, 0 to 2 percent slopes. Most areas of this soil are 2 to 20 acres in size and are irregular in shape.

Included with this soil in mapping are areas of calcareous soils, many small areas of soils in depressions, small areas of Clarion and Nicollet soils on slight rises, and areas of soils that have a fine textured subsoil. These included areas are shown on the map with special symbols.

The main management concern is wetness. This soil is suited to cultivated crops. If the soil is inadequately drained, root growth is restricted during wet seasons. Capability unit IIw–1.

Zook series

The Zook series consists of poorly drained, nearly level soils on bottom lands. These soils formed in moderately fine textured and fine textured alluvium. The native vegetation was tall grasses and sedges.

In a representative profile the surface layer is black silty clay about 40 inches thick. The subsoil is very

dark gray silty clay about 20 inches thick. The underlying material is very dark gray silty clay.

Permeability is slow, and available water capacity is high. The rooting zone is deep, but in wet seasons it is restricted by a high water table. Organic matter content is high.

Zook soils are mainly used for cultivated crops. Inadequately drained areas are mainly used for pasture.

Representative profile of Zook silty clay, 0 to 2 percent slopes, in a cultivated field, 600 feet north and 600 feet west of the southeast corner of sec. 10, T. 86 N., R. 37 W.:

Ap—0 to 6 inches; black (10YR 2/1) light silty clay; moderate very fine subangular blocky structure; firm; neutral; abrupt smooth boundary.

A12—6 to 15 inches; black (N 2/0) light silty clay; moderate very fine subangular blocky structure; firm; neutral; diffuse smooth boundary.

A13—15 to 26 inches; black (N 2/0) medium silty clay; weak fine prismatic structure parting to moderate very fine subangular blocky; firm; mildly alkaline; diffuse smooth boundary.

A3—26 to 40 inches; black (10YR 2/1) medium silty clay; weak fine prismatic structure parting to moderate very fine subangular blocky; firm; black (5Y 2/1) coatings on peds; mildly alkaline; diffuse smooth boundary.

B2g—40 to 60 inches; very dark gray (5Y 3/1) light silty clay; weak fine prismatic structure parting to moderate very fine subangular blocky; firm; black (5Y 2/1) coatings on peds; mildly alkaline; diffuse smooth boundary.

Cg—60 to 84 inches; very dark gray (5Y 3/1) light silty clay; weak fine prismatic structure parting to moderate very fine subangular blocky; firm; mildly alkaline; diffuse smooth boundary.

The solum ranges from medium acid to neutral in the most acid part. The A horizon is 24 to 40 inches thick. The upper part is silty clay loam or silty clay. The B horizon is black (N 2/0 or 5Y 2/1) to very dark gray (5Y 3/1) and is generally 10 to 20 inches thick. It is generally silty clay but in places is silty clay loam in the lower part.

Zook, Nishna, and Colo soils formed in similar parent material. Zook soils are finer textured than Colo soils. They are noncalcareous in the solum, but Nishna soils are calcareous throughout the profile.

54—Zook silty clay loam, 0 to 2 percent slopes. Many areas of this soil are 100 acres or more in size. Most are long and narrow and are parallel to the stream. This soil has a profile similar to the one described as representative of the series, but the upper part of the surface layer is silty clay loam.

The main management concern is wetness. Timely field operations are needed. Maintaining good tilth is somewhat easier on this soil than on the more clayey Zook soils. This soil is well suited to cultivated crops if drainage is adequate and if flooding is controlled. Undrained and unprotected areas are better suited to pasture. Capability unit IIw–2.

134—Zook silty clay, 0 to 2 percent slopes. Areas of this soil are 100 acres or more in size. Most are long and narrow and are parallel to the stream. This soil has the profile described as representative of the series.

The main management concern is wetness. Timely field operations are needed to maintain good tilth in this clayey soil. This soil is well suited to cultivated crops if drainage is adequate and if flooding is controlled. Undrained and unprotected areas are better suited to pasture. Capability unit IIw–2.

Planning the use and management of the soils

The soil survey is a detailed analysis and evaluation of the most basic resource of the survey area—the soil. It may be used to fit the use of the land, including urbanization, to the limitations and potentials of the natural resources and the environment and to help avoid soil-related failures in uses of the land.

During a soil survey, soil scientists, conservationists, engineers, and others keep extensive notes, not only about the nature of the soils but also about unique aspects of behavior of these soils in the field and at construction sites. These notes included observations of erosion, drought damage to specific crops, yield estimates, flooding, the functioning of septic systems, and other factors relating the kinds of soil and their productivity, potentials, and limitations under various uses and management. In this way field experience incorporated with measured data on soil properties and performance is used as a basis for predicting soil behavior.

Information in this section will be useful in applying basic facts about the soils to plans and decisions for use and management of soils for crops and pasture, woodland, and many nonfarm uses, including building sites, highways and other transportation systems, sanitary facilities, parks and other recreational developments, and wildlife habitat. From the data presented, the potential of each soil for specified land uses may be determined, soil limitations to these land uses may be identified, and costly failures in homes and other structures, because of unfavorable soil properties, may be avoided. A site can be selected where the soil properties are favorable, or practices can be planned that will overcome the soil limitations.

Planners and others using the soil survey can evaluate the impact of specific land uses on the overall productivity of the survey area or other broad planning area, and on the environment. Both of these factors are closely related to the nature of the soil. Plans can be made to maintain or create a land use pattern in harmony with the natural soil.

Contractors can find information useful in locating sources of sand and gravel, road fill, and topsoil. Other information indicates the presence of bedrock, wetness, or very firm soil horizons that cause difficulty in excavation.

Health officials, highway officials, engineers, and many other specialists can find useful information in this soil survey. The safe disposal of wastes, for ex-

ample, is closely related to properties of the soil. Pavements, sidewalks, campsites, playgrounds, lawns, trees and shrubs, and most other uses of land are influenced by the nature of the soil.

Crops and pasture

About 80 percent of the land in Sac County is used for cultivated crops. Corn and soybeans are the major row crops. As a general rule, the usefulness of a soil is measured by its suitability for these two crops. Oats and alfalfa-bromegrass hay are also important. Other kinds of hay and sorghum and popcorn are among the other crops grown to a lesser extent.

Erosion is considered to be the major hazard on about 64 percent of the cropland; wetness on about 23 percent; and droughtiness on about 5 percent. The other 8 percent is nearly level soils that have no major limitations to use.

Among the erosion control methods used in the county are contour tillage, diversions, and cropland terraces; rotations that include grasses and legumes; minimum tillage; grassed waterways; returning crop residue to the soil; and fertility management. Generally, a combination of several practices is used.

The percolation rate on the soils of Sac County is high enough so that terraces can be built with level, rather than graded, channels. Fertility management is important on all the soils. Without it, plant cover is often sparse and erosion is more difficult to control. Chemical fertilizers are widely used. Also, because of numerous livestock in the county, manure is readily available and is used on most farms. Legumes are commonly grown as a green manure crop.

Soil blowing is a hazard on all soils used for crops, especially in fields that are plowed in fall after soybeans are harvested. Plowing in fall generally has little or no advantage over plowing in spring for maintaining good tilth, but it is suitable for soils in some of the drainageways or on bottom lands and for extensive areas of poorly drained soils in the eastern part of the county.

The soils that have a wetness hazard generally can be tiled if a suitable outlet is available. A surface drainage system is generally more practical for the fine textured soils on bottom lands, such as Zook and Nishna soils.

In most years, rainfall and stored soil moisture are adequate for the commonly grown crops, but in most places where fertility is good, insufficient moisture commonly limits yields. Insufficient moisture generally is not a major limitation, and very few irrigation systems have been installed.

About 10 percent of the county is in pasture. There are three general types: (1) pastures on uplands where many of the soils are too steep for the use of machinery; (2) pastures on moderately steep to steep soils that can be worked with machinery; and (3) pastures that are in depressions, on flood plains, or in drainageways.

Controlled grazing of pastures on the very steep soils is needed. Any renovation or reseeding is done by hand. These pastures have native grasses such as big bluestem, little bluestem, and side-oats grama. There are thin stands of trees in places.

Pastures on soils where farm machinery can be used are generally in bromegrass or alfalfa-bromegrass. These pastures can be plowed and reseeded if necessary. Usually corn is planted the first year and the soil is then reseeded. Other practices that can be used are applying fertilizer by topdressing or disking and reseeding in the old sod.

Pastures in depressions, on flood plains, and in drainageways are made up of bluegrass. If flooding is controlled or drainage systems are installed, these pastures can be converted to crops. If flooding is not controlled and drainage systems are not used, bluegrass is suited to these pastures. Practices that can be used are controlled grazing, fertilization, and, if needed, renovation. Weed control is especially important because of the weed seed carried by floodwaters.

Yields per acre

The per acre average yields that can be expected of the principal crops under a high level of management are shown in table 2. In any given year, yields may be higher or lower than those indicated in table 2 because of seasonal variations in rainfall and other climatic factors. Absence of a yield estimate indicates that the crop is not suited to or is not commonly grown on the soil.

The predicted yields are based mainly on the experience and records of farmers, conservationists, and Extension agents. Results of field trials and demonstrations and available yield data from nearby counties were also considered.

The latest soil and crop management practices used by many farmers in the county are assumed in predicting the yields. Hay and pasture yields are predicted for varieties of grasses and legumes suited to the soil. A few farmers may be using more advanced practices and are obtaining average yields higher than those shown in table 2.

The management needed to achieve the indicated yields of the various crops depends upon the kind of soil and the crop. Such management provides drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate tillage practices, including time of tillage and seedbed preparation and tilling when soil moisture is favorable; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green-manure crops; harvesting crops with the smallest possible loss; and timeliness of all fieldwork.

The predicted yields reflect the relative productive capacity of the soils for each of the principal crops. Yields are likely to increase in the future as new production technology is developed. The relative productivity of a given soil compared to other soils, however, is not likely to change.

Crops other than those shown in table 2 are grown in the survey area, but because their acreage is small, predicted yields for these crops are not included. The local offices of the Soil Conservation Service and the Cooperative Extension Service can provide information about the productivity and management concerns of the soils for these crops.

TABLE 2.—*Yields per acre of crops and pasture*

[All yields were estimated for a high level of management in 1975. Absence of a yield figure indicates the crop is seldom grown or is not suited]

Map symbol and soil name	Corn	Soybeans	Oats	Grass-legume hay	Smooth bromegrass	Kentucky bluegrass
	Bu	*Bu*	*Bu*	*Tons*	*AUM* [1]	*AUM* [1]
1D3: Ida	68	26	52	2.6	4.0	2.3
1E3: Ida	54	20	41	2.1	3.0	1.7
1F3: Ida				1.5	2.8	1.2
5B: Kennebec-Ackmore	114	43	91	4.2	6.8	4.1
C5B: Kennebec-Ackmore				4.1	6.0	3.8
6: Okoboji	78	30	62	2.9	4.6	3.1
8C: Judson	110	41	88	4.8	6.7	3.7
9B: Marshall	101	38	86	4.0	6.0	3.8
9B2: Marshall	98	37	85	4.0	5.9	3.7
9C: Marshall	96	36	81	3.9	5.8	3.6
9C2: Marshall	93	35	75	3.8	5.6	3.6
9D2: Marshall	84	31	68	3.4	4.8	3.5
9D3: Marshall	78	29	64	3.2	4.6	2.8
10D3: Monona	75	28	56	2.9	4.4	2.7
10E3: Monona	60	23	45	2.3	3.3	2.3
11B: Colo-Ely	86	32	70	3.3	4.9	3.3
24C2: Shelby	86	32	70	3.3	4.9	3.3
24D2: Shelby	76	28	57	3.0	4.3	2.7
24E2: Shelby	66	25	48	2.3	3.7	2.3
26B: Kennebec	111	42	88	4.4	6.7	4.2
27C: Terril	100	38	80	4.0	6.0	3.8
31: Afton	98	37	79	3.8	5.9	3.7
33E, 33F: Steinauer:					2.0	2.0
41D: Sparta					2.0	2.0

TABLE 2.—*Yields per acre of crops and pasture*—Continued

Map symbol and soil name	Corn	Soybeans	Oats	Grass-legume hay	Smooth bromegrass	Kentucky bluegrass
	Bu	*Bu*	*Bu*	*Tons*	*AUM* [1]	*AUM* [1]
54: Zook	96	36	77	3.7	5.6	3.7
55: Nicollet	110	42	88	4.4	6.7	4.0
62C: Storden	82	32	65	3.2	5.3	3.3
62D: Storden	73	28	59	2.9	4.9	2.7
62E: Storden	60	22	47	2.4	4.0	2.3
62F: Storden				2.5		2.0
62G: Storden						2.0
73C, 73D: Salida	35	14	27	1.5	1.8	1.5
77B: Sac	97	36	78	3.9	5.7	3.7
77B2: Sac	94	35	76	3.8	5.6	3.7
77C: Sac	92	34	73	3.7	5.4	3.7
77C2: Sac	89	33	71	3.6	5.3	3.6
78B: Sac	97	36	78	3.9	5.7	3.7
78B2: Sac	94	35	76	3.8	5.6	3.7
78C: Sac	92	34	73	3.7	5.4	3.7
78C2: Sac	89	33	71	3.6	5.3	3.6
91: Primghar	107	40	86	4.3	6.5	3.8
92: Marcus	104	40	84	4.1	5.8	3.8
95: Harps	88	33	71	3.4	5.0	3.6
107: Webster	102	39	83	4.0	6.0	3.7
108: Wadena	67	25	53	2.7	3.8	2.5
108B: Wadena	65	23	52	2.6	3.7	2.3
108C2: Wadena	58	20	47	2.3	3.2	2.2
133: Colo	104	40	83	4.0	6.0	4.0
134: Zook	92	35	73	3.5	5.3	3.7

TABLE 2.—*Yields per acre of crops and pasture*—Continued

Map symbol and soil name	Corn	Soybeans	Oats	Grass-legume hay	Smooth bromegrass	Kentucky bluegrass
	Bu	*Bu*	*Bu*	*Tons*	*AUM* [1]	*AUM* [1]
135: Coland	102	39	81	4.0	6.0	3.9
135B: Coland	100	38	80	4.0	5.9	3.8
138B: Clarion	100	38	80	4.0	6.0	3.8
138C: Clarion	95	36	76	3.8	5.7	3.7
138C2: Clarion	92	35	74	3.7	5.4	3.7
138D2: Clarion	83	31	66	3.3	4.8	3.3
174B: Bolan	77	29	62	2.9	4.5	2.7
174C2: Bolan	68	26	57	2.6	3.8	2.4
174D2: Bolan	60	23	50	2.3	3.3	2.3
201B: Coland-Spillville	86	32	67	3.3	5.0	3.5
C201B: Coland-Spillville					4.9	3.4
202: Cylinder	82	31	66	3.2	4.8	3.2
203: Cylinder	96	36	77	3.8	5.8	3.7
221: Palms	84	32	67	3.3	4.9	3.3
234: Nishna	90	34	72	3.5	5.2	3.7
236B: Lester	95	35	73	3.6	5.5	3.7
259: Biscay	93	35	74	3.6	5.4	3.8
274: Rolfe	81	30	64	3.0	4.6	3.3
308: Wadena	85	32	68	3.4	5.0	3.6
308B: Wadena	80	30	64	3.2	4.7	3.3
310: Galva	102	39	82	4.0	6.1	3.7
310B: Galva	100	38	81	4.0	6.0	3.7
310B2: Galva	97	37	78	3.9	5.8	3.6
310C: Galva	95	36	76	3.8	5.5	3.5
310C2: Galva	92	35	74	3.7	5.4	3.3

TABLE 2.—*Yields per acre of crops and pasture*—Continued

Map symbol and soil name	Corn	Soybeans	Oats	Grass-legume hay	Smooth bromegrass	Kentucky bluegrass
	Bu	*Bu*	*Bu*	*Tons*	*AUM* [1]	*AUM* [1]
T310: Galva	102	39	82	4.0	6.1	3.7
T310B: Galva	100	38	81	4.0	6.0	3.7
315: Alluvial land						2.5
323B: Terril	95	32	76	3.8	5.7	3.7
325: Le Sueur	106	40	85	4.2	6.5	4.0
354: Marsh						
384: Collinwood	93	35	74	3.7	5.5	3.7
390: Waldorf	85	32	68	3.3	4.9	3.5
397B: Letri	75	28	60	2.9	4.3	2.9
428: Ely	104	40	83	4.2	6.3	3.9
430: Ackmore	99	38	80	4.0	6.0	3.8
430B: Ackmore	97	37	77	3.9	5.8	3.7
485: Spillville	100	38	80	4.0	6.0	3.8
485B: Spillville	98	37	78	4.0	5.9	3.8
506: Wacousta	93	35	74	3.6	5.4	3.7
507: Canisteo	98	37	78	3.8	5.8	3.8
511: Blue Earth	87	33	70	3.3	4.9	3.3
559: Talcot	88	33	70	3.4	5.0	3.2
577C2: Everly	86	32	68	3.4	5.1	3.1
577D2: Everly	77	28	60	3.0	4.5	2.5
606: Lanyon	83	31	67	3.2	4.8	3.4
733: Calco	92	35	74	3.6	5.3	3.7

TABLE 2.—*Yields per acre of crops and pasture*—Continued

Map symbol and soil name	Corn	Soybeans	Oats	Grass-legume hay	Smooth bromegrass	Kentucky bluegrass
	Bu	*Bu*	*Bu*	*Tons*	*AUM* [1]	*AUM* [1]
823B:						
Flagler	47	19	35	1.8	2.5	1.7
823C2:						
Flagler	39	16	30	1.6	2.0	1.5

[1] Animal-unit-month: The amount of forage or feed required to feed one animal unit (one cow, one horse, one mule, five sheep, or five goats) for a period of 30 days.

Capability grouping

Capability classification is the grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on the limitations of the soils, the risk of damage when they are used for the ordinary field crops or sown pasture, and the way they respond to treatment. The classification does not apply to horticultural crops or to other crops that have their own special requirements for economical production. The soils are classified according to degree and kind of permanent limitations, but without consideration of major, and generally expensive, landforming that would change the slope, depth, or other characteristics of the soils, and without consideration of possible major reclamation (*3*).

In the capability system, all the soils are grouped at three levels, the capability class, subclass, and unit. These are discussed in the following paragraphs.

CAPABILITY CLASSES, the broadest grouping, are designated by Roman numerals I through VIII. As the numerals increase they indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I. Soils that have few limitations that restrict their use.

Class II. Soils that have some limitations that reduce the choice of plants or require moderate conservation practices.

Class III. Soils that have severe limitations that reduce the choice of plants, require special conservation practices, or both.

Class IV. Soils that have very severe limitations that restrict the choice of plants, require very careful management, or both.

Class V. Soils that are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover.

Class VI. Soils that have severe limitations that make them generally unsuited to cultivation without major reclamation and limit their use largely to pasture, range, woodland, or wildlife food and cover.

Class VII. Soils that have very severe limitations that make them unsuited to cultivation without major reclamation and restrict their use largely to range, woodland, or wildlife food and cover.

Class VIII. Soils and landforms that have limitations that preclude their use for commercial plant production without major reclamation and restrict their use to recreation, wildlife water supply, or aesthetic purposes. (None in Sac County.)

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 shows that the main limitation is risk of erosion; *w* shows that water on or in the soil interferes with plant growth or cultivation; *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in some parts of the United States, but not in Sac County, 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, range, woodland, wildlife habitat, or recreation.

CAPABILITY UNITS are soil groups with 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–3. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitations; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

Management of soils by capability units

On the following pages the capability units, or groups of soils that have similar management requirements, are described. Some limitations are given, and suitable management is briefly discussed. To find the names of all soils in any given capability unit, refer to the "Guide to Mapping Units" at the back of the sur-

vey. The groupings of soils shown in this guide are subject to change as new methods are discovered or new information becomes available.

CAPABILITY UNIT I–1

This unit consists of nearly level or gently sloping, well drained and somewhat poorly drained soils mainly on uplands and stream benches. Slopes are 0 to 3 percent. The surface layer is loam or silty clay loam. The subsoil is dominantly loam, silty clay loam, clay loam, or sandy clay loam. Some soils have silty clay layers or a layer of loamy sand in the subsoil. Permeability is mainly moderately rapid, moderate, moderately slow, or slow, but in the substratum of some soils it is very rapid or rapid. Available water capacity is moderate to high. The organic matter content of the surface layer is moderate to high. The rooting zone is generally deep, but soils that have a sand and gravel substratum have a restricted rooting zone. Available phosphorus is generally very low or low in the surface layer and very low in the subsoil. Available potassium is medium or high in the surface layer of the soils that formed in loess, but it is low or medium in the surface layer of the soils that formed in glacial drift. Available potassium is very low or low in the subsoil. The reaction of the surface layer is slightly acid to neutral.

These soils are used mainly for cultivated crops. They are well suited to row crops. Lime and fertilizer are beneficial on cultivated crops and forage crops.

Row crops can be grown often on these soils. Tile drainage is beneficial on some of the soils that are adjacent to poorly drained and very poorly drained soils. Grassed waterways are used in places, especially on the soils that receive runoff from adjoining soils. Minimum tillage or contour farming, or both, are desirable practices, especially on long slopes that have a significant amount of runoff. A cropping system that includes oats or meadow improves tilth and helps control weeds and insects. Plowing in fall increases the hazard of soil blowing, but soil loss can be reduced by leaving a rough plowed surface and alternating plowed and unplowed strips. Chisel plowing, which leaves crop residue on the surface, greatly reduces soil blowing.

CAPABILITY UNIT IIe–1

This unit consists of gently sloping, well drained to somewhat poorly drained soils mainly on uplands, stream benches, and bottom land. Slopes are mostly 2 to 5 percent but range to as much as 7 percent in places. The surface layer is loam, silty clay loam, or silt loam. The subsoil is loam, silty clay loam, silt loam, clay loam, or sandy clay loam. Permeability is moderate or moderately rapid, and available water capacity is moderate or high. This unit includes some soils that have a substratum of sand and gravel that reduces available water capacity. The organic matter content is generally moderate to high but ranges to low. The rooting zone is generally deep, but it is restricted in the soils that have underlying sand and gravel. Available phosphorus is medium to low in both the surface layer and the subsoil. Available potassium is medium to high in the surface layer of the soils that formed in loess or in loess-derived alluvium, and it is low to medium in the surface layer of the soils that formed in glacial material. Available potassium is low to very low in the subsoil. The reaction of the surface layer is slightly acid to neutral.

These soils are used mainly for cultivated crops, but many soils on bottom lands are used for permanent pasture because they are in long, narrow areas adjacent to steeply sloping soils that are poorly suited to row crops. All the soils in this unit are well suited to row crops and are moderately susceptible to erosion.

Row crops can be grown often if the soils are adequately protected against erosion. Conservation practices such as terracing, contour farming, and minimum tillage reduce erosion. Good tilth generally can be maintained by returning all crop residue to the soil. A cropping system that includes oats and meadow helps control weeds and insects. Where cuts for terraces expose the subsoil, fertility and tilth generally can be restored in a few years by spreading a layer of topsoil, large amounts of crop residue, and manure over the cuts. Where they expose the firm subsoil, larger amounts of crop residue and a longer time are required to restore good tilth to these areas. Building terraces on the soils that formed in glacial deposits is difficult because the slopes are generally irregular. Diversion terraces are needed in places to protect the soils on bottom lands from runoff. Grassed waterways are needed in places that receive runoff from adjoining soils. On all soils in this unit, adequate erosion control is needed for intensive production of corn and soybeans.

CAPABILITY UNIT IIe–2

This unit consists of gently sloping, well drained soils on uplands and benches. Slopes are 2 to 5 percent. The surface layer is loam. The subsoil is mainly loam or sandy clay loam, but some soils are loamy fine sand in the lower part of the subsoil. Permeability is moderately rapid or moderate in the upper part of the profile and very rapid or rapid in the substratum. Available water capacity is moderate. The organic matter content of the surface layer is generally moderate. Depth of the rooting zone is restricted by sand and gravel. Available phosphorus is very low or low in the surface layer and very low in the subsoil. Available potassium is very low or low in the surface layer and subsoil. The reaction of the surface layer is slightly acid to neutral.

These soils are used mainly for cultivated crops. Lime and fertilizer are beneficial for improved crop production. These soils have a friable surface layer and are easy to work, but they are moderately susceptible to both droughtiness and erosion.

Row crops can be grown often if the soils are adequately protected against erosion. Conservation practices such as terracing, contour farming, and minimum tillage reduce erosion and conserve moisture. However, terraces are not practical in many areas because of the underlying sand and gravel. A cropping system that includes oats and meadow helps maintain good tilth and helps control weeds and insects. In building terraces, deep cuts should be avoided because of the sandy or gravelly underlying material.

CAPABILITY UNIT IIw–1

This unit consists of nearly level and gently sloping

soils mainly on uplands and benches. These soils are mostly poorly drained and somewhat poorly drained, but they range from moderately well drained to very poorly drained. Slopes are 0 to 5 percent. The surface layer is silty clay loam, clay loam, silt loam, or loam. The subsoil is silty clay loam, silty clay, clay loam, sandy clay loam, sandy loam, silt loam, or loam. Permeability is mainly moderate to moderately slow, but it is rapid in the soils that have a sand and gravel substratum. Available water capacity is high or moderate. The organic matter content of the surface layer is high to moderate. The rooting zone is mainly deep, but it is restricted in the soils that have a sand and gravel substratum. Available phosphorus is generally very low to medium in the surface layer and very low or low in the subsoil. Available potassium is very low to medium in the surface layer and very low or low in the subsoil. The reaction of the surface layer is generally slightly acid to moderately alkaline.

These soils are used mainly for cultivated crops. They are well suited to row crops. Fertilizers are beneficial on soils used for cultivated crops and forage crops. These soils are fairly easy to till, but if tilled when wet, they are likely to become hard and cloddy upon drying.

Row crops can be grown often if the soils are adequately drained. Freezing, thawing, wetting, and drying of these soils improve tilth. Better seedbeds can be prepared by plowing in fall, but this makes the soils susceptible to erosion and soil blowing. The erosion and soil blowing can be reduced by plowing in spring, leaving the surface unprotected as briefly as possible, and using tillage methods that leave residue on the surface. A cropping system that includes grasses and legumes improves tilth and helps control weeds and insects. Grassed waterways are needed in places. Tile drains function well in these soils except for a few places where suitable outlets are not available. Tile drainage helps to remove excess moisture, aerates the soils, and provides a deep rooting zone.

CAPABILITY UNIT IIw–2

This unit consists of nearly level, moderately well drained to poorly drained soils on bottom lands. Slopes are 0 to 2 percent. The surface layer is loam, silty clay, silty clay loam, or silt loam. The subsoil is silty clay loam, silty clay, clay loam, sandy clay loam, or loam. Permeability is moderate to slow, and available water capacity is high. The organic matter content of the surface layer is high in most of the soils but ranges to moderate in others. The rooting zone is deep. Available phosphorus and potassium in the surface layer are high in some of the soils, but available phosphorus is very low and available potassium is low or medium in the calcareous soils and in the surface layer of the finer textured soils. Available phosphorus is medium or low in the subsoil. Available potassium is medium to very low in the subsoil. The reaction of the surface layer is mainly slightly acid to neutral, but the calcareous soils are moderately alkaline.

These soils are used mainly for cultivated crops. They are well suited to row crops if drainage is adequate and if flooding is controlled. Lime and fertilizer are beneficial on the soils used for cultivated crops and forage crops. The soils in this unit have a seasonal high water table and a moderate wetness limitation.

Row crops can be grown often if the soils are adequately drained. These soils are generally plowed in fall because wetness may delay plowing in spring. Freezing, thawing, wetting, and drying of the areas that are plowed in fall improve tilth. Better seedbeds can be prepared by plowing in fall, but the soils are subject to soil blowing. Soil blowing can be reduced by leaving a rough plowed surface and alternating plowed and unplowed strips. Chisel plowing, which leaves crop residue on the surface, also reduces soil blowing. A cropping system that includes oats and meadow improves tilth and helps control weeds and insects. Grassed waterways are needed in places for erosion protection. Tile drainage systems are commonly used, but they function slowly in the finer textured soils. Outlets are difficult to establish in places. Surface drainage is used in places.

CAPABILITY UNIT IIs–1

This unit consists of nearly level, well drained to somewhat poorly drained soils in glacial outwash areas and on stream terraces. Slopes are 0 to 2 percent. The surface layer is loam. The subsoil is dominantly loam, clay loam, or sandy clay loam. These soils have sand and gravel at a depth of 24 to 32 inches. Permeability is moderate or moderately rapid above the sand and gravel and rapid to very rapid in the sand and gravel. Available water capacity is moderate. The organic matter content of the surface layer is moderate to high. Available phosphorus is very low in the surface layer and subsoil. The reaction of the surface layer is slightly acid to neutral.

These soils are used mainly for cultivated crops. They are well suited to corn, soybeans, small grain, and alfalfa. They are moderately susceptible to droughtiness.

Row crops can be grown often on these soils. Minimum tillage and, where slopes are steep enough, contour farming are practices that help to conserve moisture. A cropping system that includes oats and meadow improves tilth and helps control weeds and insects. Plowing in the fall increases the hazard of soil blowing, but soil loss can be reduced by leaving a rough plowed surface and alternating plowed and unplowed strips. Chisel plowing, which leaves crop residue on the surface, reduces soil blowing and helps to conserve moisture.

CAPABILITY UNIT IIIe–1

This unit consists of moderately sloping, moderately well drained to somewhat excessively drained soils on uplands and benches. Slopes are 3 to 9 percent. The surface layer is silty clay loam, clay loam, or loam. The subsoil is silty clay loam, clay loam, or loam. Permeability is moderate to moderately slow, and available water capacity is high. The organic matter content of the surface layer is high to low, depending partly on the extent of erosion. The rooting zone is deep in all of these soils. Available phosphorus is very low to medium in the surface layer and low or very low in the subsoil. Available potassium is medium to high in the surface layer of the soils that formed in loess or loess-derived alluvium, and it is medium to low in the surface layer of the soils that formed in glacial material. Avail-

able potassium is mainly very low in the subsoil, but it is high in the soils that formed in glacial till. The reaction of the surface layer is generally slightly acid to neutral, but in the calcareous soils the surface layer is moderately alkaline.

These soils are used for cultivated crops and pasture. They are moderately well suited to row crops. Lime and fertilizer are beneficial on the soils used for cultivated crops and forages. The soils in this unit have a friable surface layer and are highly susceptible to erosion.

Row crops can be grown on these soils if the soils are adequately protected against erosion. Conservation practices such as terracing, farming on the contour, and minimum tillage reduce erosion. Cropping systems that include small grain and meadow are needed to control erosion where terraces are not used. Terraces can be built and farmed easily on the soils that formed in loess because they have long, uniform slopes. Some of the soils that formed in glacial till have short, irregular slopes, so building terraces on these soils is more difficult. Where cuts for terraces expose the subsoil, special practices must be used to restore fertility and tilth. Diversion terraces are needed in places to protect the soils on foot slopes from runoff. In places, grassed waterways are needed to protect the soils against erosion. When row crops are grown on the moderately sloping soils, erosion control practices are necessary. Maintaining good tilth usually is not difficult on these soils.

CAPABILITY UNIT IIIe-2

This unit consists of strongly sloping, well drained and somewhat excessively drained soils on uplands. Slopes are 9 to 14 percent. The surface layer is silty clay loam, silt loam, clay loam, or loam. The subsoil is silt loam, silty clay loam, clay loam, or loam. Permeability is moderate to moderately slow, and available water capacity is high. The organic matter content of the surface layer is moderate to low. Rooting zone is deep. Available phosphorus is very low in the subsoil. Available potassium is medium to high in the surface layer of the soils that formed in loess, and it is medium to low in the soils that formed in glacial till. Available potassium is mainly very low to low in the subsoil, but it is high in one soil. The reaction of the surface layer is mainly slightly acid to neutral, but it is moderately alkaline in some soils.

These soils are used for corn, soybeans, oats, alfalfa, and pasture. They are moderately suited to row crops. These soils are highly susceptible to erosion.

Row crops can be grown if the soils are adequately protected against erosion. Conservation practices such as terracing, contour farming, and minimum tillage help to reduce erosion. Building terraces on these soils is very difficult in places because of short, irregular slopes. Grassed waterways are needed in places to protect the soils against runoff and erosion.

CAPABILITY UNIT IIIe-3

This unit consists of gently sloping to moderately sloping, well drained to somewhat excessively drained soils on uplands and benches. Slopes are 2 to 9 percent. The surface layer is loam or sandy loam. The subsoil is loam, sandy loam, fine sandy loam, or sandy clay loam. The substratum is sand or gravel. Permeability is moderate to moderately rapid and rapid or very rapid in the substratum. Available water capacity is moderate to low. The organic matter content of the surface layer is moderate to low. Available phosphorus and potassium are generally low to very low in the surface layer and subsoil. The reaction of the surface layer is medium acid to neutral.

These soils are used for crops and pasture. Fertilizer is beneficial on the soils used for cultivated crops and forage crops; however, applying fertilizer in large amounts is not suitable for these droughty soils. These soils are friable and are easy to till. They are highly susceptible to droughtiness, water erosion, and soil blowing.

Row crops can be grown if the soils are adequately protected against erosion. Conservation practices such as contour tillage and minimum tillage help to reduce erosion and conserve moisture. A cropping system that includes a large proportion of small grain and meadow can also be used in controlling erosion. These soils are not well suited to terraces, because of the underlying sand or gravel. If terraces are built, deep cuts that expose sand and gravel at the surface should be avoided.

CAPABILITY UNIT IIIw-1

This unit consists of very poorly drained and poorly drained soils in potholes or in depressions. Slopes are 0 to 1 percent. The surface layer is silty clay loam, silty clay, loam, or muck. The subsoil is silty clay loam, silty clay, clay loam, or clay. Permeability is moderate to slow, and available water capacity is high. The organic matter content of the surface layer is generally high, but it is moderate in one soil. The rooting zone is mainly deep, but root growth is often restricted by a seasonal high water table. Available phosphorus and potassium are very low to low in the subsoil. The reaction of the surface layer is moderately alkaline to medium acid.

These soils are used for cultivated crops if drainage is adequate and they are suited to this use. If not drained, they are generally used for pasture. Small undrained areas within large cultivated areas are left idle in most years and provide habitat for aquatic wildlife. Fertilizer is beneficial on soils used for cultivated crops and forage crops. The soils on depressions often become ponded after rain or from runoff in spring. They also have a seasonal high water table. They are normally too wet to cultivate unless artificially drained.

Row crops can be grown often if the soils are adequately drained. Tile drains, shallow ditches, and open inlets leading to tile lines are commonly used for quick removal of surface water. Tile drains are only fairly effective on the slowly permeable soils.

Maintaining a good drainage system is important because it lowers the water table enough to provide a deep rooting zone for plants. Many small areas of these soils are artificially drained so that they can be farmed with large areas of soils that are well suited to row crops. If these small areas are not drained, field operations are delayed or the soils are not farmed.

CAPABILITY UNIT IVe–1

This unit consists of moderately steep, well drained and somewhat excessively drained soils. Slopes are 14 to 20 percent. The surface layer is silt loam or loam. The underlying material is silt loam, silty clay loam, or loam. Permeability is moderate, and available water capacity is high. The organic matter content of the surface layer is moderate to low. The rooting zone is deep. Available phosphorus is very low to low in the surface layer and underlying material. Available potassium is medium to high in the surface layer of the soils that formed in loess, and it is low in the soils that formed in glacial till. Available potassium is very low in the subsoil. The reaction of the surface layer is slightly acid to moderately alkaline.

These soils are used for pasture and cultivated crops. They are moderately suited to row crops. The calcareous soils have a high content of lime. Fertilizer is beneficial on the soils used for forage crops and cultivated crops. These soils are highly susceptible to erosion.

Row crops can be grown if the soils are adequately protected against erosion. Using conservation practices such as terracing, contour farming, grassed waterways, and minimum tillage helps to reduce erosion (fig. 6). However, these conservation practices alone are seldom adequate for preventing runoff and erosion; a cropping system that includes hay and pasture is also needed.

Building terraces on these soils is very difficult because of the moderately steep, short, irregular slopes. In a commonly used cropping system, corn is grown on the contour for a year and then the soil is reseeded to meadow or pasture that is not renovated until the stand becomes thin.

CAPABILITY UNIT IVe–2

This unit consists of well drained to excessively drained, strongly sloping and moderately sloping soils. Most of these soils are on convex side slopes. Slopes are 5 to 14 percent. The surface layer is loam or gravelly loamy sand. The subsoil is loam, loamy fine sand, or gravelly sand. Permeability is moderate to very rapid in the upper part of these soils and rapid or very rapid in the underlying material. Available water capacity is moderate to low. The organic matter content of the surface layer is moderate to low. The rooting zone is restricted by sand and gravel. Available phosphorus and potassium in the surface layer and subsoil are low to very low. The reaction of the surface layer is slightly acid to mildly alkaline.

Many areas of these soils are used for cultivated

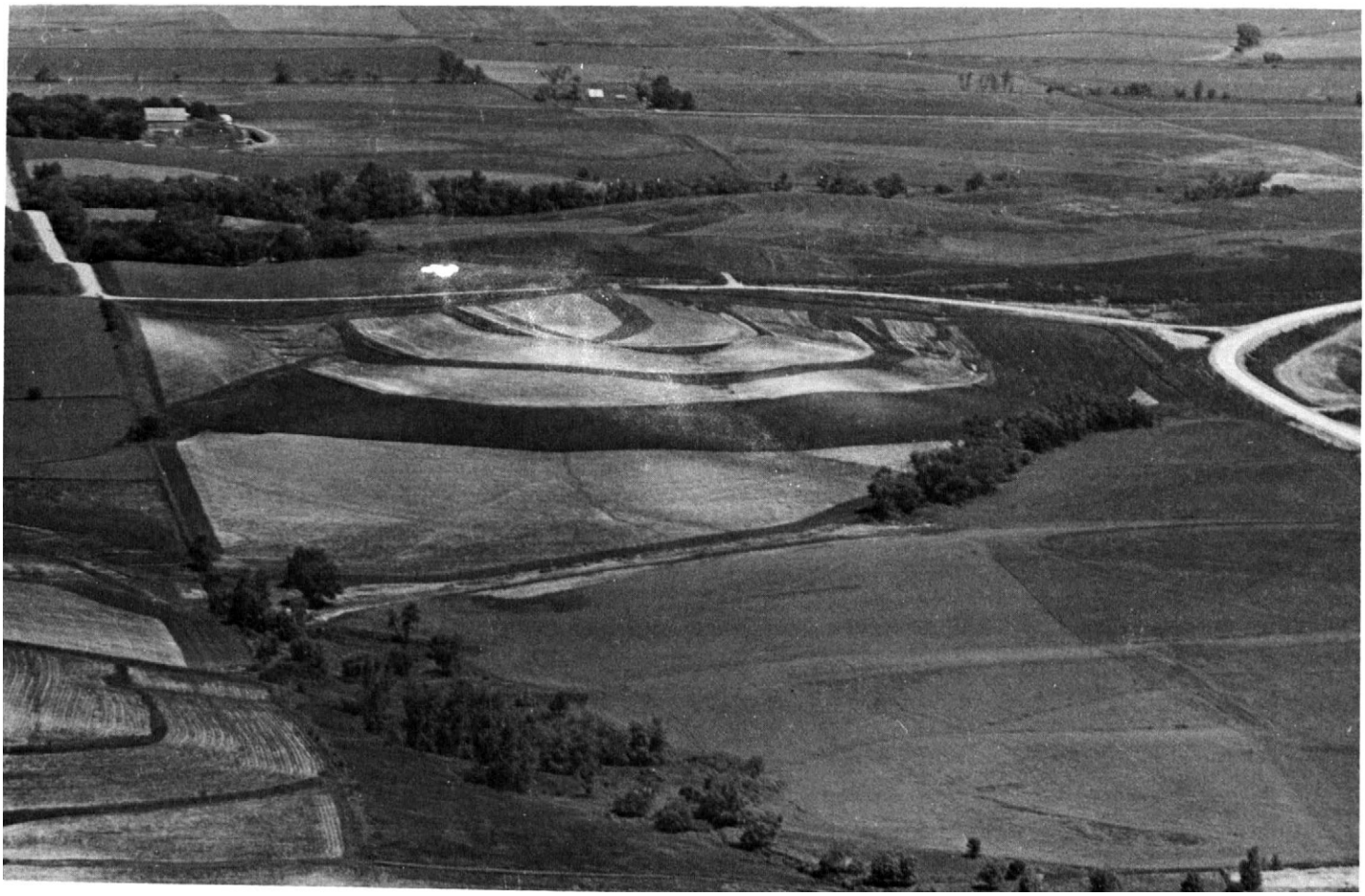

Figure 6.—Conservation practices on Monona and Ida soils in capability unit IVe–1. Marshall soils are in the less sloping areas, and Kennebec and Ackmore soils are in the drainageways.

crops, but most areas are used for hay and pasture. Some areas are in permanent pasture. These soils are well suited to hay and pasture.

A row crop is commonly grown when stands of legumes and grasses become poor and need to be plowed and reseeded. These soils are susceptible to severe sheet and gully erosion. Contour tillage and minimum tillage are practices used to control erosion. Terraces are not well suited, because of the coarse texture of the underlying material. Where terraces are built, it is important to make cuts as shallow as possible. Also, heavy applications of fertilizers and manure are needed on the disturbed areas to help plant growth. Organic matter in the form of crop residue, barnyard manure, or plowed-under green manure improves available water capacity and increases fertility.

CAPABILITY UNIT Vw-1

This unit consists of nearly level and gently sloping soils, most of which are moderately well drained to poorly drained. These soils are in drainageways and on bottom lands that are dissected by stream channels. They are frequently flooded. Slopes are 0 to 5 percent. These soils have a wide range of properties because they formed in mixed alluvium. The ranges that follow are the dominant ones for the soils in this unit. The surface layer and subsoil are silty clay loam, loam, clay loam, and silt loam. Permeability is moderately slow or moderate, and available water capacity is high. The organic matter content of the surface layer is moderate to high. Available phosphorus and potassium in the surface layer and subsoil are low to medium. The reaction of the surface layer is slightly acid to neutral.

These soils are mainly used for pasture. They are cut by stream channels or are frequently flooded, or both; thus, they are seldom cultivated. Pastures are generally unimproved and commonly contain trees and brush. Most wooded areas have poor stands and are commonly grazed.

A few areas are used for wildlife habitat and for recreation. These soils are poorly suited to row crops. However, many areas are suitable for improved pastures. Lime is needed on some of the soils, and fertilizers are beneficial on pastures. These soils are normally too wet for cultivation. Many areas are inaccessible with farm machinery because the channels are not crossable.

Reed canarygrass, birdsfoot trefoil, or a mixture of birdsfoot trefoil and bluegrass provides excellent pasture on these soils where flooding is not too severe. It is practical to fence livestock out of some wooded areas and manage these areas as woodland. If areas are to be developed for wildlife habitat, a mixed stand of conifers, hardwood trees, shrubs, sedges, and grasses that tolerate wetness and flooding can be planted (fig. 7).

CAPABILITY UNIT VIe-1

This unit consists of moderately sloping to steep, moderately well drained to somewhat excessively drained soils on uplands. Slopes are 9 to 40 percent. The surface layer and subsoil are clay loam, loam, and silt loam. Permeability is moderate to moderately slow. Available water capacity is high, but the amount of moisture absorbed generally is low because of the rapid runoff. The organic matter content in the surface layer is moderate to low. Available phosphorus is low or very low in the surface layer and subsoil. Available potassium is mainly low to medium in the surface layer, but it is high in the soils that formed in loess. Available potassium is low to very low in the subsoil of the calcareous soils and high in the soils that are leached of lime. The reaction of the surface layer is slightly acid to moderately alkaline.

Most areas are in pasture, and many of these have been used for cultivated crops. Some areas are planted to row crops, especially small areas adjacent to soils that are better suited to cultivation. The soils in this unit are not generally suited to row crops because of the steepness of slope, the hazard of erosion, and low fertility. Poor tilth is also a management concern on some of the soils.

In many areas it is feasible to operate farm machinery for renovation of pasture and for seeding of grasses and legumes to improve carrying capacity. A few areas are too rocky to prepare a seedbed. Grazing control is an important management practice that increases productivity and limits further erosion. Alfalfa and bromegrass are among the plants generally used in pasture renovation.

CAPABILITY UNIT VIs-1

Sparta loamy fine sand, 5 to 14 percent slopes, is the only soil in this unit. This excessively drained, moderately eroded soil is on uplands and has a surface layer of loamy fine sand. The subsoil is sand. Permeability is very rapid, and available water capacity is low. The organic matter content is moderately low to low. Available phosphorus and potassium are low or very low in the surface layer and very low in the subsoil. The reaction of the surface layer is medium acid.

Many areas of this soil are small and are planted to cultivated crops with areas of soils that are better suited to cultivation. Other areas are used for hay or pasture because the hazards of drought, water erosion, and soil blowing make this soil generally unsuitable for row crops. If the soil is used for pasture, grazing control is important to maintain a vegetative cover. Tillage that leaves crop residue on the surface or additions of straw manure or other mulches are generally beneficial and help to prevent erosion and damage to new seedings from blowing sand. Terraces built on this soil are not stable. Terracing the soils that are upslope from this soil helps to reduce runoff and the hazard of erosion. Conservation practices such as contour farming and minimum tillage help to reduce erosion and conserve moisture.

CAPABILITY UNIT VIIe-1

Storden loam, 25 to 40 percent slopes, is the only soil in this unit. This excessively drained soil is on uplands and has a surface layer and subsoil of loam. Permeability is moderate, and available water capacity is high. Because of rapid runoff, the amount of moisture that percolates into the soil is generally low. The organic matter content of the surface layer is low. Available phosphorus and potassium in both the surface layer and subsoil are low. The reaction of the surface layer is moderately alkaline.

Almost all areas of this soil are used for pasture.

Figure 7.—**Alluvial land along the Raccoon River typically supports scattered trees and brush. Alluvial land is in capability unit Vw–1.**

Some areas have stands of trees. Steep slopes limit the use of this soil. Gullies are a hazard in places. This soil is suited to permanent pasture, woodland, wildlife habitat, or recreational uses. Because of the steep, irregular slopes and the gullies, the use of farm machinery to renovate pastures is impractical. Fertilizers, especially phosphates, are beneficial in the areas used for native prairie grass pasture, which grows poorly without some additional nutrients.

Controlled grazing and weed and brush control are needed on the permanent pastures to maintain a good stand. The areas used for woodland require protection from grazing by livestock. Also, the cutting of the undesirable trees is needed to improve the stands.

CAPABILITY UNIT VIIw–1

This unit consists of only Marsh, which is covered by water much of the time. These areas are unsuitable for most types of farming because of very poor drainage. Willows, cattails, rushes, sedges, and other water-tolerant plants grow well in these areas. The Marsh areas provide food and cover for waterfowl, muskrats, and upland game. The potential for wildlife habitat in these areas can be improved by using management that maintains a constant water level.

Windbreaks and environmental plantings

Windbreaks are established to protect livestock, buildings, and yards from wind and snow. Windbreaks also help protect fruit trees and gardens, and they furnish habitat for wildlife. Several rows of both broadleaf and coniferous species provide protection against wind.

Field windbreaks are narrow plantings made at right angles to the prevailing wind. They are at specific intervals across the field, depending on the erodibility of the soil. They protect the soil and the crops from wind, and they hold snow on the fields.

Environmental plantings help to beautify and screen homes and other buildings and help to lessen the noise level. The plants, mostly evergreen shrubs and trees, are closely spaced. If a healthy stock of suitable species is planted properly on a well prepared site and maintained in good condition, the plants have a high degree of survival.

Table 3 shows the height that locally adapted trees and shrubs are expected to reach on various kinds of soils in 20 years. The estimates in table 3, based on measurements and observation of established plantings that have been given adequate care, can be used as a guide in planning windbreaks and screens. Addi-

TABLE 3.—*Windbreaks and environmental plantings*

[Absence of an entry means soil does not normally support trees of this height class]

Map symbol and soil name	Trees and shrubs having predicted 20-year average heights, in feet, of—				
	Less than 8	8 to 15	16 to 25	26 to 35	More than 35
1D3, 1E3, 1F3: Ida	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, Norway spruce, white spruce, European larch, eastern redcedar, hackberry, Douglas-fir.	Eastern white pine, red pine, Scotch pine, silver maple.	Green ash, eastern cottonwood.
5B:					
Kennebec part	Arrowwood, mockorange.	Siberian peashrub, American plum, lilac.	Red pine, eastern redcedar, Russian-olive.	Scotch pine, eastern white pine, blue spruce.	Green ash, eastern cottonwood, white ash.
Ackmore part	Silky dogwood, arrowwood.	Lilac, forsythia	Blue spruce, Norway spruce, white spruce, eastern redcedar, Douglas-fir.	Eastern white pine, red pine, Scotch pine, European larch, hackberry.	Green ash, eastern cottonwood.
C5B:					
Kennebec part	Arrowwood, mockorange.	Siberian peashrub, American plum, lilac.	Red pine, eastern redcedar, Russian-olive.	Scotch pine, eastern white pine, blue spruce.	Green ash, eastern cottonwood, white ash.
Ackmore part	Silky dogwood, arrowwood.	Lilac, forsythia	Blue spruce, Norway spruce, white spruce, eastern redcedar, Douglas-fir.	Eastern white pine, red pine, Scotch pine, European larch, hackberry.	Green ash, eastern cottonwood.
6: Okoboji	Silky dogwood, American cranberrybush.	Northern white-cedar.	Hackberry, eastern redcedar, white spruce, Norway spruce.	Silver maple, poplar, laurel willow, American sycamore, green ash.	Eastern cottonwood.
8C: Judson	Arrowwood, mockorange.	Tatarian honeysuckle, lilac.	Red pine, blue spruce, Norway spruce, eastern redcedar, Douglas-fir.	Eastern white pine, Scotch pine, European larch.	Green ash, eastern cottonwood.
9B, 9B2, 9C, 9C2, 9D2, 9D3: Marshall	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, Norway spruce, white spruce, eastern redcedar, Douglas-fir.	Eastern white pine, red pine, Scotch pine, silver maple.	Green ash, eastern cottonwood.
10D3, 10E3: Monona	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, Norway spruce, white spruce, eastern redcedar, hackberry.	Eastern white pine, red pine, Scotch pine, silver maple, Douglas-fir.	Green ash, eastern cottonwood.
11B:					
Colo part	Silky dogwood, American cranberrybush.	Lilac, American plum.	Hackberry, eastern redcedar, white spruce, Norway spruce.	Silver maple, laurel willow, American sycamore, poplar.	Green ash, eastern cottonwood.
Ely part	Arrowwood, mockorange.	Lilac, forsythia	Norway spruce, hackberry.	Eastern white pine, Scotch pine, red pine.	Green ash, eastern cottonwood.

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Map symbol and soil name	Trees and shrubs having predicted 20-year average heights, in feet, of—				
	Less than 8	8 to 15	16 to 25	26 to 35	More than 35
24C2, 24D2, 24E2: Shelby	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, Norway spruce, white spruce, eastern redcedar, hackberry, Douglas-fir.	Eastern white pine, red pine, Scotch pine.	Green ash, eastern cottonwood.
26B: Kennebec	Arrowwood, mockorange.	Siberian peashrub, American plum, lilac.	Red pine, eastern redcedar.	Scotch pine, eastern white pine, blue spruce.	Green ash, eastern cottonwood.
27C: Terril	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, eastern redcedar, Douglas-fir.	Eastern white pine, red pine, Scotch pine, silver maple.	Green ash, eastern cottonwood.
31: Afton	Silky dogwood, American cranberrybush.	Northern white-cedar.	Eastern redcedar, white spruce, Norway spruce.	Silver maple, poplar, laurel willow, American sycamore, green ash, hackberry, northern white-cedar.	Eastern cottonwood.
33E, 33F: Steinauer	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Eastern redcedar, Russian-olive.	Ponderosa pine, Austrian pine, Scotch pine.	Green ash, eastern cottonwood.
41D: Sparta	Gray dogwood, Peking cotoneaster.	Eastern redcedar, lilac, Siberian peashrub.	Norway spruce	Red pine, eastern white pine, jack pine.	Green ash, eastern cottonwood.
54: Zook	Silky dogwood, American cranberrybush.	Northern white-cedar.	Hackberry, eastern redcedar, white spruce.	Green ash, silver maple.	Eastern cottonwood.
55: Nicollet	Arrowwood, mockorange.	Gray dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, Siberian crabapple, Amur maple, eastern redcedar.	Red pine, eastern white pine, green ash, hackberry.	Eastern cottonwood.
62C, 62D, 62E, 62F, 62G: Storden	European cotoneaster, mockorange.	Tall purple willow, Tatarian honeysuckle, Siberian peashrub, northern whitecedar.	Eastern redcedar, white spruce.	Green ash, Russian-olive, golden willow.	Eastern cottonwood.
73C, 73D: Salida	Gray dogwood, Peking cotoneaster.	Eastern redcedar, northern white-cedar, Russian-olive, Tatarian honeysuckle.	Hackberry, bur oak, red pine.	Green ash, eastern cottonwood.	

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Map symbol and soil name	Trees and shrubs having predicted 20-year average heights, in feet, of—				
	Less than 8	8 to 15	16 to 25	26 to 35	More than 35
77B, 77B2, 77C, 77C2, 78B, 78B2, 78C, 78C2: Sac	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, Norway spruce, white spruce, European larch, eastern redcedar, hackberry, Douglas-fir.	Eastern white pine, red pine, Scotch pine, silver maple.	Green ash, eastern cottonwood.
91: Primghar	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, Norway spruce, white spruce, eastern redcedar, hackberry.	Eastern white pine, red pine, Scotch pine, silver maple, Douglas-fir.	Green ash, eastern cottonwood.
92: Marcus	Silky dogwood, American cranberrybush.	Northern white-cedar.	Hackberry, eastern redcedar, white spruce, Norway spruce.	Silver maple, poplar, laurel willow, American sycamore, green ash.	Eastern cottonwood.
95: Harps	Silky dogwood, American cranberrybush.	Northern white cedar.	Hackberry, eastern redcedar, white spruce, Norway spruce.	Silver maple, poplar, laurel willow, American sycamore, green ash.	Eastern cottonwood.
107: Webster	Silky dogwood, American cranberrybush.	Northern white-cedar.	Eastern redcedar, hackberry, white spruce.	Green ash, silver maple, American sycamore.	Eastern cottonwood.
108, 108B, 108C2: Wadena	European cotoneaster, mockorange.	Siberian crabapple, gray dogwood, Tatarian honeysuckle, lilac.	Eastern redcedar, northern white-cedar, white spruce, red pine, hackberry, bur oak.	Green ash	Eastern cottonwood.
133: Colo	Silky dogwood, American cranberrybush.	Northern white-cedar.	Hackberry, eastern redcedar, white spruce, Norway spruce.	Silver maple, laurel willow, American sycamore, poplar.	Green ash, eastern cottonwood.
134: Zook	Silky dogwood, American cranberrybush.	Northern white-cedar.	Eastern redcedar, hackberry, white spruce.	Green ash, silver maple.	Eastern cottonwood.
135, 135B: Coland	Silky dogwood, American cranberrybush.	Northern white-cedar.	Northern white-cedar, eastern redcedar, white spruce, Norway spruce.	Silver maple, poplar, laurel willow, American sycamore, green ash, hackberry.	Green ash, eastern cottonwood.
138B, 138C, 138C2, 138D2: Clarion	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, Norway spruce, white spruce, eastern redcedar, Douglas-fir.	Eastern white pine, red pine, Scotch pine, European larch, hackberry, silver maple.	Green ash, eastern cottonwood.

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Map symbol and soil name	Trees and shrubs having predicted 20-year average heights, in feet, of—				
	Less than 8	8 to 15	16 to 25	26 to 35	More than 35
174B, 174C2, 174D2: Bolan	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, Norway spruce, white spruce, eastern redcedar, Douglas-fir.	Eastern white pine, red pine, Scotch pine, European larch, silver maple.	Green ash, eastern cottonwood.
201B: Coland part	Silky dogwood, American cranberrybush.	Northern white-cedar.	Northern white-cedar, eastern redcedar, white spruce, Norway spruce.	Silver maple, poplar, laurel willow, American sycamore, green ash, hackberry.	Eastern cottonwood, green ash.
Spillville part	Arrowwood, mockorange.	Siberian peashrub, American plum.	Red pine, Norway spruce, hackberry, European larch, eastern redcedar.	Eastern white pine, Scotch pine.	Green ash, eastern cottonwood.
C201B: Coland part	Silky dogwood, American cranberrybush.	Northern white-cedar.	Northern white-cedar, eastern redcedar, white spruce, Norway spruce.	Silver maple, poplar, laurel willow, American sycamore, green ash, hackberry.	Green ash, eastern cottonwood.
Spillville part	Arrowwood, mockorange.	Siberian peashrub, American plum.	Red pine, Norway spruce, hackberry, European larch, eastern redcedar.	Eastern white pine, Scotch pine.	Green ash, eastern cottonwood.
202,203: Cylinder	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, European larch, eastern redcedar, hackberry, Douglas-fir.	Eastern white pine, red pine, Norway spruce, Scotch pine, white spruce, silver maple.	Green ash, eastern cottonwood.
221: Palms	Silky dogwood, American cranberrybush.	Tatarian honeysuckle.	Laurel willow, Austrian pine.	Northern white-cedar, eastern white pine, Norway spruce.	Eastern cottonwood, American sycamore.
234: Nishna	Silky dogwood, American cranberrybush.	Northern white-cedar.	Hackberry, eastern redcedar, white spruce, Norway spruce.	Silver maple, poplar, laurel willow, American sycamore, green ash.	Eastern cottonwood.
236B: Lester	European cotoneaster, mockorange.	Gray dogwood, Tatarian honeysuckle, lilac.	Siberian crabapple, Amur maple.	Eastern white pine, green ash, hackberry.	Eastern cottonwood, American elm.
259: Biscay	Silky dogwood, American cranberrybush.	Northern white-cedar, lilac.	White spruce, Amur maple.	Silver maple, golden willow.	Eastern cottonwood, green ash.
274: Rolfe	Silky dogwood, American cranberrybush.	Northern white-cedar, lilac.	Hackberry, eastern redcedar, white spruce, Norway spruce.	Silver maple, poplar, laurel willow, American sycamore, green ash.	Eastern cottonwood.

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Map symbol and soil name	Trees and shrubs having predicted 20-year average heights, in feet, of—				
	Less than 8	8 to 15	16 to 25	26 to 35	More than 35
308, 308B: Wadena	European cotoneaster, mockorange.	Siberian crabapple, gray dogwood, Tatarian honeysuckle, lilac.	Eastern redcedar, northern white-cedar, white spruce, red pine, hackberry, bur oak.	Green ash	Eastern cottonwood.
310, 310B, 310B2, 310C, 310C2, T310, T310B: Galva	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, Norway spruce, white spruce, European larch, eastern redcedar, hackberry, Douglas-fir.	Eastern white pine, red pine, Scotch pine, silver maple.	Green ash, eastern cottonwood.
315: Alluvial land	Silky dogwood, American cranberrybush.	Northern white-cedar, lilac.	Blue spruce, Norway spruce, eastern redcedar.	Eastern white pine, European larch, hackberry.	Green ash, eastern cottonwood.
323B: Terril	European cotoneaster, mockorange.	Siberian peashrub, gray dogwood.	Blue spruce, Norway spruce, white spruce, eastern redcedar, hackberry, Douglas-fir.	Eastern white pine, red pine, Scotch pine, silver maple.	Green ash. eastern cottonwood.
325: Le Sueur	European cotoneaster, mockorange.	Gray dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, Siberian crabapple, Amur maple, eastern redcedar.	Red pine, eastern white pine, hackberry.	Eastern cottonwood, green ash.
354: Marsh					
384: Collinwood	European cotoneaster, mockorange.	Gray dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, Siberian crabapple, Amur maple, eastern redcedar.	Red pine, eastern white pine, green ash, hackberry.	Eastern cottonwood.
390: Waldorf	Silky dogwood, American cranberrybush.	Northern white-cedar, lilac, tall purple willow, Tatarian honeysuckle.	White spruce, Amur maple.	Golden willow, silver maple, green ash, black ash.	Eastern cottonwood.
397B: Letri	Silky dogwood, American cranberrybush.	Eastern redcedar, lilac, Amur honeysuckle, northern white-cedar.	Black Hills spruce, eastern white pine, Amur maple.	Laurel willow, green ash, silver maple.	Siberian elm, eastern cottonwood.
428: Ely	Arrowwood, mockorange.	Lilac, forsythia	Norway spruce, hackberry.	Eastern white pine, Scotch pine, red pine.	Green ash, eastern cottonwood.

TABLE 3.—*Windbreaks and environmental plantings*—Continued

Map symbol and soil name	Trees and shrubs having predicted 20-year average heights, in feet, of—				
	Less than 8	8 to 15	16 to 25	26 to 35	More than 35
430, 430B: Ackmore	Silky dogwood, arrowwood.	Lilac, forsythia	Blue spruce, Norway spruce, white spruce, eastern redcedar, Douglas-fir.	Eastern white pine, red pine, Scotch pine, European larch, hackberry.	Green ash, eastern cottonwood.
485, 485B: Spillville	Arrowwood, mockorange.	Lilac, forsythia	Red pine, Norway spruce, hackberry, European larch, eastern redcedar.	Eastern white pine, Scotch pine.	Green ash, eastern cottonwood.
506: Wacousta	Silky dogwood, American cranberrybush.	Redosier dogwood, Siberian peashrub.	Russian-olive, eastern redcedar.	Silver maple, green ash.	Eastern cottonwood.
507: Canisteo	Silky dogwood, American cranberrybush.	Tall purple willow, redosier dogwood, Tatarian honeysuckle, Siberian peashrub.	Russian-olive, eastern redcedar, northern white-cedar.	Green ash, American elm.	Eastern cottonwood, golden willow, Siberian elm.
511: Blue Earth	Silky dogwood, American cranberrybush.	Eastern redcedar, lilac, northern white-cedar.	Laurel willow, Austrian pine.	Eastern white pine, Norway spruce.	Green ash, eastern cottonwood.
559: Talcot	Silky dogwood, American cranberrybush.	Eastern redcedar, lilac, northern white-cedar.	Russian-olive, eastern redcedar.	Green ash, silver maple, American sycamore.	Eastern cottonwood.
577C2, 577D2: Everly	European cotoneaster, mockorange.	Siberian peashrub, Tatarian honeysuckle, lilac.	Blue spruce, European larch, eastern redcedar, hackberry, Douglas-fir.	Eastern white pine, red pine, Norway spruce, Scotch pine, white spruce, silver maple.	Green ash, eastern cottonwood.
606: Lanyon	Silky dogwood, American cranberrybush.	Eastern redcedar, lilac, northern white-cedar.	White spruce, Amur maple.	Silver maple, green ash, American sycamore.	Eastern cottonwood.
733: Calco	Silky dogwood, American cranberrybush.	Redosier dogwood, tall purple willow.	Russian-olive, eastern redcedar.	Green ash, silver maple.	Eastern cottonwood.
823B, 823C2: Flagler	European cotoneaster, mockorange.	Siberian peashrub, Russian-olive.	Eastern redcedar, hackberry, ponderosa pine.	Eastern white pine, red pine, Scotch pine, Austrian pine.	Green ash, eastern cottonwood.

tional information about planning windbreaks and screens and the planting and care of trees can be obtained from the local office of the Soil Conservation Service or the Extension Service.

Engineering[2]

This section provides information about the use of soils for building sites, sanitary facilities, construction materials, and water management. Among those who can benefit from this section are engineers, landowners, community decision makers and planners, town and city managers, land developers, builders, contractors, and farmers.

The ratings in tables in this section are based on test data and estimated data in the "Soil Properties" section. The ratings were determined jointly by soil scientists and engineers of the Soil Conservation Service, using known relationships between the soil properties and the behavior of soils in various engineering uses.

Soil properties and site conditions identified by the soil survey that are used in determining the ratings in this section include grain-size distribution, liquid limit, plasticity index, soil reaction, depth to and hardness of bedrock at a depth of less than 5 or 6 feet, soil wetness characteristics, depth to a seasonal water table, slope, likelihood of flooding, natural soil structure or aggregation, in-place soil density, and geologic origin of the soil material. Where pertinent, data about kinds of clay minerals, mineralogy of sand and silt fractions, and the kind of absorbed cations were also considered.

Based on the information assembled about soil properties, ranges of values may be estimated for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, shear strength, compressibility, slope stability, and other factors of expected soil behavior in engineering uses. As appropriate, these values may be applied to each major horizon of each soil or to the entire profile.

These factors of soil behavior affect construction and maintenance of roads, airport runways, pipelines, foundations for small buildings, ponds and small dams, irrigation projects, drainage systems, sewage and refuse disposal systems, and other engineering works. The ranges of values can be used to—

1. Select potential residential, commercial, industrial, and recreational areas.
2. Make preliminary estimates pertinent to construction in a particular area.
3. Evaluate alternate routes for roads, streets, highways, pipelines, and underground cables.
4. Evaluate alternate sites for location of sanitary landfills, onsite sewage disposal systems, and other waste disposal facilities.
5. Plan detailed onsite investigations of soils and geology.
6. Find sources of gravel, sand, clay, and topsoil.
7. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation.
8. Relate performance of structures already built to properties of the kinds of soil on which they are built. In this way, performance of similar structures on the same or a similar soil in other locations can be predicted.
9. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.

Data presented in this section are useful for land-use planning and for choosing alternative practices or general designs that will overcome unfavorable soil properties and minimize soil-related failures. Limitations to the use of these data, however, should be well understood. The data are generally not presented for soil below a depth of 5 or 6 feet. Also, because of the scale of the detailed map in this soil survey, small areas of soils that differ from the dominant soil may be included in mapping. Thus, these data do not eliminate the need for onsite investigations and testing.

The information is presented mainly in tables. Table 4 shows, for each kind of soil, ratings for the degree and kinds of limitations for building site development; table 5 for sanitary facilities; and table 7 for water management. Table 6 shows the suitability of each soil as a source of construction material.

The information in the tables, the soil map, the soil descriptions, and other data provided in this survey can be used to make additional interpretations and to construct interpretive maps for specific land uses.

Some terms used in this soil survey have different meanings in soil science and in engineering. These and other special terms used in this soil survey are defined in the Glossary at the back of this survey.

Building site development

The degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, and local roads and streets are indicated in table 4. A *slight* limitation indicates that soil properties are favorable for the specified use; limitations are minor and easily overcome. A *moderate* limitation indicates that soil properties and site features are unfavorable for the specified use, but the limitations can be overcome or minimized by special planning and design. A *severe* limitation indicates one or more soil properties or site features are so unfavorable or difficult to overcome that a major increase in construction effort, special design, or intensive maintenance is required. For some soils rated severe, such costly measures may not be feasible.

Shallow excavations are used for pipelines, sewerlines, telephone and power transmission lines, basements, open ditches, and cemeteries. Such digging or trenching is influenced by the soil wetness, a seasonal high water table, the texture and consistence of soils, the tendency of soils to cave in or slough, and the presence of very firm, dense soil layers, bedrock, or large stones. In addition, excavations are affected by slope of the soil and by probability of flooding. Ratings do not apply to soil horizons below a depth of 6 feet unless otherwise noted.

In the soil series descriptions, the consistence of

[2] VOLNEY SMITH, assistant state engineer, Soil Conservation Service, assisted in the preparation of this section.

TABLE 4.—*Building site development*

[Terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry means soil was not rated]

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
1D3: Ida	Moderate: slope	Moderate: slope	Moderate: slope	Severe: slope	Severe: frost action.
1E3, 1F3: Ida	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope, frost action.
5B: Kennebec part	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Severe: floods, frost action, low strength.
Ackmore part	Severe: floods, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell.	Severe: floods, low strength, shrink-swell.
C5B: Kennebec part	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Severe: floods, frost action, low strength.
Ackmore part	Severe: floods, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell.	Severe: floods, low strength, shrink-swell.
6: Okoboji	Severe: wetness	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.
8C: Judson	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: slope, shrink-swell.	Severe: frost action, low strength.
9B, 9B2: Marshall	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength, frost action.
9C, 9C2: Marshall	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength, frost action.
9D2, 9D3: Marshall	Moderate: slope	Moderate: shrink-swell, slope.	Moderate: shrink-swell, slope.	Severe: slope	Severe: low strength, frost action.
10D3: Monona	Moderate: slope	Moderate: low strength, slope, shrink-swell.	Moderate: low strength, slope, shrink-swell.	Severe: slope	Severe: low strength, frost action.
10E3: Monona	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: low strength, slope, frost action.
11B: Colo part	Severe: wetness, floods.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, low strength, frost action.
Ely part	Severe: wetness	Moderate: wetness, shrink-swell, low strength.	Severe: wetness, shrink-swell.	Moderate: wetness, shrink-swell, low strength.	Severe: frost action, low strength.

TABLE 4.—*Building site development*—Continued

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
24C2: Shelby	Moderate: too clayey.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength, slope.	Severe: low strength.
24D2: Shelby	Moderate: slope, too clayey.	Moderate: slope, shrink-swell, low strength.	Moderate: slope, shrink-swell, low strength.	Severe: slope	Severe: low strength.
24E2: Shelby	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: low strength, slope.
26B: Kennebec	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Severe: floods, frost action, low strength.
27C: Terril	Moderate: wetness.	Slight	Moderate: wetness.	Moderate: slope	Moderate: low strength, frost action.
31: Afton	Severe: wetness	Severe: wetness, shrink-swell, floods.	Severe: wetness, shrink-swell, floods.	Severe: wetness, shrink-swell, floods.	Severe: wetness, low strength, shrink-swell.
33E: Steinauer	Moderate: slope, too clayey.	Moderate: slope, shrink-swell, low strength.	Moderate: slope, shrink-swell, low strength.	Severe: slope	Severe: low strength.
33F: Steinauer	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope, low strength.
41D: Sparta	Severe: cutbanks cave.	Moderate: slope	Moderate: slope	Severe: slope	Moderate: slope.
54: Zook	Severe: wetness, floods.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength.
55: Nicollet	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness, shrink-swell.	Moderate: shrink-swell.	Severe: frost action, low strength.
62C, 62D: Storden	Moderate: slope	Moderate: slope	Moderate: slope	Severe: slope	Moderate: slope, frost action.
62E, 62F, 62G: Storden	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
73C: Salida	Severe: cutbanks cave.	Slight	Slight	Moderate: slope	Slight.
73D: Salida	Severe: cutbanks cave.	Moderate: slope	Moderate: slope	Severe: slope	Moderate: slope.
77B, 77B2, 78B, 78B2: Sac	Slight	Moderate: low strength.	Moderate: low strength.	Moderate: low strength.	Severe: low strength, frost action.

TABLE 4.—*Building site development*—Continued

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
77C, 77C2, 78C, 78C2: Sac	Slight	Moderate: low strength.	Moderate: low strength.	Moderate: low strength, slope.	Severe: low strength, frost action.
91: Primghar	Severe: wetness	Severe: shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength, frost action.
92: Marcus	Severe: wetness	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.
95: Harps	Severe: wetness	Severe: wetness, low strength.	Severe: wetness, low strength.	Severe: wetness, low strength.	Severe: wetness, low strength, frost action.
107: Webster	Severe: wetness	Severe: low strength, shrink-swell, wetness.	Severe: low strength, shrink-swell, wetness.	Severe: low strength, shrink-swell, wetness.	Severe: low strength, shrink-swell, wetness.
108, 108B: Wadena	Severe: cutbanks cave.	Slight	Slight	Slight	Moderate: frost action.
108C2: Wadena	Severe: cutbanks cave.	Moderate: slope	Moderate: slope	Severe: slope	Moderate: frost action, slope.
133: Colo	Severe: wetness, floods.	Severe: floods, frost action, wetness.	Severe: floods, frost action, wetness.	Severe: floods, frost action, wetness.	Severe: floods, low strength, frost action.
134: Zook	Severe: wetness, floods.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength.
135, 135B: Coland	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness, frost action.
138B: Clarion	Slight	Slight	Slight	Slight	Moderate: low strength, frost action.
138C, 138C2: Clarion	Slight	Slight	Slight	Moderate: slope	Moderate: low strength, frost action.
138D2: Clarion	Moderate: slope	Moderate: slope	Moderate: slope	Severe: slope	Moderate: slope, low strength, frost action.
174B: Bolan	Moderate: cutbanks cave.	Slight	Slight	Slight	Moderate: frost action.
174C2: Bolan	Moderate: cutbanks cave.	Slight	Slight	Moderate: slope	Moderate: frost action.

TABLE 4.—*Building site development*—Continued

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
174D2: Bolan	Moderate: cutbanks cave, slope.	Moderate: slope	Moderate: slope	Severe: slope	Moderate: frost action, slope.
201B: Coland part	Severe: floods, wetness.	Severe: floods, wetness, frost action.	Severe: floods, wetness, frost action.	Severe: floods, wetness, frost action.	Severe: floods, wetness, frost action.
Spillville part	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Severe: floods, frost action.
C201B: Coland part	Severe: floods, wetness.	Severe: floods, wetness, frost action.	Severe: floods, wetness, frost action.	Severe: floods, wetness, frost action.	Severe: floods, wetness, frost action.
Spillville part	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Severe: floods, frost action.
202, 203: Cylinder	Severe: wetness, cutbanks cave.	Moderate: wetness.	Severe: wetness	Moderate: wetness.	Severe: frost action.
221: Palms	Severe: wetness, excess humus, cutbanks cave.	Severe: wetness, excess humus.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, frost action, low strength.
234: Nishna	Severe: wetness, floods, too clayey.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.
236B: Lester	Moderate: too clayey.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Moderate: slope, shrink-swell, low strength.	Severe: low strength.
259: Biscay	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness, frost action.
274: Rolfe	Severe: wetness, floods.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.	Severe: wetness, low strength, shrink-swell.
308, 308B: Wadena	Severe: cutbanks cave.	Slight	Slight	Slight	Moderate: frost action.
310, 310B, 310B2: Galva	Slight	Moderate: low strength, shrink-swell.	Moderate: low strength, shrink-swell.	Moderate: low strength, shrink-swell.	Severe: low strength, frost action.
310C, 310C2: Galva	Slight	Moderate: low strength, shrink-swell.	Moderate: low strength, shrink-swell.	Moderate: low strength, slope, shrink-swell.	Severe: low strength, frost action.
T310, T310B: Galva	Moderate: cutbanks cave.	Moderate: low strength, shrink-swell.	Moderate: low strength, shrink-swell.	Moderate: low strength, shrink-swell.	Severe: low strength, frost action.
315: Alluvial land	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Severe: floods.

TABLE 4.—*Building site development*—Continued

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
323B: Terril	Moderate: wetness, cutbanks cave.	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Moderate: low strength, frost action.
325: Le Sueur	Moderate: wetness, too clayey.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Moderate: shrink-swell, low strength.	Severe: frost action, low strength.
354: Marsh	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
384: Collinwood	Severe: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell, low strength.	Severe: shrink-swell, low strength.
390: Waldorf	Severe: wetness, too clayey.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, frost action, shrink-swell.
397B: Letri	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Severe: frost action, low strength.
428: Ely	Severe: wetness	Moderate: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Moderate: wetness, shrink-swell.	Severe: frost action, low strength.
430, 430B: Ackmore	Severe: floods, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell, wetness.	Severe: floods, shrink-swell.	Severe: floods, low strength, shrink-swell.
485, 485B: Spillville	Severe: floods, wetness.	Severe: floods	Severe: floods	Severe: floods	Severe: floods.
506: Wacousta	Severe: wetness	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: frost action, wetness, shrink-swell.
507: Canisteo	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Severe: frost action, wetness.
511: Blue Earth	Severe: wetness, floods.	Severe: wetness, floods, frost action.	Severe: wetness, floods.	Severe: wetness, floods, frost action.	Severe: wetness, floods, frost action.
559: Talcot	Severe: wetness, cutbanks cave.	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
577C2: Everly	Moderate: too clayey.	Moderate: low strength, shrink-swell.	Moderate: low strength, shrink-swell.	Moderate: low strength, slope, shrink-swell.	Severe: low strength, frost action, shrink-swell.
577D2: Everly	Moderate: slope, too clayey.	Moderate: low strength, slope, shrink-swell.	Moderate: low strength, slope.	Severe: slope	Severe: low strength, frost action, shrink-swell.

TABLE 4.—*Building site development*—Continued

Map symbol and soil name	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets
606: Lanyon	Severe: wetness, too clayey.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: frost action, wetness, shrink-swell.
733: Calco	Severe: wetness, floods.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.	Severe: floods, low strength, shrink-swell.
823B: Flagler	Severe: cutbanks cave.	Slight	Slight	Slight	Slight.
823C2: Flagler	Severe: cutbanks cave.	Slight	Slight	Moderate: slope	Slight.

each soil horizon is defined, and the presence of very firm or extremely firm horizons, usually difficult to excavate, is indicated.

Dwellings and small commercial buildings referred to in table 4 are built on undisturbed soil. The foundation load is that of a dwelling no more than three stories high. Separate ratings are made for small commercial buildings without basements and for dwellings with and without basements. For such structures, soils should be sufficiently stable that cracking or subsidence from settling or shear failure of the foundation do not occur. These ratings were determined from estimates of the shear strength, compressibility, and shrink-swell potential of the soil. Soil texture, plasticity and in-place density, potential frost action, soil wetness, and depth to a seasonal high water table indicate potential difficulty in providing adequate drainage for basements, lawns, and gardens. Depth to bedrock, slope, and large stones in or on the soil are also important considerations in the choice of sites for these structures and were considered in determining the ratings. Susceptibility to flooding is a serious limitation.

Local roads and streets referred to in table 4 have an all-weather surface that can carry light to medium traffic all year. They consist of a subgrade of the underlying soil material; a base of gravel, crushed rock fragments, or soil stabilized with lime or cement; and a flexible or rigid surface, commonly asphalt or concrete. The roads are graded with local soil. Most cuts and fills are less than 6 feet deep.

The load supporting capacity and soil stability, as well as the quantity and workability of available fill material, are important in design and construction of roads and streets. The AASHTO and Unified classifications of soil and soil texture, density, shrink-swell potential, and frost action potential were used in making the ratings. Also considered were soil wetness, flooding, slope, depth to hard rock or very compact layers, and content of large stones, all of which affect stability and ease of excavation.

Sanitary facilities

Favorable soil properties and site features are needed for proper functioning of septic tank absorption fields, sewage lagoons, and sanitary landfills. The nature of the soil is important in selecting sites for these facilities, and in identifying limiting soil properties and site features to be considered in design and installation. Also, soil properties that are relevant to ease of excavation or installation of these facilities will be of interest to contractors and local officials. Table 5 shows the degree and kind of limitations of each soil for these uses and for use of the soil as daily cover for landfills.

If the degree of soil limitation is indicated by the ratings *slight,* soils are favorable for the specified use and limitations are minor and easily overcome; if *moderate,* soil properties or site features are unfavorable for the specified use, but limitations can be overcome by special planning and design; and if *severe,* soil properties or site features are so unfavorable or difficult to overcome that major soil reclamation, special designs, or intensive maintenance are required.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into the natural soil. Only the soil horizons between depths of 18 and 72 inches are evaluated for this use. Soil properties and site features considered are those that affect the absorption of effluent and those that affect construction of the system.

Properties and features that affect the absorption of effluent are permeability, depth to seasonal high water table, depth to bedrock, and susceptibility to flooding. Stones, boulders, and a shallow depth to bedrock interfere with installation. Excessive slope may cause lateral seepage and surfacing of effluent in downslope areas. Also, soil erosion and soil slippage are hazards where absorption fields are installed in sloping soils.

Some soils are underlain by loose sand and gravel or fractured bedrock at a depth of less than 4 feet

TABLE 5.—*Sanitary facilities*

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and other terms used to rate soils. Absence of an entry means soil was not rated]

Map symbol and soil name	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
1D3:					
Ida	Moderate: slope	Severe: slope	Slight	Moderate: slope	Fair: slope.
1E3:					
Ida	Severe: slope	Severe: slope	Moderate: slope	Severe: slope	Poor: slope.
1F3:					
Ida	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Poor: slope.
5B:					
Kennebec part	Severe: floods, wetness.	Severe: floods	Severe: floods, wetness.	Severe: floods, wetness.	Fair: too clayey.
Ackmore part	Severe: percs slowly, floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Fair: thin layer.
C5B:					
Kennebec part	Severe: floods, wetness.	Severe: floods	Severe: floods, wetness.	Severe: floods, wetness.	Fair: too clayey.
Ackmore part	Severe: percs slowly, floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Fair: thin layer.
6:					
Okoboji	Severe: percs slowly, wetness, floods.	Severe: excess humus, wetness.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
8C:					
Judson	Slight	Moderate: slope, seepage.	Moderate: too clayey.	Slight	Fair: too clayey.
9B, 9B2:					
Marshall	Slight	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
9C, 9C2:					
Marshall	Slight	Severe: slope	Moderate: too clayey.	Slight	Fair: too clayey.
9D2, 9D3:					
Marshall	Moderate: slope	Severe: slope	Moderate: too clayey.	Moderate: slope	Fair: too clayey, slope.
10D3:					
Monona	Moderate: slope	Severe: slope	Slight	Moderate: slope	Fair: slope.
10E3:					
Monona	Severe: slope	Severe: slope	Moderate: slope	Severe: slope	Poor: slope.
11B:					
Colo part	Severe: percs slowly, wetness, floods.	Severe: excess humus, wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
Ely part	Severe: wetness	Moderate: excess humus, seepage, wetness.	Severe: wetness	Moderate: wetness.	Fair: too clayey.
24C2:					
Shelby	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Slight	Fair: too clayey, slope.
24D2:					
Shelby	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Moderate: slope	Fair: too clayey, slope.

TABLE 5.—*Sanitary facilities*—Continued

Map symbol and soil name	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
24E2: Shelby	Severe: percs slowly, slope.	Severe: slope	Moderate: too clayey, slope.	Severe: slope	Poor: slope.
26B: Kennebec	Severe: floods, wetness.	Severe: floods	Severe: floods, wetness.	Severe: floods, wetness.	Fair: too clayey.
27C: Terril	Slight	Moderate: seepage, excess humus.	Slight	Slight	Good.
31: Afton	Severe: percs slowly, wetness.	Severe: wetness, excess humus.	Severe: wetness	Severe: wetness	Poor: wetness.
33E: Steinauer	Severe: percs slowly.	Severe: slope	Moderate: too clayey.	Moderate: slope	Fair: too clayey, slope.
33F: Steinauer	Severe: percs slowly, slope.	Severe: slope	Moderate: slope, too clayey.	Severe: slope	Poor: slope.
41D: Sparta	Moderate: slope.[1]	Severe: seepage, slope.	Severe: seepage	Severe: seepage	Fair: too sandy, slope.
54: Zook	Severe: percs slowly, wetness, floods.	Severe: excess humus, wetness, floods.	Severe: wetness, too clayey, floods.	Severe: wetness, floods.	Poor: wetness, too clayey.
55: Nicollet	Severe: wetness	Moderate: wetness, slope.	Severe: wetness	Moderate: wetness.	Fair: too clayey.
62C, 62D: Storden	Moderate: slope	Severe: slope	Slight	Moderate: slope	Fair: slope.
62E, 62F: Storden	Severe: slope	Severe: slope	Moderate: slope	Severe: slope	Poor: slope.
62G: Storden	Severe: slope	Severe: slope	Severe: slope	Severe: slope	Poor: slope.
73C: Salida	Slight[1]	Severe: seepage, slope.	Severe: seepage	Severe: seepage	Poor: too sandy.
73D: Salida	Moderate: slope[1]	Severe: seepage, slope.	Severe: seepage	Severe: seepage	Poor: too sandy.
77B, 77B2: Sac	Slight	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
77C, 77C2: Sac	Slight	Severe: slope	Moderate: too clayey.	Slight	Fair: too clayey.
78B, 78B2: Sac	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
78C, 78C2: Sac	Moderate: percs slowly.	Severe: slope	Moderate: too clayey.	Slight	Fair: too clayey.

TABLE 5.—*Sanitary facilities*—Continued

Map symbol and soil name	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
91: Primghar	Severe: percs slowly, wetness.	Moderate: wetness, excess humus.	Severe: wetness	Moderate: wetness.	Fair: too clayey.
92: Marcus	Severe: percs slowly, wetness.	Severe: wetness, excess humus.	Severe: wetness	Severe: wetness	Poor: wetness.
95: Harps	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
107: Webster	Severe: wetness	Severe: excess humus, wetness.	Severe: wetness	Severe: wetness	Poor: wetness.
108, 108B: Wadena	Slight[1]	Severe: seepage	Severe: seepage	Severe: seepage	Fair: thin layer.
108C2: Wadena	Moderate: slope.[1]	Severe: seepage, slope.	Severe: seepage	Severe: seepage	Fair: thin layer, slope.
133: Colo	Severe: percs slowly, wetness, floods.	Severe: excess humus, wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
134: Zook	Severe: percs slowly, wetness, floods.	Severe: excess humus, wetness, floods.	Severe: wetness, too clayey, floods.	Severe: wetness, floods.	Poor: wetness, too clayey.
135, 135B: Coland	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Poor: wetness.
138B: Clarion	Slight	Moderate: slope, seepage.	Slight	Slight	Good.
138C, 138C2: Clarion	Slight	Severe: slope, seepage.	Slight	Slight	Good.
138D2: Clarion	Moderate: slope	Severe: slope, seepage.	Slight	Moderate: slope	Fair: slope.
174B: Bolan	Slight[1]	Severe: seepage	Severe: seepage	Severe: seepage	Fair: thin layer, slope.
174C2: Bolan	Slight[1]	Severe: slope, seepage.	Severe: seepage	Severe: seepage	Fair: thin layer, slope.
174D2: Bolan	Moderate: slope.[1]	Severe: slope, seepage.	Severe: seepage	Severe: seepage	Fair: slope.
201B: Coland part	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Poor: wetness.
Spillville part	Severe: floods, wetness.	Severe: floods.	Severe: floods	Severe: floods	Good.
C201B: Coland part	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Poor: wetness.

TABLE 5.—*Sanitary facilities*—Continued

Map symbol and soil name	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
C201B: Spillville part	Severe: floods, wetness.	Severe: floods	Severe: floods	Severe: floods	Good.
202, 203: Cylinder	Severe: wetness.[1]	Severe: seepage	Severe: seepage	Severe: seepage	Fair: thin layer.
221: Palms	Severe: wetness, floods.	Severe: wetness, excess humus, seepage.	Severe: wetness, floods, seepage.	Severe: wetness, floods, seepage.	Poor: excess humus, hard to pack.
234: Nishna	Severe: floods, percs slowly, wetness.	Severe: floods, wetness.	Severe: floods, wetness, too clayey.	Severe: floods, wetness.	Poor: too clayey, wetness.
236B: Lester	Moderate: percs slowly.	Moderate: slope, seepage.	Slight	Slight	Fair: too clayey.
259: Biscay	Severe: wetness.[1]	Severe: seepage, wetness.	Severe: seepage, wetness.	Severe: wetness	Poor: wetness.
274: Rolfe	Severe: floods, percs slowly, wetness.	Severe: floods, wetness, excess humus.	Severe: floods, wetness, too clayey.	Severe: floods, wetness.	Poor: wetness.
308, 308B: Wadena	Slight[1]	Severe: seepage	Severe: seepage	Severe: seepage	Fair: thin layer.
310: Galva	Slight	Moderate: seepage.	Moderate: too clayey.	Slight	Fair: too clayey.
310B, 310B2: Galva	Slight	Moderate: slope, seepage.	Moderate: too clayey.	Slight	Fair: too clayey.
310C, 310C2: Galva	Slight	Severe: slope	Moderate: too clayey.	Slight	Fair: too clayey.
T310, T310B: Galva	Slight[1]	Severe: seepage	Severe: seepage	Slight	Fair: too clayey.
315: Alluvial land	Severe: floods	Severe: floods	Severe: floods	Severe: floods	Poor: wetness.
323B: Terril	Slight[1]	Severe: seepage	Severe: seepage	Slight	Good.
325: Le Sueur	Severe: wetness	Moderate: wetness.	Severe: wetness	Moderate: wetness.	Fair: too clayey.
354: Marsh	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
384: Collinwood	Severe: percs slowly.	Moderate: wetness.	Severe: wetness, too clayey.	Moderate: wetness.	Poor: too clayey.
390: Waldorf	Severe: wetness, percs slowly.	Severe: wetness	Severe: wetness, too clayey.	Severe: wetness	Poor: wetness, too clayey.
397B: Letri	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.

TABLE 5.—*Sanitary facilities*—Continued

Map symbol and soil name	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
428: Ely	Severe: wetness	Moderate: excess humus, seepage, wetness.	Severe: wetness	Moderate: wetness.	Fair: too clayey.
430, 430B: Ackmore	Severe: percs slowly, floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Fair: too clayey.
485, 485B: Spillville	Severe: floods, wetness.	Severe: floods, wetness, excess humus.	Severe: floods, wetness.	Severe: floods, wetness.	Good.
506: Wacousta	Severe: percs slowly, wetness, floods.	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness, too clayey.
507: Canisteo	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness	Poor: wetness.
511: Blue Earth	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
559: Talcot	Severe: wetness.[1]	Severe: wetness, seepage.	Severe: wetness, seepage.	Severe: wetness, seepage.	Poor: wetness.
577C2: Everly	Slight	Moderate: seepage, excess humus, slope.	Slight	Slight	Fair: too clayey.
577D2: Everly	Moderate: slope	Severe: slope	Slight	Moderate: slope	Fair: too clayey, slope.
606: Lanyon	Severe: percs slowly, wetness.	Moderate: excess humus.	Severe: wetness, too clayey.	Severe: wetness	Poor: wetness, too clayey.
733: Calco	Severe: percs slowly, wetness, floods.	Severe: excess humus, wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
823B: Flagler	Slight	Severe: seepage	Severe: seepage	Severe: seepage	Fair: thin layer.
823C2: Flagler	Slight	Severe: slope, seepage.	Severe: seepage	Severe: seepage	Fair: thin layer.

[1] Danger of contamination of ground water because of porous substratum.

below the tile lines. In these soils the absorption field does not adequately filter effluent, and as a result, ground water supplies in the area may be contaminated. Soils that have a hazard of inadequate filtration are indicated by footnotes in table 5.

Percolation tests are performed to determine the absorptive capacity of the soil and its suitability for septic tank absorption fields. These tests should be performed during the season when the water table is highest and the soil has minimum absorptive capacity.

In many soils that have moderate or severe limitations for septic tank absorption fields, it may be possible to install special systems that lower the seasonal water table or to increase the size of the absorption field to achieve satisfactory performance.

Sewage lagoon areas are shallow ponds constructed to hold sewage while bacteria decompose solid and liquid wastes. Lagoons have a nearly level flow area surrounded by cut slopes or embankments of compacted, nearly impervious soil material. They are gen-

TABLE 6.—*Construction materials*

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," and "poor." Absence of an entry means soil was not rated]

Map symbol and soil name	Roadfill	Sand	Gravel	Topsoil
1D3: Ida	Poor: frost action	Unsuited	Unsuited	Fair: slope.
1E3: Ida	Poor: frost action	Unsuited	Unsuited	Poor: slope.
1F3: Ida	Poor: slope, frost action	Unsuited	Unsuited	Poor: slope.
5B: Kennebec part	Poor: excess humus, frost action, low strength.	Unsuited	Unsuited	Fair: too clayey.
Ackmore part	Poor: low strength, shrink-swell, frost action.	Unsuited	Unsuited	Good.
C5B: Kennebec part	Poor: excess humus, frost action, low strength.	Unsuited	Unsuited	Fair: too clayey.
Ackmore part	Poor: low strength, shrink-swell, frost action.	Unsuited	Unsuited	Good.
6: Okoboji	Poor: wetness, low strength, shrink-swell.	Unsuited	Unsuited	Poor: wetness.
8C: Judson	Poor: frost action, low strength.	Unsuited	Unsuited	Fair: too clayey.
9B, 9B2, 9C, 9C2: Marshall	Poor: low strength, frost action.	Unsuited	Unsuited	Fair: too clayey.
9D2, 9D3: Marshall	Poor: low strength, frost action.	Unsuited	Unsuited	Fair: too clayey, slope.
10D3: Monona	Poor: low strength, frost action.	Unsuited	Unsuited	Fair: slope.
10E3: Monona	Poor: low strength, frost action.	Unsuited	Unsuited	Poor: slope.
11B: Colo part	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness.
Ely part	Poor: frost action, low strength.	Unsuited	Unsuited	Fair: too clayey.
24C2: Shelby	Poor: low strength	Unsuited	Unsuited	Fair: thin layer.
24D2: Shelby	Poor: low strength	Unsuited	Unsuited	Fair: thin layer, slope.
24E2: Shelby	Poor: low strength	Unsuited	Unsuited	Poor: slope.
26B: Kennebec	Poor: excess humus, frost action, low strength.	Unsuited	Unsuited	Fair: too clayey.
27C: Terril	Fair: low strength, frost action.	Unsuited	Unsuited	Good.

TABLE 6.—*Construction materials*—Continued

Map symbol and soil name	Roadfill	Sand	Gravel	Topsoil
31: Afton	Poor: wetness, low strength, shrink-swell.	Unsuited	Unsuited	Poor: wetness.
33E: Steinauer	Poor: low strength	Unsuited	Unsuited	Poor: thin layer.
33F: Steinauer	Poor: low strength	Unsuited	Unsuited	Poor: thin layer, slope.
41D: Sparta	Good	Good	Unsuited	Poor: too sandy.
54: Zook	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness, too clayey.
55: Nicollet	Poor: frost action, low strength.	Unsuited	Unsuited	Good.
62C, 62D: Storden	Fair: frost action	Unsuited	Unsuited	Fair: slope, thin layer.
62E, 62F: Storden	Fair: slope, frost action	Unsuited	Unsuited	Poor: slope.
62G: Storden	Poor: slope	Unsuited	Unsuited	Poor: slope.
73C, 73D: Salida	Good	Good	Fair: excess fines	Poor: too sandy, area reclaim.
77B, 77B2, 77C, 77C2, 78B, 78B2, 78C, 78C2: Sac	Poor: low strength	Unsuited	Unsuited	Fair: too clayey.
91: Primghar	Poor: low strength, shrink-swell, frost action.	Unsuited	Unsuited	Fair: too clayey.
92: Marcus	Poor: wetness, low strength, shrink-swell.	Unsuited	Unsuited	Poor: wetness, too clayey.
95: Harps	Poor: low strength, frost action, wetness.	Unsuited	Unsuited	Poor: wetness.
107: Webster	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness.
108, 108B: Wadena	Good	Good	Fair: excess fines	Good.
108C2: Wadena	Good	Good	Fair: excess fines	Fair: slope.
133: Colo	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness.
134: Zook	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness, too clayey.
135, 135B: Coland	Poor: low strength, excess humus, frost action.	Unsuited	Unsuited	Poor: wetness.

TABLE 6.—*Construction materials*—Continued

Map symbol and soil name	Roadfill	Sand	Gravel	Topsoil
138B, 138C, 138C2: Clarion	Fair: frost action, low strength.	Unsuited	Unsuited	Good.
138D2: Clarion	Fair: frost action, low strength.	Unsuited	Unsuited	Fair: slope.
174B, 174C2: Bolan	Good	Poor: excess fines	Unsuited	Good.
174D2: Bolan	Good	Poor: excess fines	Unsuited	Fair: slope.
201B: Coland part	Poor: low strength, excess humus, frost action.	Unsuited	Unsuited	Poor: wetness.
Spillville part	Fair: shrink-swell, wetness, frost action.	Unsuited	Unsuited	Good.
C201B: Coland part	Poor: low strength, excess humus, frost action.	Unsuited	Unsuited	Poor: wetness.
Spillville part	Fair: shrink-swell, wetness, frost action.	Unsuited	Unsuited	Good.
202, 203: Cylinder	Good	Good	Fair: excess fines	Good.
221: Palms	Poor: wetness, excess humus.	Unsuited	Unsuited	Poor: wetness.
234: Nishna	Poor: low strength, shrink-swell, wetness.	Unsuited	Unsuited	Poor: too clayey, wetness.
236B: Lester	Poor: low strength	Unsuited	Unsuited	Fair: too clayey.
259: Biscay	Poor: frost action	Good	Poor: excess fines	Poor: wetness.
274: Rolfe	Poor: low strength, shrink-swell, wetness.	Unsuited	Unsuited	Poor: wetness.
308, 308B: Wadena	Good	Good	Fair: excess fines	Good.
310, 310B, 310B2, 310C, 310C2: Galva	Poor: low strength, frost action.	Unsuited	Unsuited	Fair: too clayey.
T310, T310B: Galva	Poor: low strength, frost action.	Good	Good	Fair: too clayey.
315: Alluvial land	Poor: wetness, frost action.	Fair	Fair	Good.
323B: Terril	Fair: low strength, frost action.	Fair: excess fines	Poor: excess fines	Good.
325: Le Sueur	Poor: frost action, low strength.	Unsuited	Unsuited	Fair: thin layer.

TABLE 6.—*Construction materials*—Continued

Map symbol and soil name	Roadfill	Sand	Gravel	Topsoil
354: Marsh	Poor: wetness	Unsuited	Unsuited	Poor: wetness.
384: Collinwood	Poor: shrink-swell	Unsuited	Unsuited	Poor: too clayey.
390: Waldorf	Poor: wetness, frost action, shrink-swell.	Unsuited	Unsuited	Poor: wetness, too clayey.
397B: Letri	Poor: frost action, low strength.	Unsuited	Unsuited	Poor: wetness.
428: Ely	Poor: frost action, low strength.	Unsuited	Unsuited	Fair: too clayey.
430, 430B: Ackmore	Poor: low strength, shrink-swell, frost action.	Unsuited	Unsuited	Good.
485, 485B: Spillville	Fair: shrink-swell, wetness, frost action.	Unsuited	Unsuited	Good.
506: Wacousta	Poor: area reclaim, shrink-swell, wetness.	Unsuited	Unsuited	Poor: area reclaim, wetness, too clayey.
507: Canisteo	Poor: frost action	Unsuited	Unsuited	Poor: excess lime, wetness.
511: Blue Earth	Poor: excess humus, low strength.	Unsuited	Unsuited	Poor: wetness.
559: Talcot	Poor: wetness, frost action.	Good	Fair: excess fines	Poor: wetness.
577C2: Everly	Fair: low strength, frost action.	Unsuited	Unsuited	Fair: too clayey.
577D2: Everly	Fair: low strength, frost action.	Unsuited	Unsuited	Fair: too clayey, slope.
606: Lanyon	Poor: area reclaim, shrink-swell, wetness.	Unsuited	Unsuited	Poor: area reclaim, wetness, too clayey.
733: Calco	Poor: wetness, shrink-swell, low strength.	Unsuited	Unsuited	Poor: wetness.
823B, 823C2: Flagler	Good	Good	Fair: excess fines	Good.

erally designed so that depth of sewage is 2 to 5 feet. Impervious soil at least 4 feet thick for the lagoon floor and sides is required to minimize seepage and contamination of local ground water. Soils that are very high in organic matter content and those that have stones and boulders are undesirable. Unless the soil is very slowly permeable, contamination of local ground water is a hazard in areas where the seasonal high water table is above the level of the lagoon floor. In soils that have a high water table, seepage of ground water into the lagoon can seriously reduce its capacity for liquid waste. Slope, depth to bedrock, and susceptibility to flooding also affect the location of sites for sewage lagoons and the cost of construction. Shear

TABLE 7.—*Water management*

[Some terms that describe restrictive soil features are defined in the Glossary. Absence of an entry means soil was not evaluated]

Map symbol and soil name	Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Drainage	Irrigation	Terraces and diversions	Grassed waterways
1D3, 1E3, 1F3: Ida	Seepage	Low strength, compressible, piping.	No water	Not needed	Slope, erodes easily, excess lime.	Slope, erodes easily, piping.	Erodes easily, slope.
5B: Kennebec part	Seepage	Low strength, compressible, excess humus.	Deep to water.	Floods	Floods	Favorable	Favorable.
Ackmore part	Favorable	Low strength, compressible, shrink-swell.	Deep to water.	Floods, wetness.	Floods, wetness.	Not needed	Wetness.
C5B: Kennebec part	Seepage	Low strength, compressible, excess humus.	Deep to water	Floods	Floods	Favorable	Favorable.
Ackmore part	Favorable	Low strength, compressible, shrink-swell.	Deep to water.	Floods, wetness.	Floods, wetness.	Not needed	Wetness.
6: Okoboji	Favorable	Compressible, low strength, shrink-swell.	Slow refill	Percs slowly, poor outlets, wetness.	Wetness, percs slowly.	Not needed	Not needed.
8C: Judson	Seepage	Compressible, low strength, shrink-swell.	No water	Not needed	Slope	Favorable	Favorable.
9B, 9B2, 9C, 9C2, 9D2, 9D3: Marshall	Seepage	Compressible, low strength, shrink-swell.	No water	Not needed	Erodes easily, slope.	Favorable	Favorable.
10D3, 10E3: Monona	Seepage	Low strength, compressible, piping.	No water	Not needed	Erodes easily, slope.	Erodes easily.	Erodes easily.
11B: Colo part	Favorable	Compressible, low strength, hard to pack.	Slow refill	Floods, wetness.	Floods, wetness.	Not needed	Wetness.
Ely part	Favorable	Low strength, compressible, shrink-swell.	Deep to water.	Favorable	Favorable	Favorable	Favorable.
24C2: Shelby	Favorable	Low strength, shrink-swell.	No water	Not needed	Slow intake, slope, erodes easily.	Favorable	Erodes easily, slope.
24D2, 24E2: Shelby	Favorable	Low strength, shrink-swell.	No water	Not needed	Slow intake, slope, erodes easily.	Erodes easily, slope.	Erodes easily, slope.
26B: Kennebec	Seepage	Low strength, compressible, excess humus.	Deep to water.	Floods	Floods	Favorable	Favorable.

TABLE 7.—*Water management*—Continued

Map symbol and soil name	Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Drainage	Irrigation	Terraces and diversions	Grassed waterways
27C: Terril	Favorable	Low strength, compressible.	No water	Not needed	Slope	Favorable	Favorable.
31: Afton	Favorable	Compressible, low strength, shrink-swell.	Slow refill	Percs slowly, poor outlets, wetness.	Wetness, percs slowly.	Not needed	Wetness.
33E, 33F: Steinauer	Favorable	Low strength, shrink-swell.	No water	Not needed	Erodes easily, complex slope.	Erodes easily, complex slope.	Erodes easily, slope.
41D: Sparta	Seepage	Piping	No water	Not needed	Seepage, droughty.	Too sandy	Droughty.
54: Zook	Favorable	Shrink-swell, low strength, hard to pack.	Slow refill	Floods, wetness, percs slowly.	Floods, wetness, percs slowly.	Not needed	Wetness.
55: Nicollet	Favorable	Shrink-swell, low strength, piping.	Slow refill	Favorable	Favorable	Not needed	Favorable.
62C, 62D, 62E, 62F, 62G: Storden	Seepage	Low strength	No water	Not needed	Complex slope, erodes easily.	Complex slope, erodes easily.	Erodes easily.
73C, 73D: Salida	Seepage	Seepage	No water	Not needed	Droughty, seepage.	Erodes easily, rooting depth.	Droughty, rooting depth.
77B, 77B2, 77C, 77C2, 78B, 78B2, 78C, 78C2: Sac	Favorable	Low strength, shrink-swell.	No water	Not needed	Slope, erodes easily.	Favorable	Slope.
91: Primghar	Favorable	Low strength, shrink-swell.	Deep to water.	Favorable	Favorable	Favorable	Favorable.
92: Marcus	Favorable	Compressible, low strength, shrink-swell.	Slow refill	Percs slowly, poor outlets, wetness.	Wetness, percs slowly.	Not needed	Wetness.
95: Harps	Favorable	Low strength, compressible.	Deep to water.	Poor outlets.	Excess lime, wetness.	Not needed	Not needed.
107: Webster	Favorable	Compressible, low strength, hard to pack.	Deep to water.	Wetness	Wetness	Not needed	Wetness.
108, 108B, 108C2: Wadena	Seepage	Seepage	No water	Not needed	Seepage, rooting depth.	Rooting depth.	Rooting depth.

TABLE 7.—*Water management*—Continued

Map symbol and soil name	Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Drainage	Irrigation	Terraces and diversions	Grassed waterways
133: Colo	Favorable	Compressible, low strength, hard to pack.	Slow refill	Floods, wetness.	Floods, wetness.	Not needed	Wetness.
134: Zook	Favorable	Shrink-swell, low strength, hard to pack.	Slow refill	Floods, wetness, percs slowly.	Floods, wetness, percs slowly.	Not needed	Wetness.
135, 135B: Coland	Favorable	Compressible, low strength, excess humus.	Slow refill	Floods, wetness.	Wetness, floods.	Wetness	Wetness.
138B, 138C, 138C2, 138D2: Clarion	Favorable	Low strength, piping	No water	Not needed	Complex slope, erodes easily.	Complex slope, erodes easily.	Erodes easily.
174B, 174C2, 174D2: Bolan	Seepage	Seepage, piping	No water	Not needed	Slope	Complex slope, piping.	Favorable.
201B: Coland part	Favorable	Compressible, low strength, excess humus.	Slow refill	Floods, wetness.	Wetness, floods.	Wetness	Wetness.
Spillville part	Seepage	Hard to pack, piping, excess humus.	Deep to water.	Not needed	Favorable	Favorable	Favorable.
C201B: Coland part	Favorable	Compressible, low strength, excess humus.	Slow refill	Floods, wetness.	Wetness, floods.	Wetness	Wetness.
Spillville part	Seepage	Hard to pack, piping, excess humus.	Deep to water.	Not needed	Favorable	Favorable	Favorable.
202, 203: Cylinder	Seepage	Seepage, piping	Deep to water.	Cutbanks cave.	Rooting depth.	Not needed	Not needed.
221: Palms	Seepage	Compressible, hard to pack, low strength.	Favorable	Wetness, floods, cutbanks cave.	Wetness, fast intake, soil blowing.	Not needed	Not needed.
234: Nishna	Favorable	Low strength, compressible, shrink-swell.	Slow refill	Floods, percs slowly, poor outlets.	Floods, percs slowly, wetness.	Not needed	Not needed.
236B: Lester	Favorable	Low strength	No water	Not needed	Complex slope, erodes easily.	Complex slope, erodes easily.	Erodes easily, slope.
259: Biscay	Seepage	Favorable	Slow refill	Cutbanks cave, wetness.	Wetness	Not needed	Wetness.

TABLE 7.—*Water management*—Continued

Map symbol and soil name	Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Drainage	Irrigation	Terraces and diversions	Grassed waterways
274: Rolfe	Favorable	Low strength, compressible, shrink-swell.	Slow refill	Floods, percs slowly, poor outlets.	Floods, percs slowly, wetness.	Not needed	Not needed.
308, 308B: Wadena	Seepage	Seepage	No water	Not needed	Seepage, rooting depth.	Rooting depth.	Rooting depth.
310, 310B, 310B2, 310C, 310C2: Galva	Favorable	Low strength, compressible, piping.	No water	Not needed	Erodes easily.	Favorable	Favorable.
T310: Galva	Seepage	Low strength, shrink-swell.	No water	Not needed	Favorable	Rooting depth.	Favorable.
T310B: Galva	Seepage	Low strength, shrink-swell.	No water	Not needed	Slope, erodes easily.	Rooting depth.	Favorable.
315: Alluvial land	Seepage		Slow refill	Floods	Floods	Not needed	Not needed.
323B: Terril	Seepage	Low strength, compressible.	Deep to water.	Not needed	Seepage	Favorable	Favorable.
325: Le Sueur	Favorable	Shrink-swell, low strength.	Deep to water.	Favorable	Favorable	Not needed	Favorable.
354: Marsh	Favorable	Unstable fill	Favorable	Poor outlets.	Floods, wetness.	Not needed	Wetness.
384: Collinwood	Favorable	Compressible, low strength, shrink-swell.	Slow refill	Not needed	Percs slowly, slow intake.	Percs slowly.	Percs slowly.
390: Waldorf	Favorable	Shrink-swell, low strength.	Slow refill	Wetness, percs slowly.	Wetness, percs slowly.	Not needed	Wetness, percs slowly.
397B: Letri	Favorable	Low strength, shrink-swell.	Slow refill	Wetness	Wetness	Not needed	Wetness.
428: Ely	Favorable	Low strength, compressible, shrink-swell.	Deep to water.	Favorable	Favorable	Wetness	Favorable.
430, 430B: Ackmore	Favorable	Low strength, compressible, shrink-swell.	Deep to water.	Floods, wetness.	Floods, wetness.	Not needed	Wetness.
485, 485B: Spillville	Seepage	Hard to pack, piping, excess humus.	Deep to water.	Not needed	Floods	Favorable	Favorable

TABLE 7.—*Water management*—Continued

Map symbol and soil name	Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Drainage	Irrigation	Terraces and diversions	Grassed waterways
506: Wacousta	Slope	Compressible, low strength, hard to pack.	Slow refill	Percs slowly, poor outlets.	Percs slowly, wetness.	Not needed	Not needed.
507: Canisteo	Favorable	Compressible, low strength.	Deep to water.	Favorable	Wetness	Not needed	Not needed.
511: Blue Earth	Favorable	Low strength, compressible, excess humus.	Slow refill	Wetness, floods.	Wetness	Not needed	Not needed.
559: Talcot	Seepage	Seepage	Slow refill	Cutbanks cave, wetness.	Wetness	Not needed	Not needed.
577C2, 577D2: Everly	Favorable	Low strength, piping	No water	Not needed	Erodes easily.	Favorable	Slope.
606: Lanyon	Favorable	Compressible, low strength, hard to pack.	Slow refill	Percs slowly, poor outlets, wetness.	Percs slowly, wetness.	Not needed	Not needed.
733: Calco	Favorable	Compressible, low strength, hard to pack.	Slow refill	Floods, wetness.	Floods, wetness.	Not needed	Wetness.
823B, 823C2: Flagler	Seepage	Seepage, piping	No water	Not needed	Droughty, soil blowing.	Too sandy, piping.	Droughty.

strength and permeability of compacted soils affect the performance of embankments.

Sanitary landfill is a method of disposing of solid waste, either in excavated trenches or on the surface of the soil. The waste is spread, compacted in layers, and covered with thin layers of soil. Landfill areas are subject to heavy vehicular traffic. Ease of excavation, risk of polluting ground water, and trafficability affect the suitability of a soil for this purpose. The best soils have a loamy or silty texture, are moderately or slowly permeable, are deep to bedrock and a seasonal water table, are free of large stones and boulders, and are not subject to flooding. In areas where the seasonal water table is high, water seeps into the trenches and causes problems in excavating and filling the trenches. Also, seepage into refuse increases the risk of pollution of ground water. Clayey soils are likely to be sticky and difficult to spread. Since sandy or gravelly soils are generally rapidly permeable, noxious liquids might contaminate local ground water.

Unless otherwise stated, the ratings in table 5 apply only to soil properties and features that are at a depth of less than 6 feet. If the trench is deeper, ratings of slight or moderate may not be valid. A site should be investigated before it is selected.

In the area type of sanitary landfill, refuse is placed on the soil surface in successive layers. The limitations of soil texture, depth to bedrock, and stone content do not apply to this type of landfill. Soil wetness, however, may be a limitation to operating equipment.

Daily cover for landfill should be soil that is easy to excavate and spread over the compacted fill during both wet and dry weather. Soils that are loamy or silty and free of stones or boulders are more suitable for cover than other soils. Clayey soils may be sticky and difficult to spread; sandy soils may be subject to soil blowing.

In addition to these features, the soils selected for final cover of landfills should be suited to plant growth. In comparison with other horizons, the A horizon in most soils has the best workability, higher organic matter content, and the best potential for plant growth. Thus, for either the area- or trench-type landfill, stockpiling material from the A horizon for use as the surface layer of the final cover is desirable.

If it is necessary to bring in soil material for daily

or final cover, thickness of suitable soil material that is available and depth to a seasonal high water table in soils surrounding the sites should be evaluated. Other factors to be evaluated are those that affect reclamation of the borrow areas, such as slope, erodibility, and potential for plant growth.

Construction materials

The suitability of each soil as a source of road fill, sand, gravel, and topsoil is indicated in table 6 by ratings of good, fair, or poor. Texture, thickness, and organic matter content of each soil horizon are important factors in rating soils for use as construction materials. Each soil is evaluated to the depth described in the survey, generally about 6 feet.

Roadfill is soil material used in road embankments. The ratings reflect the ease of excavating and working the material. They also show the expected performance of the soil after it has been compacted and adequately drained. The performance of soil after it is stabilized with lime or cement is not considered in the ratings, but information about soil properties that determine such performance is given in the descriptions of soil series.

The ratings apply to the soil profile between the A horizon and a depth of 5 to 6 feet. It is assumed that soil horizons will be mixed during excavation and spreading. Many soils have horizons of contrasting suitability within the profile. The estimated engineering properties in table 10 provide more specific information about the nature of each horizon that help determine its suitability for road fill.

Soils rated *good* have low shrink-swell potential, low frost action potential, and few cobbles and stones. They are at least moderately well drained and have slopes of 15 percent or less. Soils rated *fair* have a plasticity index of less than 15 and have other limiting features, such as high shrink-swell potential, high frost action potential, steep slopes, wetness, or many stones. If the thickness of suitable soil is less than 3 feet, the entire soil is rated *poor,* regardless of the quality of the suitable soil.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 6 provide guidance as to where to look for probable sources. They are based on the probability that soils in a given area contain sizable quantities of sand and gravel. A soil rated *good* or *fair* has a layer of suitable material at least 3 feet thick, the top of which is at a depth of less than 6 feet. Coarse fragments of soft bedrock material, such as shale and siltstone, are not considered as sand and gravel. Fine grained soils are not suitable sources of sand and gravel.

The ratings do not take into account depth to the water table or other factors that affect excavation of the material. Descriptions of grain size, kinds of minerals, reaction, and stratification are given in the soil series descriptions and in table 11.

Topsoil is used in areas where vegetation is to be established and maintained. Suitability ratings relate mainly to the ease of working and spreading the soil when preparing a seedbed, and potential of the soil for plant growth. Also considered in the ratings is the damage that would result to the area from which the topsoil is taken.

Soils rated *good* have at least 16 inches of friable loamy soil at the surface. They are free of stones, are low in content of gravel and other coarse fragments, and have gentle slopes. They are low in soluble salts, which can limit plant growth. They are naturally fertile or respond well to fertilization. They are not so wet as to make excavation difficult during most of the year.

Soils rated *fair* are loose sandy, firm loamy or clayey soils in which the suitable layer is only 8 to 16 inches thick. Others have appreciable amounts of gravel, stones, or soluble salt.

Soils rated *poor* are very sandy soils, very firm clayey soils, soils that have suitable material less than 8 inches thick, soils that have a high content of gravel, stones, or soluble salt, steep soils, and poorly drained soils.

Although a rating of *good* is not based entirely on high organic matter content, a surface horizon is much preferred for topsoil because of its organic matter content. This horizon is designed as A1 or Ap in the soil series descriptions. The absorption and retention of moisture and nutrients for plant growth are greatly increased by organic matter. Consequently careful preservation and use of material from these horizons is desirable.

Water management

Many soil properties and site features that affect water management have been identified in this soil survey. In table 7 the soil and site features that affect use are indicated for each kind of soil. This information is significant in planning, installing, and maintaining water control structures.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for this use have low seepage potential, which is determined by permeability and by depth to underlying fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material that is resistant to seepage, erosion, and piping and is of favorable stability, shrink-swell potential, shear strength, and compaction characteristics. Stones and organic matter in a soil downgrade the suitability of a soil for use in embankments, dikes, and levees.

An *aquifer-fed excavated pond* is a body of water created by excavating a pit or dugout into a groundwater aquifer. Excluded are ponds that are fed by surface runoff, and embankment ponds that impound water 3 feet or more above the original surface. Ratings in table 7 are for ponds that are properly designed, located, and constructed. Soil properties and site features that affect aquifer-fed ponds are depth to a permanent water table, permeability of the aquifer, water quality, and ease of excavation.

Drainage of soil is affected by such soil properties as permeability, texture, structure, depth to claypan or other layers that influence rate of water movement, depth to the water table, slope, stability of ditchbanks, susceptibility to flooding, salinity and alkalinity, and availability of drainage outlets.

Irrigation is affected by such features as slope, susceptibility to flooding, hazards of water erosion and soil blowing, texture, presence of salts and alkali,

depth of root zone, rate of water intake at the surface, permeability of the soil below the surface layer, available water capacity, need for drainage, and depth to the water table.

Terraces and diversions are embankments, or a combination of channels and ridges, constructed across a slope to intercept runoff and to allow water to soak into the soil or flow slowly to an outlet. Features that affect suitability of a soil for terraces are uniformity of slope and steepness, depth to bedrock or other unfavorable material, permeability, ease of establishing vegetation, and resistance to water erosion, soil blowing, soil slipping, and piping.

Grassed waterways are constructed to channel runoff to outlets at nonerosive velocities. Features that affect the use of soils for waterways are slope, permeability, erodibility, and suitability for permanent vegetation.

Recreation

The soils in the survey area are rated in table 8 according to limitations that affect their suitability for camp areas, picnic areas, playgrounds, and paths and trails. The ratings are based on such restrictive soil features as flooding, wetness, slope, and texture of the surface layer. Not considered in these ratings, but important in evaluating a site, are location and accessibility of the area, size and shape of the area, scenic quality of an area, the ability of the soil to support vegetation, access to water, potential water impoundment sites available, and either access to public sewerlines or capacity of the soil to absorb septic tank effluent. Soils subject to flooding are limited, in varying degrees, for recreational use by the duration of flooding and the season when it occurs. Onsite assessment of height, duration, and frequency of flooding is essential in planning recreational facilities.

In table 8 the limitations of soils are rated as slight, moderate, or severe. *Slight* means that the soil properties are generally favorable and that the limitations are minor and easily overcome. *Moderate* means that the limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or by a combination of these measures.

The information in table 8 can be supplemented by additional information in other parts of this survey. Especially helpful are interpretations for septic tank absorption fields, given in table 5, and interpretations for dwellings without basements and for local roads and streets, given in table 4.

Camp areas require preparation that includes shaping and leveling tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and to some vehicular traffic. The best soils for this use have mild slopes and are neither wet nor subject to flooding during the period of use. The surface has few or no stones or boulders, absorbs rainfall readily but remains firm, and is not dusty when dry. Strong slopes and stones or boulders can greatly increase the cost of constructing camping sites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for use as picnic areas are firm when wet, are not dusty when dry, and are not subject to flooding during the period of use. They do not have slopes or stones or boulders that will increase the cost of shaping sites or of building access roads and parking areas.

Playgrounds require soils that can withstand intensive foot traffic. The best soils are almost level and not wet nor subject to flooding during the season of use. The surface is free of stones or boulders, is firm after rains, and is not dusty when dry. If shaping is required to obtain a uniform grade, the depth of the soil to the underlying rock should be sufficient to allow necessary grading.

The design and layout of paths and trails for walking, horseback riding, and bicycling should require little or no cutting and filling. The best soils for this use are those that are not wet, are firm after rains, are not dusty when dry, and are not subject to flooding more than once during the period of use. They should have moderate slopes and have few or no stones or boulders on the surface.

Wildlife habitat

Soils directly affect the kind and amount of vegetation that is available to wildlife as food and cover, and they affect the development of water impoundments. The kind and abundance of wildlife that populate an area depend largely on the amount and distribution of food, cover, and water. If any one of these elements is missing, inadequate, or inaccessible, wildlife will either be scarce or will not inhabit the area.

If the soils have the potential, wildlife habitat can be created or improved by planting appropriate vegetation, by properly managing the existing plant cover, and by fostering the natural establishment of desirable plants.

In table 9 the soils in the survey area are rated according to their potential to support the main kinds of wildlife habitat in the area. This information can be used in—

1. Planning the use of parks, wildlife refuges, nature study areas, and other developments for wildlife.
2. Selecting soils that are suitable for creating, improving, or maintaining specific elements of wildlife habitat.
3. Determining the intensity of management needed for each element of the habitat.
4. Determining areas that are suitable for acquisition to manage for wildlife.

The potential of the soil is rated good, fair, poor, or very poor. A rating of *good* means that the element of wildlife habitat or the kind of habitat is easily created, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected if the soil is used for the designated purpose. A rating of *fair* means that the element of wildlife habitat or kind of habitat can be created, im-

TABLE 8.—*Recreational development*

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry means soil was not rated]

Map symbol and soil name	Camp areas	Picnic areas	Playgrounds	Paths and trails
1D3: Ida	Moderate: slope	Moderate: slope	Severe: slope	Slight.
1E3: Ida	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
1F3: Ida	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
5B: Kennebec part	Severe: floods	Moderate: floods	Moderate: floods	Moderate: too clayey.
Ackmore part	Severe: floods, wetness.	Moderate: floods, wetness.	Moderate: floods, percs slowly, wetness.	Moderate: floods, wetness.
C5B: Kennebec part	Severe: floods	Moderate: floods	Moderate: floods	Moderate: too clayey.
Ackmore part	Severe: floods, wetness.	Moderate: floods, wetness.	Moderate: floods, percs slowly, wetness.	Moderate: floods, wetness.
6: Okoboji	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
8C: Judson	Moderate: too clayey	Moderate: too clayey	Moderate: slope, too clayey.	Moderate: too clayey.
9B, 9B2: Marshall	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey, slope.	Moderate: too clayey.
9C, 9C2: Marshall	Moderate: too clayey	Moderate: too clayey	Severe: slope	Moderate: too clayey.
9D2, 9D3: Marshall	Moderate: too clayey, slope.	Moderate: too clayey, slope.	Severe: slope	Moderate: too clayey.
10D3: Monona	Moderate: slope	Moderate: slope	Severe: slope	Slight.
10E3: Monona	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
11B: Colo part	Severe: floods, wetness.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
Ely part	Severe: floods	Moderate: wetness, too clayey.	Moderate: wetness, too clayey, slope.	Moderate: wetness, too clayey.
24C2: Shelby	Moderate: percs slowly.	Slight	Severe: slope	Slight.
24D2: Shelby	Moderate: percs slowly, slope.	Moderate: slope	Severe: slope	Slight.
24E2: Shelby	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
26B: Kennebec	Severe: floods	Moderate: floods	Moderate: floods	Moderate: too clayey.
27C: Terril	Slight	Slight	Moderate: slope	Slight.

TABLE 8.—*Recreational development*—Continued

Map symbol and soil name	Camp areas	Picnic areas	Playgrounds	Paths and trails
31: Afton	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
33E: Steinauer	Moderate: percs slowly, slope.	Moderate: slope	Severe: slope	Slight.
33F: Steinauer	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
41D: Sparta	Moderate: too sandy, slope.	Moderate: too sandy, slope.	Severe: slope	Moderate: too sandy.
54: Zook	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
55: Nicollet	Slight	Slight	Moderate: slope	Slight.
62C, 62D: Storden	Moderate: slope	Moderate: slope	Severe: slope	Slight.
62E, 62F: Storden	Severe: slope	Severe: slope	Severe: slope	Moderate: slope.
62G: Storden	Severe: slope	Severe: slope	Severe: slope	Severe: slope.
73C: Salida	Moderate: too sandy	Moderate: too sandy	Severe: slope	Moderate: too sandy.
73D: Salida	Moderate: slope, too sandy.	Moderate: slope, too sandy.	Severe: slope	Moderate: too sandy.
77B, 77B2, 78B, 78B2: Sac	Moderate: too clayey.	Moderate: too clayey	Moderate: too clayey, slope.	Moderate: too clayey.
77C, 77C2, 78C, 78C2: Sac	Moderate: too clayey.	Moderate: too clayey	Severe: slope	Moderate: too clayey.
91: Primghar	Moderate: too clayey, wetness.	Moderate: too clayey	Moderate: too clayey, wetness.	Moderate: wetness, too clayey.
92: Marcus	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
95: Harps	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
107: Webster	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
108: Wadena	Slight	Slight	Slight	Slight.
108B: Wadena	Slight	Slight	Moderate: slope	Slight.
108C2: Wadena	Moderate: slope	Moderate: slope	Severe: slope	Slight.
133: Colo	Severe: floods, wetness.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
134: Zook	Severe: wetness, floods, too clayey.	Severe: wetness, floods, too clayey.	Severe: wetness, floods, too clayey.	Severe: wetness, too clayey.

TABLE 8.—*Recreational development*—Continued

Map symbol and soil name	Camp areas	Picnic areas	Playgrounds	Paths and trails
135, 135B: Coland	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: wetness.
138B: Clarion	Slight	Slight	Moderate: slope	Slight.
138C, 138C2: Clarion	Slight	Slight	Severe: slope	Slight.
138D2: Clarion	Moderate: slope	Moderate: slope	Severe: slope	Slight.
174B: Bolan	Slight	Slight	Moderate: slope	Slight.
174C2: Bolan	Slight	Slight	Severe: slope	Slight.
174D2: Bolan	Moderate: slope	Moderate: slope	Severe: slope	Slight.
201B: Coland part	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.
Spillville part	Severe: floods	Moderate: floods	Moderate: floods, slope.	Moderate: floods.
C201B: Coland part	Severe: floods, wetness, percs slowly.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.
Spillville part	Severe: floods	Moderate: floods	Moderate: floods, slope.	Moderate: floods.
202, 203: Cylinder	Slight	Slight	Moderate: wetness	Moderate: wetness.
221: Palms	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.	Severe: wetness, floods, excess humus.
234: Nishna	Severe: floods, too clayey, wetness.	Severe: wetness, too clayey.	Severe: wetness, floods, too clayey.	Severe: wetness, too clayey.
236B: Lester	Slight	Slight	Moderate: slope	Slight.
259: Biscay	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
274: Rolfe	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
308: Wadena	Slight	Slight	Slight	Slight.
308B: Wadena	Slight	Slight	Moderate: slope	Slight.
310: Galva	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey.
310B, 310B2: Galva	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey, slope.	Moderate: too clayey.
310C, 310C2: Galva	Moderate: too clayey	Moderate: too clayey	Severe: slope	Moderate: too clayey.

TABLE 8.—*Recreational development*—Continued

Map symbol and soil name	Camp areas	Picnic areas	Playgrounds	Paths and trails
T310: Galva	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey.
T310B: Galva	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey	Moderate: too clayey.
315: Alluvial land	Severe: floods	Severe: floods	Severe: floods	Moderate: floods.
323B: Terril	Slight	Slight	Moderate: slope	Slight.
325: Le Sueur	Moderate: wetness	Slight	Moderate: slope	Slight.
354: Marsh	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
384: Collinwood	Severe: too clayey	Severe: too clayey	Severe: wetness, too clayey.	Severe: too clayey.
390: Waldorf	Severe: wetness, percs slowly, too clayey.	Severe: wetness, too clayey.	Severe: wetness, percs slowly, too clayey.	Severe: wetness, too clayey.
397B: Letri	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
428: Ely	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.	Moderate: wetness, too clayey.
430, 430B: Ackmore	Severe: floods, wetness.	Moderate: floods, wetness.	Moderate: floods, percs slowly, wetness.	Moderate: floods, wetness.
485, 485B: Spillville	Severe: floods	Severe: floods	Severe: floods	Moderate: floods.
506: Wacousta	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
507: Canisteo	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
511: Blue Earth	Severe: wetness, floods.	Severe: wetness	Severe: wetness, floods.	Severe: wetness.
559: Talcot	Severe: wetness	Severe: wetness	Severe: wetness	Severe: wetness.
577C2: Everly	Moderate: too clayey	Moderate: too clayey	Severe: slope	Moderate: too clayey.
577D2: Everly	Moderate: too clayey, slope.	Moderate: too clayey, slope.	Severe: slope	Moderate: too clayey.
606: Lanyon	Severe: wetness	Severe: too clayey, wetness.	Severe: percs slowly, wetness, too clayey.	Severe: too clayey, wetness.
733: Calco	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness.
823B: Flagler	Slight	Slight	Moderate: slope	Slight.
823C2: Flagler	Slight	Slight	Severe: slope	Slight.

TABLE 9.—*Wildlife habitat potentials*

[See text for definitions of "good," "fair," "poor," and "very poor." Absence of an entry indicates the soil was not rated]

Map symbol and soil name	Potential for habitat elements							Potential as habitat for—		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
1D3:										
Ida	Fair	Good	Good	Fair	Fair	Very poor	Very poor	Good	Fair	Very poor.
1E3:										
Ida	Fair	Good	Good	Fair	Fair	Very poor	Very poor	Good	Fair	Very poor.
1F3:										
Ida	Poor	Fair	Good	Poor	Poor	Very poor	Very poor	Fair	Poor	Very poor.
5B:										
Kennebec part	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
Ackmore part	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
C5B:										
Kennebec part	Poor	Poor	Good	Good	Good	Poor	Very poor	Poor	Good	Very poor.
Ackmore part	Poor	Poor	Good	Good	Good	Fair	Fair	Poor	Good	Fair.
6:										
Okoboji	Fair	Fair	Fair	Poor	Very poor	Good	Good	Fair	Poor	Good.
8C:										
Judson	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Poor.
9B, 9B2, 9C, 9C2, 9D2, 9D3:										
Marshall	Good	Good	Good	Good	Good	Poor	Very poor	Good	Fair	Poor.
10D3:										
Monona	Good	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
10E3:										
Monona	Fair	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
11B:										
Colo part	Good	Fair	Good	Fair	Poor	Good	Fair	Good	Fair	Fair.
Ely part	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Poor.
24C2, 24D2:										
Shelby	Fair	Good	Good	Good	Good	Very poor	Very poor	Fair	Good	Very poor.
24F2:										
Shelby	Poor	Fair	Fair	Fair	Fair	Very poor	Very poor	Fair	Fair	Very poor.
26B:										
Kennebec	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
27C:										
Terril	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
31:										
Afton	Good	Fair	Good	Fair	Poor	Good	Fair	Good	Fair	Fair.

TABLE 9.—*Wildlife habitat potentials*—Continued

Map symbol and soil name	Potential for habitat elements							Potential as habitat for—		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
33E, 33F: Steinauer	Poor	Fair	Good	Fair	Poor	Very poor	Very poor	Fair	Fair	Very poor.
41D: Sparta	Poor	Fair	Fair	Fair	Fair	Very poor	Very poor	Fair	Fair	Very poor.
54: Zook	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
55: Nicollet	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
62C, 62D, 62E: Storden	Fair	Good	Good	Fair	Poor	Very poor	Very poor	Fair	Fair	Very poor.
62F, 62G: Storden	Poor	Fair	Good	Poor	Poor	Very poor	Very poor	Fair	Fair	Very poor.
73C, 73D: Salida	Poor	Poor	Poor	Poor	Poor	Very poor	Very poor	Poor	Poor	Very poor.
77B, 77B2, 78B, 78B2: Sac	Good	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
77C, 77C2, 78C, 78C2: Sac	Good	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
91: Primghar	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
92: Marcus	Good	Fair	Good	Fair	Poor	Good	Fair	Good	Fair	Fair.
95: Harps	Good	Fair	Fair	Fair	Poor	Good	Fair	Fair	Fair	Fair.
107: Webster	Good	Fair	Good	Fair	Poor	Good	Fair	Good	Fair	Fair.
108, 108B: Wadena	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
108C2: Wadena	Fair	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
133: Colo	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
134: Zook	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
135: Coland	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
135B: Coland	Good	Fair	Good	Fair	Poor	Fair	Poor	Fair	Fair	Very poor.

TABLE 9.—*Wildlife habitat potentials*—Continued

Map symbol and soil name	Potential for habitat elements							Potential as habitat for—		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
138B: Clarion	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
138C, 138C2, 138D2: Clarion	Good	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
174B: Bolan	Good	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
174C2, 174D2: Bolan	Fair	Fair	Good	Good	Good	Very poor	Very poor	Fair	Good	Very poor.
201B: Coland part	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
Spillville part	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
C201B: Coland part	Poor	Poor	Good	Fair	Poor	Poor	Very poor	Poor	Fair	Good.
Spillville part	Poor	Poor	Good	Good	Good	Poor	Very poor	Poor	Good	Very poor.
202, 203: Cylinder	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
221: Palms	Good	Poor	Poor	Poor	Very poor	Good	Good	Fair	Poor	Good.
234: Nishna	Good	Fair	Fair	Poor	Very poor	Good	Good	Fair	Poor	Good.
236B: Lester	Good	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
259: Biscay	Good	Fair	Good	Fair	Poor	Good	Poor	Fair	Fair	Fair.
274: Rolfe	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
308, 308B: Wadena	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
310, 310B, 310B2: Galva	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
310C, 310C2: Galva	Good	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
T310, T310B: Galva	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
315: Alluvial land	Poor	Fair	Fair	Fair	Poor	Good	Fair	Fair	Fair	Fair.

TABLE 9.—*Wildlife habitat potentials*—Continued

Map symbol and soil name	Potential for habitat elements							Potential as habitat for—		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
323B: Terril	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
325: Le Sueur	Good	Good	Good	Good	Good	Fair	Poor	Good	Good	Poor.
354: Marsh	Very poor	Very poor	Very poor	Very poor	Very poor	Good	Good	Very poor	Very poor	Good.
384: Collinwood	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
390: Waldorf	Fair	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
397B: Letri	Fair	Fair	Good	Fair	Poor	Fair	Poor	Fair	Fair	Poor.
428: Ely	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
430, 430B: Ackmore	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
485: Spillville	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
485B: Spillville	Good	Good	Good	Good	Good	Poor	Very poor	Good	Good	Very poor.
506: Wacousta	Fair	Fair	Fair	Poor	Very poor	Good	Good	Poor	Poor	Good.
507: Canisteo	Good	Fair	Good	Poor	Very poor	Good	Fair	Fair	Poor	Fair.
511: Blue Earth	Fair	Fair	Fair	Poor	Very poor	Good	Good	Fair	Poor	Good.
559: Talcot	Fair	Fair	Good	Fair	Poor	Good	Poor	Fair	Poor	Fair.
577C2, 577D2: Everly	Fair	Good	Good	Good	Good	Very poor	Very poor	Good	Good	Very poor.
606: Lanyon	Fair	Fair	Fair	Poor	Poor	Good	Good	Fair	Poor	Good.
733: Calco	Good	Fair	Good	Poor	Very poor	Good	Fair	Fair	Poor	Fair.
823B, 823C2: Flagler	Fair	Fair	Fair	Fair	Fair	Very poor	Very poor	Fair	Fair	Very poor.

proved, or maintained in most places. Moderate intensity of management and fairly frequent attention are required for satisfactory results. A rating of *poor* means that limitations are severe for the designated element or kind of wildlife habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and requires intensive effort. A rating of *very poor* means that restrictions for the element of wildlife habitat or kind of wildlife are very severe, and that unsatisfactory results can be expected. Wildlife habitat is impractical or even impossible to create, improve, or maintain on soils having such a rating.

The elements of wildlife habitat are briefly described in the following paragraphs.

Grain and seed crops are seed-producing annuals used by wildlife. Examples are corn, sorghum, wheat, oats, barley, millet, buckwheat, cowpeas, soybeans, and sunflowers. The major soil properties that affect the growth of grain and seed crops are depth of the root zone, texture of the surface layer, available water capacity, wetness, slope, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations.

Grasses and legumes are domestic perennial grasses and herbaceous legumes that are planted for wildlife food and cover. Examples are fescue, bluegrass, lovegrass, switchgrass, bromegrass, timothy, orchardgrass, clover, alfalfa, trefoil, and crownvetch. Major soil properties that affect growth of grasses and legumes are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, flood hazard, and slope. Soil temperature and soil moisture are also considerations.

Wild herbaceous plants are native or naturally established herbaceous grasses and forbs, including weeds, that provide food and cover for wildlife. Examples are bluestem, indiangrass, goldenrod, beggarweed, pokeweed, partridgepea, wheatgrass, fescue, and grama. Major soil properties that affect the growth of these plants are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations.

Hardwood trees and the associated woody understory provide cover for wildlife and produce nuts or other fruit, buds, catkins, twigs, bark, or foliage that wildlife eat. Examples of native plants are oak, poplar, cherry, sweetgum, apple, hawthorn, dogwood, persimmon, sassafras, sumac, hickory, hazelnut, black walnut, blackberry, grape, blackhaw, viburnum, blueberry, bayberry, and briers. Examples of fruit-producing shrubs that are commercially available and suitable for planting on soils rated good are Russian-olive, autumn-olive, and crabapple. Major soil properties that affect growth of hardwood trees and shrubs are depth of the root zone, available water capacity, and wetness.

Coniferous plants are cone-bearing trees, shrubs, or ground cover that furnish habitat or that supply food in the form of browse, seeds, or fruitlike cones. Examples are pine, spruce, hemlock, fir, yew, cedar, and juniper. Major soil properties that affect the growth of coniferous plants are depth of the root zone, available water capacity, and wetness.

Wetland plants are annual and perennial wild herbaceous plants that grow on moist or wet sites, exclusive of submerged or floating aquatics. They produce food or cover for wildlife that use wetland as habitat. Examples of wetland plants are smartweed, wild millet, rushes, sedges, reeds, wildrice, saltgrass, cordgrass, and cattail. Major soil properties affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness.

Shallow water areas are bodies of surface water that have an average depth of less than 5 feet and are useful to wildlife. They can be naturally wet areas, or they can be created by dams or levees or by water-control devices in marshes or streams. Examples are muskrat marshes, waterfowl feeding areas, wildlife watering developments, beaver ponds, and other wildlife ponds. Major soil properties affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slopes, and permeability. The availability of a dependable water supply is important if water areas are to be developed.

The kinds of wildlife habitat are briefly described in the following paragraphs.

Openland wildlife habitat consists of croplands, pastures, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. The kinds of wildlife attracted to these areas include bobwhite quail, pheasant, meadowlark, field sparrow, killdeer, cottontail rabbit, red fox, and woodchuck.

Woodland wildlife habitat consists of hardwoods or conifers or a mixture of both, with associated grasses, legumes, and wild herbaceous plants. Examples of wildlife attracted to this habitat are wild turkey, ruffed grouse, woodcock, thrushes, vireos, woodpeckers, tree squirrels, grey fox, raccoon, deer, elk, and black bear.

Wetland wildlife habitat consists of water-tolerant plants in open, marshy, or swampy shallow water areas. Examples of wildlife attracted to this habitat are ducks, geese, herons, shore birds, rails, kingfishers, muskrat, mink, and beaver.

Soil properties

Extensive data about soil properties collected during the soil survey are summarized on the following pages. The two main sources of these data are the many soil borings made during the course of the survey and the laboratory analyses of samples selected from representative soil profiles in the field.

When the soil scientist makes soil borings during field mapping, he can identify several important soil properties. He notes the seasonal soil moisture condition, or the presence of free water and its depth in the profile. For each horizon, he notes the thickness of the soil and its color; the texture, or the amount of clay, silt, sand, and gravel or other coarse fragments; the structure, or natural pattern of cracks and pores in the undisturbed soil; and the consistence of soil in-place under the existing soil moisture conditions. He records the root depth of existing plants,

determines soil pH or reaction, and identifies any free carbonates.

Samples of soil material are analyzed in the laboratory to verify the field estimates of soil properties and to characterize key soils, especially properties that cannot be estimated accurately by field observation. Laboratory analyses are not conducted for all soil series in the survey area, but laboratory data for many of the soil series are available from nearby areas (*14*).

Based on summaries of available field and laboratory data, and listed in tables in this section, are estimated ranges in engineering properties and classifications, and in physical and chemical properties for some major horizon of each soil in the survey area. Also, pertinent soil and water features, engineering test data, and data obtained from laboratory analyses, both physical and chemical, are presented.

Engineering properties

Table 10 gives estimates of engineering properties and classifications for the major horizons of each soil in the survey area. These estimates are presented as ranges in values most likely to exist in areas where the soil is mapped.

Most soils have, within the upper 5 or 6 feet, horizons of contrasting properties. Information is presented for each of these contrasting horizons. Depth to the upper and lower boundaries of each horizon in a typical profile of each soil is indicated. More information about the range in depth and in properties of each horizon is given for each soil series in "Descriptions of the Soils."

Texture is described in table 10 in standard terms used by the United States Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If a soil contains gravel or other particles coarser than sand, an appropriate modifier is added, for example, "gravelly loam." Other texture terms used by USDA are defined in the Glossary.

The two systems commonly used in classifying soils for engineering use are the Unified soil classification system (*2*) and the American Association of State Highway and Transportation Officials soil classification system (AASHTO) (*1*). In table 10, soils in the survey area are classified according to both systems.

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 3 inches in diameter, plasticity index, liquid limit, and organic matter content. Soils are grouped into 15 classes—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 have a dual classification symbol, for example CL–ML.

The AASHTO system classifies soils according to those properties that affect their use in highway construction and maintenance. In this system a mineral soil is classified as one of seven basic groups ranging from A–1 through A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A–1 are coarse grained and low in content of fine grains. At the other extreme, in group A–7, are fine-grained soils. Highly organic soils are classified as A–8 on the basis of visual inspection.

If laboratory data are available, the A–1, A–2, and A–7 groups are further classified 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 an additional refinement, the desirability of soils as subgrade material can be indicated by a group index number. These numbers range from 0 for the best subgrade material to 20 or more for the poorest. The estimated classification, without group index numbers, is given in table 10.

Also in table 10 the percentage, by weight, of cobbles or the rock fragments more than 3 inches in diameter are estimated for each major horizon. These estimates are determined largely by observing volume percentage in the field and then converting it, by formula, to weight percentage.

Percentage of the soil material less than 3 inches in diameter that passes each of four standard sieves is estimated for each major horizon. The estimates are based on tests of soils that were sampled in the survey area and in nearby areas, and on field estimates from many borings made during the survey.

Liquid limit and plasticity index indicate the effect of water on the strength and consistency of soil. These indexes are used in both the Unified and the AASHTO soil classification systems. They are also used as indicators in making general predictions of soil behavior.

Range in liquid limit and plasticity index are estimated on the basis of test data from the survey area or from nearby areas and on observations of the many soil borings made during the survey.

Physical and chemical properties

Table 11 shows estimated values for several soil characteristics and features that affect behavior of soils in engineering uses. These estimates are given for each major horizon, at the depths indicated, in the representative profile of each soil. The estimates are based on field observations and on test data for these and similar soils.

Permeability is estimated on the basis of known relationships between the soil characteristics observed in the field—particularly soil structure, porosity, and gradation or texture—that influence the downward movement of water in the soil. The estimates are for water movement in a vertical direction when the soil is saturated. Not considered in the estimates are lateral seepage or such transient soil features as plowpans and surface crusts. Permeability of the soil is an important factor to be considered in the planning and design of drainage systems, in evaluating the potential of soils for septic tank systems and other waste disposal systems, and in many other aspects of land use and management.

Available water capacity is rated on the basis of soil characteristics that influence the ability of the soil to hold water and make it available to plants. Important characteristics are organic matter content, soil texture, and soil structure. Shallow-rooted plants are not

likely to use the available water from the deeper soil horizons. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design of irrigation systems.

Soil reaction is expressed as range in pH values. The range in pH of each major horizon is based on many field checks. For many soils, the values have been verified by laboratory analyses. Soil reaction is important in selecting the crops and ornamental or other plants to be grown, in evaluating the corrosivity of soils.

Shrink-swell potential depends mainly on the amount and kind of clay in the soil. Laboratory measurements of the swelling of undisturbed clods were made for many soils. For others it was estimated on the basis of the kind of clay and on measurements of similar soils. Size of imposed loadings and the magnitude of changes in soil moisture content are also important factors that influence the swelling of soils. Shrinking and swelling of some soils can cause damage to building foundations, basement walls, roads, and other structures unless special designs are used. A *high* shrink-swell potential indicates that special design and added expense may be required if the planned use of the soil will not tolerate large volume changes.

Risk of corrosion, as used in table 11, pertains to potential soil-induced chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to soil moisture, particle-size distribution, total acidity, and electrical conductivity of the soil material. The rating of soils for corrosivity to concrete is based mainly on the sulfate content, soil texture, and acidity. Protective measures for steel or more resistant concrete help to avoid or minimize damage resulting from the corrosion. Installations of steel that intersect soil boundaries or soil horizons are more susceptible to corrosion than installations entirely within one kind of soil or within one soil horizon.

Erosion factors are used to predict the erodibility of a soil and its tolerance to erosion in relation to specific kinds of land use and treatment. The soil erodibility factor (K) is a measure of the susceptibility of the soil to erosion by water. Soils having the highest K values are the most erodible. K values range from 0.10 to 0.64. To estimate annual soil loss per acre, the K value of a soil is modified by factors representing plant cover, grade and length of slope, management practices, and climate. The soil-loss tolerance factor (T) is the maximum rate of soil erosion, whether from rainfall or soil blowing, that can occur without reducing crop production or environmental quality. The rate is expressed in tons of soil loss per acre per year.

Wind erodibility groups are made up of soils that have similar properties that affect their resistance to soil blowing if cultivated. The groups are used to predict the susceptibility of soil to blowing and the amount of soil lost as a result of blowing. Soils are grouped according to the following distinctions:

1. Sands, coarse sands, fine sands, and very fine sands. These soils are extremely erodible, so vegetation is difficult to establish. They are generally not suitable for crops.

2. Loamy sands, loamy fine sands, and loamy very fine sands. These soils are very highly erodible, but crops can be grown if intensive measures to control soil blowing are used.

3. Sandy loams, coarse sandy loams, fine sandy loams, and very fine sandy loams. These soils are highly erodible, but crops can be grown if intensive measures to control soil blowing are used.

4L. Calcareous loamy soils that are less than 35 percent clay and more than 5 percent finely divided calcium carbonate. These soils are erodible, but crops can be grown if intensive measures to control soil blowing are used.

4. Clays, silty clays, clay loams, and silty clay loams that are more than 35 percent clay. These soils are moderately erodible, but crops can be grown if measures to control soil blowing are used.

5. Loamy soils that are less than 18 percent clay and less than 5 percent finely divided calcium carbonate and sandy clay loams and sandy clays that are less than 5 percent finely divided calcium carbonate. These soils are slightly erodible, but crops can be grown if measures to control soil blowing are used.

6. Loamy soils that are 18 to 35 percent clay and less than 5 percent finely divided calcium carbonate, except silty clay loams. These soils are very slightly erodible, and crops can easily be grown.

7. Silty clay loams that are less than 35 percent clay and less than 5 percent finely divided calcium carbonate. These soils are very slightly erodible, and crops can easily be grown.

8. Stony or gravelly soils and other soils not subject to soil blowing.

Soil and water features

Features that relate to runoff or infiltration of water, to flooding, to grading and excavation, and to subsidence and frost action of each soil are indicated in table 12. This information is helpful in planning land use and engineering projects that are likely to be affected by the amount of runoff from watersheds, by flooding and a seasonal high water table, by the presence of bedrock or a cemented pan in the upper 5 or 6 feet of the soil, by subsidence, or by frost action.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are placed in one of four groups on the basis of the intake of water after the soils have been wetted and have received precipitation from long-duration storms. The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist chiefly of deep, well drained to excessively drained sands or gravels. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep to deep, moderately well drained to well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils that have a layer that impedes the downward movement of water of soils that have moderately fine texture or fine

TABLE 10.—*Engineering properties*

[The symbol < means less than; > means greater than.

Map symbol and soil name	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
1D3, 1E3, 1F3:				
Ida	0–60	Silt loam	ML, CL	A–4, A–6
5B:				
Kennebec part	0–46	Silty clay loam	CL, ML	A–6, A–7
	46–60	Silt loam, silty clay loam	CL, ML	A–6, A–7, A–4
Ackmore part	0–35	Silt loam	CL, ML	A–4, A–6, A–7
	35–70	Silty clay loam, silt loam	CH, CL, MH	A–7, A–6
C5B:				
Kennebec part	0–46	Silty clay loam	CL, ML	A–6, A–7
	46–60	Silt loam, silty clay loam	CL, ML	A–6, A–7, A–4
Ackmore part	0–35	Silt loam	CL, ML	A–4, A–6, A–7
	35–70	Silty clay loam, silt loam	CH, CL, MH	A–7, A–6
6:				
Okoboji	0–31	Silty clay loam	MH, CH	A–7
	31–60	Silty clay loam	CH, MH, CL	A–7
8C:				
Judson	0–25	Silty clay loam	CL	A–6, A–7
	25–93	Silty clay loam, silt loam	CL	A–6, A–7
9B, 9B2, 9C, 9C2, 9D2, 9D3:				
Marshall	0–12	Silty clay loam	CL	A–6, A–7
	12–67	Silty clay loam	CL, CH	A–7
	67–85	Silt loam	CL	A–7, A–6
10D3, 10E3:				
Monona	0–9	Silt loam	ML, CL	A–6, A–7
	9–35	Silt loam, silty clay loam	ML, CL	A–6, A–7
	35–60	Silt loam	ML, CL	A–6, A–7
11B:				
Colo part	0–47	Silty clay loam	CL, CH, ML, MH	A–7
	47–62	Silty clay loam	CL, CH	A–7
Ely part	0–26	Silty clay loam	CL, ML, CH, MH	A–7, A–6
	26–52	Silty clay loam	CL	A–7, A–6
	52–84	Silt loam, clay loam, loam	CL	A–6
24C2, 24D2, 24E2:				
Shelby	0–14	Loam	CL	A–6
	14–36	Clay loam	CL	A–6, A–7
	36–76	Clay loam	CL	A–6, A–7
26B:				
Kennebec	0–46	Silty clay loam	CL, ML	A–6, A–7
	46–72	Silt loam, silty clay loam	CL, ML	A–6, A–7, A–4
27C:				
Terril	0–31	Loam	OL, CL	A–4, A–6
	31–73	Loam, clay loam	CL	A–4, A–6
31:				
Afton	0–25	Silty clay loam	MH, CH	A–7
	25–48	Silty clay loam	CL, CH	A–7
	48–60	Clay loam, silt loam, silty clay loam	CL	A–6, A–7

and classifications

Absence of an entry means data were not estimated]

Fragments > 3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	100	100	100	95–100	30–40	5–15
0	100	100	95–100	90–100	30–50	10–20
0	100	100	95–100	90–100	30–50	5–20
0	100	100	95–100	85–100	25–50	8–20
0	100	100	95–100	85–100	35–65	15–30
0	100	100	95–100	90–100	30–50	10–20
0	100	100	95–100	90–100	30–50	5–20
0	100	100	95–100	85–100	25–50	8–20
0	100	100	95–100	85–100	35–65	15–30
0	100	100	90–100	80–95	50–85	20–50
0–5	95–100	95–100	90–100	80–95	45–80	20–50
0	100	100	100	95–100	30–50	10–25
0	100	100	100	95–100	30–50	10–25
0	100	100	100	95–100	35–50	15–25
0	100	100	100	95–100	45–60	20–30
0	100	100	100	95–100	35–50	15–30
0	100	100	95–100	95–100	35–50	10–25
0	100	100	95–100	95–100	35–50	10–25
0	100	100	95–100	95–100	30–45	10–20
0	100	100	90–100	90–100	40–65	20–35
0	100	100	90–100	90–100	40–60	20–35
0	100	100	95–100	95–100	30–55	10–25
0	100	100	95–100	95–100	35–50	10–25
0	100	100	90–100	85–100	25–40	10–20
0	90–100	85–98	75–90	55–70	30–40	11–20
0	90–100	85–98	75–90	55–70	35–45	15–25
0	90–100	85–98	75–90	55–70	35–45	15–25
0	100	100	95–100	90–100	30–50	10–20
0	100	100	95–100	90–100	30–50	5–20
0–5	100	95–100	70–90	50–70	25–40	8–15
0–5	100	90–100	70–90	50–70	25–40	8–15
0	100	100	100	95–100	50–65	20–35
0	100	100	100	95–100	40–60	20–35
0	100	95–100	80–100	60–90	35–50	20–30

TABLE 10.—*Engineering properties*

Map symbol and soil name	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
33E, 33F:				
Steinauer	0–5	Loam	ML, CL,	A–4, A–6
	5–73	Clay loam	CL, CH	A–6, A–7
41D:				
Sparta	0–60	Loamy fine sand	SM, SP–SM	A–2
54:				
Zook	0–20	Silty clay loam	MH, CH, CL, OL	A–7
	20–60	Silty clay, silty clay loam	CH	A–7
55:				
Nicollet	0–14	Loam	OL, ML, CL	A–6, A–7, A–4
	14–45	Clay loam	CL	A–6, A–7
	45–69	Loam	CL, ML	A–6, A–4
62C, 62D, 62E, 62F, 62G:				
Storden	0–5	Loam	ML, CL	A–4, A–6
	5–60	Loam	CL–ML, CL	A–4, A–6
73C, 73D:				
Salida	0–18	Gravelly loamy sand	SP–SM	A–1
	18–60	Sand and gravel	SP	A–1
77B, 77B2, 77C, 77C2, 78B, 78B2, 78C, 78C2:				
Sac	0–14	Silty clay loam	ML, CL	A–7
	14–28	Silty clay loam	CL, ML	A–7
	28–76	Clay loam, loam	CL, ML	A–6, A–7
91:				
Primghar	0–20	Silty clay loam	MH, CH	A–7
	20–44	Silty clay loam	CL, CH	A–7
	44–64	Silt loam	CL	A–6
92:				
Marcus	0–15	Silty clay loam	MH, CH	A–7
	15–40	Silty clay loam, silty clay	CH, MH	A–7
	40–60	Silt loam	CL	A–6, A–7
	57–62	Loam	CL	A–6
95:				
Harps	0–21	Loam	CL, CH	A–6, A–7
	21–42	Loam, clay loam, sandy clay loam	CL, CH	A–6, A–7
	42–70	Loam	CL	A–6
107:				
Webster	0–12	Silty clay loam	ML, MH, CL, CH	A–7
	12–25	Clay loam, silty clay loam	CL	A–6, A–7
	25–76	Loam, sandy loam, clay loam	CL, ML	A–6, A–7
108, 108B, 108C2:				
Wadena	0–13	Loam	CL, CL–ML	A–4
	13–27	Loam, sandy loam	SC, SM–SC, CL, CL–ML	A–4, A–6
	27–60	Sand and gravel	SP	A–1
133:				
Colo	0–47	Silty clay loam	CL, CH, ML, MH	A–7
	47–62	Silty clay loam	CL, CH	A–7
134:				
Zook	0–40	Silty clay	CH	A–7
	40–84	Silty clay, silty clay loam	CH	A–7

and classifications—Continued

Fragments > 3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0–5	95–100	95–100	85–95	60–70	25–40	4–15
0–5	95–100	95–100	90–100	70–90	30–55	15–30
0	100	100	60–70	10–20	----------	[1] NP
0	100	100	95–100	95–100	45–70	20–40
0	100	100	95–100	95–100	60–85	40–60
0	95–100	95–100	85–98	65–85	30–50	8–20
0	95–100	95–100	80–95	60–80	30–45	10–25
0	95–100	85–95	75–90	60–75	30–40	5–15
0–5	95–100	95–100	70–85	55–70	30–40	5–15
0–5	95–100	85–97	70–85	55–70	20–40	5–15
0	80–95	50–85	20–40	5–10	----------	NP
0	80–90	40–60	10–30	0–5	----------	NP
0	100	100	95–100	90–100	40–50	15–25
0	100	100	95–100	90–100	40–50	15–25
0	95–100	90–100	75–90	65–80	35–50	10–25
0	100	100	95–100	90–100	50–70	20–40
0	100	100	95–100	90–100	40–60	20–40
0	100	100	95–100	90–100	30–40	11–20
0	100	100	95–100	90–100	50–65	20–35
0	100	100	95–100	90–100	50–65	20–35
0	100	100	95–100	85–95	35–45	15–25
0–5	90–100	85–100	80–90	50–75	30–40	15–25
0–5	100	95–100	80–90	65–80	30–55	15–35
0–5	95–100	95–100	80–90	65–80	30–60	15–35
0–5	95–100	90–100	70–80	50–75	25–40	10–25
0–5	100	95–100	85–95	70–90	40–60	15–30
0–5	95–100	95–100	85–95	60–80	35–50	15–30
0–5	95–100	90–100	75–85	50–75	35–50	10–25
0	95–100	85–100	80–95	50–60	25–40	5–15
0	95–100	85–100	80–95	40–55	25–40	5–15
0	80–95	70–95	30–50	2–5	----------	NP
0	100	100	90–100	90–100	40–65	20–35
0	100	100	90–100	90–100	40–60	20–35
0	100	100	95–100	95–100	60–85	40–60
0	100	100	95–100	95–100	60–85	40–60

TABLE 10.—*Engineering properties*

Map symbol and soil name	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
135, 135B:				
Coland	0–42	Clay loam	OL, CL, CH, MH	A–6, A–7
	42–60	Loam, sandy loam, sandy clay loam	CL, SC	A–4, A–6
138B, 138C, 138C2, 138D2:				
Clarion	0–16	Loam	CL, CL–ML	A–4, A–6
	16–32	Loam, clay loam	CL, CL–ML	A–4, A–6
	32–60	Loam, sandy loam	CL, CL–ML	A–4, A–6
174B, 174C2, 174D2:				
Bolan	0–11	Loam	CL, ML	A–4, A–6
	11–24	Loam	CL, SC, CL–ML, SM–SC	A–4, A–6
	24–60	Fine sandy loam	SM, SM–SC, SC	A–4
201B:				
Coland part	0–42	Clay loam	OL, CL, CH, MH	A–6, A–7
	42–60	Loam, sandy loam, sandy clay loam	CL, SC	A–4, A–6
Spillville part	0–47	Loam	CL	A–6
	47–66	Sandy clay loam, loam, sandy clay	CL, SC	A–6, A–4
C201B:				
Coland part	0–42	Clay loam	OL, CL, CH, MH	A–6, A–7
	42–60	Loam, sandy loam, sandy clay loam	CL, SC	A–4, A–6
Spillville part	0–47	Loam	CL	A–6
	47–66	Sandy clay loam, loam, sandy clay loam	CL, SC	A–6, A–4
202, 203:				
Cylinder	0–14	Loam	CL	A–6, A–7
	14–34	Loam, clay loam, sandy clay loam	CL, ML	A–4, A–6, A–7
	34–60	Gravelly coarse sand, loamy sand	SP–SM, SM	A–1, A–2
221:				
Palms	0–24	Sapric material	Pt	
	24–60	Clay loam, loam, silt loam	CL–ML, CL	A–4, A–6
234:				
Nishna	0–48	Silty clay loam	CH, MH	A–7
	48–60	Silty clay, silty clay loam	CH	A–7
236B:				
Lester	0–14	Loam	CL, ML	A–6, A–4, A–7
	14–48	Clay loam	CL	A–7, A–6
	48–72	Loam, clay loam	CL, CL–ML	A–6, A–4
259:				
Biscay	0–12	Clay loam	CL, ML	A–7, A–6
	12–28	Loam, clay loam	CL, ML	A–6, A–7
	28–84	Stratified coarse sand to gravel	SP	A–1
274:				
Rolfe	0–17	Loam	OL, CL, ML	A–6, A–4
	17–47	Clay, silty clay, clay loam	CH, MH	A–7
	47–65	Clay loam, loam	CL	A–7, A–6

and classifications—Continued

Fragments > 3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	100	100	95–100	70–90	45–55	20–30
0	100	95–100	60–70	40–60	20–40	8–15
0–5	95–100	95–100	75–90	50–75	25–40	5–15
0–5	90–100	85–100	75–90	50–75	25–40	5–15
0–5	90–100	85–100	75–90	50–75	20–35	5–15
0	100	100	85–95	50–70	30–40	5–15
0	100	100	80–90	40–55	25–35	5–15
0	100	100	80–90	35–50	15–25	2–8
0	100	100	95–100	70–90	45–55	20–30
0	100	95–100	60–70	40–60	20–40	8–15
0	100	95–100	85–95	60–80	25–40	10–20
0	100	95–100	80–90	50–75	25–40	8–15
0	100	100	95–100	70–90	45–55	20–30
0	100	95–100	60–70	40–60	20–40	8–15
0	100	95–100	85–95	60–80	25–40	10–20
0	100	95–100	80–90	50–75	25–40	8–15
0–5	100	90–100	80–100	50–75	30–50	11–25
0–10	95–100	80–100	80–95	60–75	30–50	7–20
10–50	75–95	75–95	20–40	5–25	----------	NP
0	85–100	80–100	70–95	50–80	<30	5–15
0	100	100	95–100	90–100	55–65	25–35
0	100	100	95–100	90–100	60–70	30–40
0	95–100	90–100	80–95	50–70	30–45	5–15
0	95–100	90–100	80–95	55–75	35–45	15–25
0	95–100	90–100	75–90	50–70	20–40	5–20
0	95–100	95–100	70–90	50–75	35–50	10–25
0	95–100	90–100	70–90	50–75	30–45	10–25
0–5	65–90	60–80	20–45	2–5	----------	NP
0	100	95–100	90–100	80–95	30–40	5–15
0	100	95–100	90–100	75–95	50–70	15–35
0	95–100	90–100	80–90	55–75	30–50	10–25

TABLE 10.—*Engineering properties*

Map symbol and soil name	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
308, 308B:				
Wadena	0–13	Loam	CL, CL–ML	A–4
	13–35	Loam, sandy loam	SC, CL–ML, CL, SM–SC	A–4, A–6
	35–60	Sand and gravel	SP	A–1
310, 310B, 310B2, 310C, 310C2:				
Galva	0–16	Silty clay loam	ML, CL	A–7
	16–40	Silty clay loam	CL	A–7
	40–60	Silt loam, silty clay loam	CL	A–6, A–7
T310, T310B:				
Galva	0–11	Silty clay loam	CL, ML	A–7
	11–36	Silty clay loam	CL, ML	A–7
	36–50	Silt loam	CL	A–6, A–7
	50–60	Sand and gravel	SP–SM, SM	A–1, A–2
315:				
Alluvial land	0–60	Variable	----------	----------
323B:				
Terril	0–31	Loam	CL	A–4, A–6
	31–45	Loam, clay loam	CL	A–4, A–6
	45–60	Sand, gravelly sand	SP–SM, SM	A–2–4
325:				
Le Sueur	0–14	Loam	CL	A–6
	14–44	Clay loam	CL, CH	A–6, A–7
	44–60	Loam	CL–ML, CL	A–6, A–4
354:				
Marsh	0–60	Variable	----------	----------
384:				
Collinwood	0–23	Silty clay loam	OH, OL, CL, CH	A–7
	23–39	Silty clay, clay	MH, CH	A–7
	39–60	Silty clay, clay, silty clay loam	MH, CH	A–7
390:				
Waldorf	0–24	Silty clay loam	ML, MH	A–7
	24–47	Silty clay, silty clay loam	MH	A–7
	47–64	Silty clay loam, silty clay	MH, ML, CL, CH	A–7, A–6
397B:				
Letri	0–14	Silty clay loam	OL, CL	A–7
	14–34	Clay loam, silty clay loam	CL	A–7
	34–65	Loam, clay loam	CL, ML	A–6, A–7
428:				
Ely	0–26	Silty clay loam	CL, ML, CH, MH	A–7, A–6
	26–52	Silty clay loam	CL	A–7, A–6
	52–84	Silt loam, clay loam, loam	CL	A–6
430, 430B:				
Ackmore	0–35	Silt loam	CL, ML	A–4, A–6, A–7
	35–70	Silty clay loam, silt loam	CH, CL, MH	A–7, A–6
485, 485B:				
Spillville	0–47	Loam	CL	A–6
	47–66	Sandy clay loam, loam, sandy clay	CL, SC	A–6, A–4
506:				
Wacousta	0–15	Silty clay loam	CH, CL	A–7
	15–60	Silty clay loam	CH, CL	A–7

and classifications—Continued

Fragments > 3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	95–100	85–100	80–95	50–60	25–40	5–15
0	95–100	85–100	80–95	40–55	25–40	5–15
0	80–95	70–95	30–50	2–5	----------	NP
0	100	100	95–100	90–100	40–50	15–25
0	100	100	95–100	90–100	40–50	15–25
0	100	100	95–100	90–100	35–50	15–25
0	100	100	95–100	90–100	40–50	15–25
0	100	100	95–100	90–100	40–50	15–25
0	100	100	95–100	90–100	35–50	15–25
10–56	75–95	70–90	20–40	5–25	----------	NP
0–5	100	95–100	70–90	60–80	25–40	8–15
0–5	100	90–100	70–90	60–80	25–40	8–15
0–25	90–100	75–90	60–80	10–35	----------	NP
0	95–100	95–100	90–98	70–85	25–40	10–20
0	95–100	95–100	85–98	60–80	35–60	12–35
0	95–100	90–100	85–95	60–75	20–40	5–20
0	100	100	95–100	90–95	45–60	20–30
0	100	100	95–100	90–95	50–60	20–30
0	100	100	95–100	90–95	45–60	15–30
0	100	100	95–100	90–100	44–55	14–25
0	100	100	95–100	95–100	50–70	20–30
0	100	100	95–100	95–100	35–55	11–25
0	95–100	95–100	95–100	80–95	40–50	15–25
0–5	95–100	90–100	85–95	75–85	40–50	15–25
0–5	95–100	90–100	85–95	65–75	30–50	7–25
0	100	100	95–100	95–100	30–55	10–25
0	100	100	95–100	95–100	35–50	11–25
0	100	100	90–100	85–100	25–40	10–20
0	100	100	95–100	85–100	25–50	8–20
0	100	100	95–100	85–100	35–65	15–30
0	100	95–100	85–95	60–80	25–40	10–20
0	100	95–100	80–90	50–75	25–40	8–15
0	100	100	95–100	95–100	40–65	20–40
0	100	100	90–100	90–100	40–60	20–40

TABLE 10.—*Engineering properties*

Map symbol and soil name	Depth	USDA texture	Classification	
			Unified	AASHTO
	In			
507:				
Canisteo	0–16	Silty clay loam	OL, CL, CH	A–7
	16–31	Clay loam, loam	CL	A–7, A–6
	31–70	Clay loam, loam	CL	A–6
511:				
Blue Earth	0–40	Silty clay loam	OL	A–5
	40–60	Clay loam, loam, silty clay loam	CL, ML	A–6, A–7
559:				
Talcot	0–18	Clay loam	CL	A–7
	18–37	Clay loam, silty clay loam, loam	CL	A–7
	37–60	Sand and gravel	SP	A–1
577C2, 577D2:				
Everly	0–6	Clay loam	CL	A–6, A–7
	6–17	Clay loam	CL	A–6, A–7
	17–60	Loam, clay loam	CL	A–6, A–7
606:				
Lanyon	0–15	Silty clay loam	CH	A–7
	15–56	Silty clay, silty clay loam	CH	A–7
	56–66	Clay loam	CL, CH	A–6, A–7
733:				
Calco	0–36	Silty clay loam	ML, MH, CH, CL	A–7
	36–63	Silty clay loam	CH, CL	A–7
823B, 823C2:				
Flagler	0–13	Sandy loam	SM, SC, SM–SC	A–2, A–4
	13–28	Sandy loam, loamy sand	SM, SC, SM–SC	A–2, A–4
	28–63	Gravelly loamy sand, gravelly sand; sand	SW, SP, SM, SM–SC	A–1, A–2, A–3

[1] NP means nonplastic.

texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clay soils that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

Flooding is rated in general terms that describe the frequency, duration, and period of the year when flooding is most likely. The ratings are based on evidences in the soil profile of the effects of flooding, namely thin strata of gravel, sand, silt, or, in places, clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; absence of distinctive soil horizons that form in soils of the area that are not subject to flooding; local information about floodwater heights and the extent of flooding; and local knowledge that relates the unique landscape position of each soil to historic floods.

The generalized description of flood hazards is of value in land use planning and provides a valid basis for land use restrictions. The soil data are less specific, however, than those provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

A high water table is the highest level of a saturated zone that is more than 6 inches thick in soils for a continuous period of more than 2 weeks during most years. The depth to a high water table applies to undrained soils. Estimates are based mainly on the relationships between grayish colors or mottles in the soil and the depth to free water observed during the course of the soil survey. Indicated are the depth to the high water table; the kind of water table, whether perched, artesian, or the upper part of the ground water table; and the months of the year that the high water commonly is present. Only those saturated zones above a depth of 5 or 6 feet are indicated.

Information about the high water table helps in assessing the need for specially designed foundation, the need for specific kinds of drainage systems, and the need for footing drains to insure dry basements. Such information is also needed to decide whether or not to construct basements, and to determine how septic tank absorption fields and other underground installa-

and classifications—Continued

Fragments > 3 inches	Percentage passing sieve number—				Liquid limit	Plasticity index
	4	10	40	200		
Pct					*Pct*	
0	98–100	95–100	85–98	60–90	40–55	15–25
0	98–100	90–100	85–95	65–85	38–50	25–35
0	95–100	90–98	80–95	60–75	30–40	12–20
0	95–100	95–100	85–95	80–95	41–50	2–8
0	95–100	90–100	80–100	70–80	35–50	11–20
0	100	100	80–90	60–85	40–50	15–25
0	95–100	90–100	70–90	60–85	40–50	15–25
0	65–90	60–85	20–50	2–5		NP
0	100	95–100	85–95	65–80	30–45	11–20
0	95–100	95–100	85–95	70–90	30–50	15–25
0	90–100	85–95	75–85	60–80	30–50	15–25
0	100	100	95–100	90–100	55–70	30–40
0	100	95–100	85–100	80–95	60–75	30–40
0	95–100	90–100	75–85	60–80	35–65	20–40
0	100	100	95–100	85–100	41–60	15–30
0	100	100	90–100	80–100	40–55	15–30
0	95–100	90–100	70–90	25–50	15–30	2–10
0	95–100	85–100	65–85	20–45	15–30	2–10
0–5	80–95	75–95	35–60	2–15	<25	NP–8

tions will function. Also, a high water table affects ease of excavation.

Potential frost action refers to likelihood of damage to pavements and other structures by frost heaving and low soil strength after thawing. Frost action is defined as freezing temperatures in the soil and movement of soil moisture into the freezing zone, which causes the formation of ice lenses. Soil texture, temperature, moisture content, porosity, permeability, and organic matter content are the most important soil properties that affect frost action. It is assumed that the soil is not covered by insulating vegetation or snow and is not artificially drained. Silty and clayey soils that have a high water table in winter are most susceptible to frost action. Well drained very gravelly or sandy soils are the least susceptible.

Formation and classification of soils

This section discusses the factors of soil formation as they relate to the soils of Sac County, describes the processes that result in the formation, and places each soil series represented in the county in its respective family, subgroup, and order in the current system for classifying soils. Detailed descriptions of the representative profiles of the soil series are given in the section "Descriptions of the soils."

Factors of soil formation

Soil is produced by the action of soil-forming processes on material deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material, (2) the climate under which the soil material has accumulated and existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, or lay of the land, and (5) the length of time the forces of soil development have acted on the soil material.

Climate and vegetation are active factors of soil genesis. 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 vegetation are conditioned by relief. The parent material also affects the kind of profile that can be formed and, in extreme

TABLE 11.—*Physical and chemical properties of soils*

[The symbol < means less than; > means greater than. The erosion tolerance factor (T) is for the entire profile. Absence of an entry means data were not available or were not estimated]

Map symbol and soil name	Depth	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility group
						Uncoated steel	Concrete	K	T	
	In	*In/hr*	*In/in*	*pH*						
1D3, 1E3, 1F3:										
Ida	0–60	0.6–2.0	0.20–0.22	6.6–8.4	Low	Low	Low	0.43	5–4	4L
5B:										
Kennebec part	0–46	0.6–2.0	0.22–0.24	5.6–7.3	Moderate	Moderate	Low	0.32	5	6
	46–60	0.6–2.0	0.20–0.22	6.1–7.3	Moderate	Moderate	Low	0.43		
Ackmore part	0–35	0.6–2.0	0.21–0.23	5.6–7.3	Moderate	High	Low	0.32	5	6
	35–70	0.2–0.6	0.18–0.20	5.6–7.8	High	High	Low	0.32		
C5B:										
Kennebec part	0–46	0.6–2.0	0.22–0.24	5.6–7.3	Moderate	Moderate	Low	0.32	5	6
	46–60	0.6–2.0	0.20–0.22	6.1–7.3	Moderate	Moderate	Low	0.43		
Ackmore part	0–35	0.6–2.0	0.21–0.23	5.6–7.3	Moderate	High	Low	0.32	5	6
	35–70	0.2–0.6	0.18–0.20	5.6–7.8	High	High	Low	0.32		
6:										
Okoboji	0–31	0.06–0.2	0.21–0.23	7.4–7.8	High	High	Low			4
	31–60	0.06–0.2	0.18–0.20	7.4–8.4	High	High	Low			
8C:										
Judson	0–25	0.6–2.0	0.21–0.23	6.1–7.3	Moderate	Moderate	Low	0.28	5	7
	25–93	0.6–2.0	0.21–0.23	6.1–7.8	Moderate	Moderate	Low	0.43		
9B, 9B2, 9C, 9C2, 9D2, 9D3:										
Marshall	0–12	0.6–2.0	0.21–0.23	5.6–6.5	Moderate	Moderate	Moderate	0.32	5–4	7
	12–67	0.6–2.0	0.18–0.20	5.6–7.3	Moderate	Moderate	Low	0.43		
	67–85	0.6–2.0	0.20–0.22	6.6–7.3	Moderate	Moderate	Low	0.43		
10D3, 10E3:										
Monona	0–9	0.6–2.0	0.22–0.24	5.6–7.3	Moderate	Low	Low	0.32	5–4	6
	9–35	0.6–2.0	0.20–0.22	6.1–7.3	Moderate	Low	Low	0.43		
	35–60	0.6–2.0	0.20–0.22	6.6–8.4	Moderate	Low	Low	0.43		
11B:										
Colo part	0–47	0.2–0.6	0.21–0.23	5.6–7.3	High	High	Moderate			7
	47–62	0.2–0.6	0.18–0.20	6.1–7.3	High	High	Moderate			
Ely part	0–26	0.6–2.0	0.21–0.23	5.6–7.3	Moderate	High	Moderate	0.32	5	7
	26–52	0.6–2.0	0.18–0.20	6.1–7.3	Moderate	High	Low	0.43		
	52–84	0.6–2.0	0.18–0.20	6.6–8.4	Moderate	High	Low	0.43		
24C2, 24D2, 24E2:										
Shelby	0–14	0.6–2.0	0.20–0.22	5.6–6.5	Moderate	Moderate	Moderate	0.28	5–4	6
	14–36	0.2–0.6	0.16–0.18	5.6–7.8	Moderate	Moderate	Moderate	0.28		
	36–76	0.2–0.6	0.16–0.18	6.6–8.4	Moderate	Moderate	Moderate	0.37		
26B:										
Kennebec	0–46	0.6–2.0	0.22–0.24	5.6–7.3	Moderate	Moderate	Low	0.32	5	6
	46–72	0.6–2.0	0.20–0.22	6.1–7.3	Moderate	Moderate	Low	0.43		

27C: Terril	0–31 31–73	0.6–2.0 0.6–2.0	0.20–0.22 0.16–0.18	6.1–7.3 6.1–7.3	Low Low	Moderate Moderate	Low Low	0.24 0.32	5	6
31: Afton	0–25 25–48 48–60	0.2–0.6 0.2–0.6 0.2–2.0	0.21–0.23 0.18–0.20 0.14–0.16	6.6–7.3 6.6–7.8 7.9–8.4	High High High	High High High	Low Low Low			4
33E, 33F: Steinauer	0–5 5–73	0.6–2.0 0.2–2.0	0.18–0.20 0.14–0.17	7.4–8.4 7.9–8.4	Low Moderate	High High	Low Low	0.32 0.32	5–4	4L
41D: Sparta	0–60	6.0–20	0.12–0.14	5.6–6.5	Low	Low	Low	0.17	5	2
54: Zook	0–20 20–60	0.2–0.6 0.06–0.2	0.21–0.23 0.11–0.13	5.6–7.8 5.6–7.8	High High	High High	Moderate Moderate			7
55: Nicollet	0–14 14–45 45–69	0.6–2.0 0.6–2.0 0.6–2.0	0.17–0.22 0.15–0.19 0.14–0.19	6.1–7.3 5.6–7.8 7.4–7.8	Moderate Moderate Moderate	High High High	Low Low Low	0.24 0.32 0.32	5–4	6
62C, 62D, 62E, 62F, 62G: Storden	0–5 5–60	0.6–2.0 0.6–2.0	0.20–0.22 0.17–0.19	7.4–8.4 7.4–8.4	Low Low	Low Low	Low Low	0.28 0.37	5–4	4L
73C, 73D: Salida	0–18 18–60	6.0–20 >20	0.09–0.11 0.02–0.04	6.6–8.4 7.4–8.4	Low Low	Low Low	Low Low	0.10 0.10		
77B, 77B2, 77C, 77C2, 78B, 78B2, 78C, 78C2: Sac	0–14 14–28 28–76	0.6–2.0 0.6–2.0 0.6–2.0	0.21–0.23 0.18–0.20 0.14–0.16	5.6–6.5 6.1–7.3 6.6–8.4	Moderate Moderate Moderate	Moderate Moderate Moderate	Low Low Low	0.32 0.43 0.43	5–4	4
91: Primghar	0–20 20–44 44–64	0.6–2.0 0.2–2.0 0.6–2.0	0.21–0.23 0.18–0.20 0.20–0.22	5.6–7.3 6.1–8.4 7.9–8.4	High High Moderate	Moderate Moderate Moderate	Moderate Low Low			4
92: Marcus	0–15 15–40 40–60 57–62	0.2–0.6 0.2–0.6 0.6–2.0 0.6–2.0	0.21–0.23 0.18–0.20 0.20–0.22 0.17–0.19	6.1–7.8 6.1–8.4 7.9–8.4 7.9–8.4	High High Moderate Moderate	High High High High	Low Low Low Low			4
95: Harps	0–21 21–42 42–70	0.6–2.0 0.6–2.0 0.6–2.0	0.19–0.21 0.17–0.19 0.17–0.19	7.9–8.4 7.9–8.4 7.9–8.4	Moderate Moderate Moderate	High High High	Low Low Low			4L
107: Webster	0–12 12–25 25–76	0.6–2.0 0.2–2.0 0.6–2.0	0.19–0.21 0.16–0.18 0.17–0.19	6.6–7.3 6.6–7.8 7.9–8.4	High High Moderate	High High High	Low Low Low			6
108, 108B, 108C2: Wadena	0–13 13–27 27–60	2.0–6.0 2.0–6.0 >20	0.20–0.22 0.12–0.14 0.02–0.04	6.1–7.3 6.1–7.3 6.6–8.4	Low Low Low	Low Low Low	Low Low Low	0.24 0.32 0.10	4–3	5

TABLE 11.—*Physical and chemical properties of soils*—Continued

Map symbol and soil name	Depth	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility group
						Uncoated steel	Concrete	K	T	
	In	*In/hr*	*In/in*	*pH*						
133:										
Colo	0–47	0.2–0.6	0.21–0.23	5.6–7.3	High	High	Moderate			7
	47–62	0.2–0.6	0.18–0.20	6.1–7.3	High	High	Moderate			
134:										
Zook	0–40	0.06–0.2	0.11–0.13	5.6–7.8	High	High	Moderate			4
	40–84	0.06–0.2	0.11–0.13	5.6–7.8	High	High	Moderate			
135, 135B:										
Coland	0–42	0.2–0.6	0.20–0.22	6.1–7.3	High	High	Low			7
	42–60	2.0–6.0	0.13–0.17	6.1–7.3	Low	High	Low			
138B, 138C, 138C2, 138D2:										
Clarion	0–16	0.6–2.0	0.20–0.22	6.1–7.3	Low	Low	Low	0.28	5–4	6
	16–32	0.6–2.0	0.17–0.19	5.6–7.8	Low	Low	Low	0.28		
	32–60	0.6–2.0	0.17–0.19	7.9–8.4	Low	Low	Low	0.37		
174B, 174C2, 174D2:										
Bolan	0–11	0.6–2.0	0.20–0.22	6.1–7.3	Low	Moderate	Moderate	0.28	4–3	6
	11–24	0.6–2.0	0.17–0.19	5.6–7.3	Low	Moderate	Moderate	0.28		
	24–60	2.0–6.0	0.11–0.13	5.6–7.3	Very low	Moderate	Moderate	0.28		
201B:										
Coland part	0–42	0.2–0.6	0.20–0.22	6.1–7.3	High	High	Low			7
	42–60	2.0–6.0	0.13–0.17	6.1–7.3	Low	High	Low			
Spillville part	0–47	0.6–2.0	0.19–0.21	6.1–7.3	Moderate	High	Moderate	0.28	5–4	6
	47–66	0.6–6.0	0.15–0.18	6.1–7.8	Low	High	Moderate	0.28		
C201B:										
Coland part	0–42	0.2–0.6	0.20–0.22	6.1–7.3	High	High	Low			7
	42–60	2.0–6.0	0.13–0.17	6.1–7.3	Low	High	Low			
Spillville part	0–47	0.6–2.0	0.19–0.21	6.1–7.3	Moderate	High	Moderate	0.28	5–4	6
	47–66	0.6–6.0	0.15–0.18	6.1–7.8	Low	High	Moderate	0.28		
202, 203:										
Cylinder	0–14	0.6–2.0	0.20–0.22	5.6–7.3	Moderate	Moderate	Low			6
	14–34	0.6–2.0	0.17–0.19	6.1–7.3	Moderate	Moderate	Low			
	34–60	6.0–20	0.02–0.04	7.4–8.4	Low	Moderate	Low			
221:										
Palms	0–24	0.2–6.0	0.35–0.45	5.1–8.4		High	Moderate			3
	24–60	0.2–2.0	0.05–0.19	6.1–8.4	Low	High	Low			
234:										
Nishna	0–48	0.06–0.2	0.12–0.14	7.4–8.4	High	High	Low			4
	48–60	0.06–0.2	0.11–0.13	7.4–8.4	High	High	Low			
236B:										
Lester	0–14	0.6–2.0	0.20–0.22	5.6–6.5	Low	Low	Moderate	0.28	5–4	6
	14–48	0.6–2.0	0.15–0.19	5.1–7.3	Moderate	Low	Moderate	0.28		
	48–72	0.6–2.0	0.14–0.19	6.6–8.4	Low	Low	Low	0.37		

259:										
Biscay	0–12	0.6–2.0	0.20–0.22	6.1–7.8	Moderate	Moderate	Low			6
	12–28	0.6–2.0	0.17–0.19	6.6–7.8	Moderate	Moderate	Low			
	28–84	6.0–20	0.02–0.04	6.6–7.8	Low	Moderate	Low			
274:										
Rolfe	0–17	0.6–2.0	0.22–0.24	5.1–6.5	Moderate	High	Moderate			6
	17–47	0.06–0.2	0.11–0.13	6.1–7.3	High	High	Moderate			
	47–65	0.2–2.0	0.14–0.16	6.1–8.4	Moderate	High	Low			
308, 308B:										
Wadena	0–13	2.0–6.0	0.20–0.22	6.1–7.3	Low	Low	Low	0.24	4–3	5
	13–35	2.0–6.0	0.12–0.14	6.1–7.3	Low	Low	Low	0.32		
	35–60	>20	0.02–0.04	6.6–8.4	Low	Low	Low	0.10		
310, 310B, 310B2, 310C, 310C2:										
Galva	0–16	0.6–2.0	0.21–0.23	5.6–6.5	Moderate	Moderate	Moderate	0.32	5–4	7
	16–40	0.6–2.0	0.18–0.20	6.1–7.3	Moderate	Moderate	Low	0.43		
	40–60	0.6–2.0	0.20–0.22	6.6–8.4	Moderate	Moderate	Low	0.43		
T310, T310B:										
Galva	0–11	0.6–2.0	0.21–0.23	5.6–6.5	Moderate	Moderate	Moderate	0.32	5–4	7
	11–36	0.6–2.0	0.18–0.20	6.1–7.3	Moderate	Moderate	Low	0.43		
	36–50	0.6–2.0	0.20–0.22	6.6–8.4	Moderate	Moderate	Low	0.43		
	50–60	6.0–20	0.02–0.04	7.4–8.4	Low	Moderate	Low	0.10		
315:										
Alluvial land	0–60									
323B:										
Terril	0–31	0.6–2.0	0.20–0.22	6.1–7.3	Low	Moderate	Low	0.32	5	6
	31–45	0.6–2.0	0.16–0.18	6.6–7.3	Low	Moderate	Low	0.32		
	45–60	6.0–20	0.05–0.07	6.6–8.4	Low	Moderate	Low	0.10		
325:										
Le Sueur	0–14	0.6–2.0	0.17–0.19	5.6–7.3	Moderate	Moderate	Low	0.24	5–4	6
	14–44	0.6–2.0	0.15–0.19	5.6–8.4	Moderate	Moderate	Low	0.32		
	44–60	0.6–2.0	0.14–0.16	7.4–8.4	Moderate	Moderate	Low	0.32		
354:										
Marsh	0–60									
384:										
Collinwood	0–23	0.2–0.6	0.14–0.17	5.6–6.5	High	High	Low	0.32	5	4
	23–39	0.06–0.6	0.13–0.16	5.6–7.3	High	High	Low	0.32		
	39–60	0.06–0.6	0.11–0.15	7.4–8.4	High	High	Low	0.32		
390:										
Waldorf	0–24	0.2–2.0	0.18–0.25	6.6–7.8	Moderate	High	Low			4
	24–47	0.2–0.6	0.13–0.16	6.6–7.8	High	High	Low			
	47–64	0.2–2.0	0.20–0.22	7.4–8.4	Moderate	High	Low			
397B:										
Letri	0–14	0.6–6.0	0.18–0.22	6.6–7.3	Moderate	High	Low			7
	14–34	0.6–2.0	0.15–0.19	6.6–7.8	Moderate	High	Low			
	34–65	0.6–2.0	0.17–0.19	7.4–8.4	Moderate	High	Low			
428:										
Ely	0–26	0.6–2.0	0.21–0.23	5.6–7.3	Moderate	High	Moderate	0.32	5	7
	26–52	0.6–2.0	0.18–0.20	6.1–7.3	Moderate	High	Low	0.43		
	52–84	0.6–2.0	0.18–0.20	6.6–8.4	Moderate	High	Low	0.43		
430, 430B:										
Ackmore	0–35	0.6–2.0	0.21–0.23	5.6–7.3	Moderate	High	Low	0.32	5	6
	35–70	0.2–0.6	0.18–0.20	5.6–7.8	High	High	Low	0.32		

TABLE 11.—*Physical and chemical properties of soils*—Continued

Map symbol and soil name	Depth	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Risk of corrosion		Erosion factors		Wind erodibility group
						Uncoated steel	Concrete	K	T	
	In	*In/hr*	*In/in*	*pH*						
485, 485B:										
Spillville	0–47	0.6–2.0	0.19–0.21	6.1–7.3	Moderate	High	Moderate	0.28	5–4	6
	47–66	0.6–6.0	0.15–0.18	6.1–7.8	Low	High	Moderate	0.28		
506:										
Wacousta	0–15	0.2–2.0	0.21–0.23	6.6–7.3	High	High	Low			7
	15–60	0.2–2.0	0.18–0.20	7.4–8.4	High	High	Low			
507:										
Canisteo	0–16	0.6–2.0	0.18–0.22	7.4–8.4	Moderate	High	Low			4L
	16–31	0.6–2.0	0.15–0.19	7.4–8.4	Moderate	High	Low			
	31–70	0.6–2.0	0.14–0.16	7.4–8.4	Moderate	High	Low			
511:										
Blue Earth	0–40	2.0–6.0	0.18–0.24	7.4–8.4	Moderate	High	Low			8
	40–60	0.2–2.0	0.14–0.16	7.4–8.4	Moderate	High	Low			
559:										
Talcot	0–18	0.6–2.0	0.18–0.22	7.4–8.4	Moderate	High	Low			7
	18–37	0.6–2.0	0.17–0.20	7.4–8.4	Moderate	High	Low			
	37–60	6.0–20	0.02–0.04	7.4–8.4	Low	High	Low			
577C2, 577D2:										
Everly	0–6	0.6–2.0	0.17–0.19	5.6–6.5	Moderate	Moderate	Moderate	0.24	5–4	6
	6–17	0.6–2.0	0.15–0.17	6.1–7.3	Moderate	Moderate	Moderate	0.32		
	17–60	0.6–2.0	0.17–0.19	7.4–8.4	Moderate	Moderate	Low	0.32		
606:										
Lanyon	0–15	0.06–0.6	0.14–0.16	6.6–7.8	High	High	Low			4
	15–56	0.06–0.6	0.12–0.14	7.4–8.4	High	High	Low			
	56–66	0.6–2.0	0.13–0.15	7.9–8.4	Moderate	High	Low			
733:										
Calco	0–36	0.2–0.6	0.21–0.23	7.4–8.4	High	High	Low			7
	36–63	0.2–0.6	0.18–0.20	7.4–8.4	High	High	Low			
823B, 823C2:										
Flagler	0–13	2.0–6.0	0.14–0.17	5.6–7.3	Low	Low	Low	0.20	4	3
	13–28	2.0–6.0	0.10–0.14	5.6–7.3	Low	Low	Low	0.20		
	28–63	>6.0	0.03–0.05	6.6–8.4	Low	Low	Low	0.10		

TABLE 12.—*Soil and water features*

[Absence of an entry indicates the feature is not a concern. See Glossary, under the definition of "flooding" and "water table," for descriptions of such terms as "rare," "brief," and "perched." The symbol < means less than; > means greater than]

Map symbol and soil name	Hydrologic group	Flooding			High water table			Potential frost action
		Frequency	Duration	Months	Depth	Kind	Months	
					Ft			
1D3, 1E3, 1F3: Ida	B	None			>6.0			High.
5B: Kennebec part	B	Common	Brief	Feb-Nov	2.0–5.0	Apparent	Nov-Jun	High.
Ackmore part	B	Common	Very brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	High.
C5B: Kennebec part	B	Common	Brief	Feb-Nov	2.0–5.0	Apparent	Nov-Jun	High.
Ackmore part	B	Common	Very brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	High.
6: Okoboji	B/D	Common	Brief	Mar-Jun	0–3.0	Apparent	Nov-Jun	High.
8C: Judson	B	None			>6.0			High.
9B, 9B2, 9C, 9C2, 9D2, 9D3: Marshall	B	None			>6.0			High.
10D3, 10E3: Monona	B	None			>6.0			High.
11B: Colo part	B/D	Common	Brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	High.
Ely part	B	None			3.0–5.0	Apparent	Nov-Jun	High.
24C2, 24D2, 24E2: Shelby	B	None			>6.0			Moderate.
26B: Kennebec	B	Common	Brief	Feb-Nov	2.0–5.0	Apparent	Nov-Jun	High.
27C: Terril	B	None			>6.0			Moderate.
31: Afton	C/D	Common	Very brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	High.
33E, 33F: Steinauer	B	None			>6.0			Moderate.
41D: Sparta	A	None			>6.0			Low.
54: Zook	C/D	Common	Brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	High.
55: Nicollet	B	None			3.0–5.0	Apparent	Nov-Jun	High.
62C, 62D, 62E, 62F, 62G: Storden	B	None			>6.0			Moderate.
73C, 73D: Salida	A	None			>6.0			Low.
77B, 77B2, 77C, 77C2, 78B, 78B2, 78C, 78C2: Sac	B	None			>6.0			High.

TABLE 12.—*Soil and water features*—Continued

Map symbol and soil name	Hydrologic group	Flooding			High water table			Potential frost action
		Frequency	Duration	Months	Depth	Kind	Months	
					Ft			
91: Primghar	B	None			3.0–5.0	Apparent	Nov-Jun	High.
92: Marcus	B/D	None			1.0–3.0	Apparent	Nov-Jun	High.
95: Harps	B/D	None			1.0–3.0	Apparent	Nov-Jun	High.
107: Webster	B/D	None			1.0–3.0	Apparent	Nov-Jun	High.
108, 108B, 108C2: Wadena	B	None			>6.0			Moderate.
133: Colo	B/D	Common	Brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	High.
134: Zook	C/D	Common	Brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	High.
135, 135B: Coland	B/D	Common	Brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	High.
138B, 138C, 138C2, 138D2: Clarion	B	None			>6.0			Moderate.
174B, 174C2, 174D2: Bolan	B	None			>6.0			Moderate.
201B: Coland part	B/D	Common	Brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	High.
Spillville part	B	Common	Very brief	Feb-Nov	3.0–5.0	Apparent	Nov-Jun	Moderate.
C201B: Coland part	B/D	Common	Brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	High.
Spillville part	B	Common	Very brief	Feb-Nov	3.0–5.0	Apparent	Nov-Jun	Moderate.
202, 203: Cylinder	B	None			3.0–5.0	Apparent	Nov-Jun	High.
221: Palms	A/D	Frequent	Long	Mar-Jun	0–1.0	Apparent	Nov-Jun	High.
234: Nishna	C/D	Common	Brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	Moderate.
236B: Lester	B	None			>6.0			Moderate.
259: Biscay	B/D	None			1.0–3.0	Apparent	Nov-Jun	High.
274: Rolfe	C	Common	Brief	Mar-Jun	0–3.0	Apparent	Nov-Jun	High.
308, 308B: Wadena	B	None			>6.0			Moderate.
310, 310B, 310B2, 310C, 310C2, T310, T310B: Galva	B	None			>6.0			High.
315: Alluvial land	B	Frequent	Brief	Feb-Nov	0–4.0	Apparent	Nov-Jun	High.

TABLE 12.—*Soil and water features*—Continued

Map symbol and soil name	Hydrologic group	Flooding			High water table			Potential frost action
		Frequency	Duration	Months	Depth	Kind	Months	
					Ft			
323B: Terril	B	None			>6.0			Moderate.
325: Le Sueur	B	None			3.0–5.0	Apparent	Nov-Jun	High.
354: Marsh		Frequent	Very long	Jan-Dec	0–1.0	Apparent	Jan-Dec	High.
384: Collinwood	C	None			2.0–4.0	Apparent	Nov-Jun	Moderate.
390: Waldorf	C/D	None			1.0–3.0	Apparent	Nov-Jun	High.
397B: Letri	B/D	None			0–2.0	Apparent	Nov-Jun	High.
428: Ely	B	None			3.0–5.0	Apparent	Nov-Jun	High.
430, 430B: Ackmore	B	Common	Very brief	Feb-Nov	1.0–3.0	Apparent	Nov-Jun	High.
485, 485B: Spillville	B	Common	Very brief	Feb-Nov	3.0–5.0	Apparent	Nov-Jun	Moderate.
506: Wacousta	B/D	Frequent	Very brief to very long.	Mar-Jun	0–3.0	Apparent	Nov-Jun	High.
507: Canisteo	C/D	None			1.0–3.0	Apparent	Nov-Jun	High.
511: Blue Earth	C/D	Occasional	Brief	Mar-Jun	0–1.0	Apparent	Nov-Jun	High.
559: Talcot	B/D	None			0–3.0	Apparent	Nov-Jun	High.
577C2, 577D2: Everly	B	None			>6.0			Moderate.
606: Lanyon	C/D	Frequent	Very brief to very long.	Mar-Jun	0–3.0	Apparent	Nov-Jun	High.
733: Calco	B/D	Common	Brief	Mar-Jun	1.0–3.0	Apparent	Nov-Jun	High.
823B, 823C2: Flagler	B	None			>6.0			Low.

cases, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. Time is always required for horizon differentiation. A long time generally is required for the development of distinct horizons.

The factors of soil genesis are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one unless conditions are specified for the other four. Many of the processes of soil development are unknown.

Parent material

The soils of Sac County formed in several kinds of parent material. Among these are loess, glacial till and sediment from glacial till, alluvium, lacustrine sediment, deposits of organic material, and eolian sand. Bedrock is exposed only in a few outcrops near Grant City. No soil series that formed in bedrock was mapped. The different parent materials are discussed briefly in the paragraphs that follow. Soil-parent ma-

terial relationships for some major soils are described in the section "General Soil Map."

Glacial drift includes all material deposited by glaciers. Much material has been sorted by water and is referred to as glacial outwash or glacial sediment. The heterogenous, unsorted deposits are called glacial till.

Glacial till is the parent material for many of the soils in the eastern part of the county and for a few in the western part. Sac County has been subjected to three stages of glaciation. The first two, the Nebraskan and Kansan, covered all of the county. The Tazewell substage of the Wisconsin glacier advanced from the northeast to near the southwest corner of the county, and the Cary substage of the Wisconsin glacier covered approximately the eastern half of the county (*6*, *8*). All the stages left deposits of glacial debris many feet thick.

The glacial deposit in the western part of the county has been covered by wind-deposited silt (loess), and it is exposed only where the loess has been eroded away. The glacial material in eastern Sac County was deposited after the period of loess deposition and is exposed at the surface. Radiocarbon dating estimated the period of deposition of loess to be 14,000 to 30,000 years ago, of the Tazewell drift to be about 20,000 years ago, and of the Cary drift to be 13,000 to 14,000 years ago (*6*).

Soils that formed in glacial till include the Clarion and Lester soils in the Cary till; Storden soils, which are mapped in the Cary and Tazewell areas; and Shelby and Steinauer soils, which are assumed to be in Kansan till.

The Nebraskan drift was buried by the Kansan drift. It is possible that some areas of the Nebraskan drift are exposed along lower slopes and that some Steinauer and Shelby soils formed in Nebraskan till rather than in Kansan till. The Nebraskan and Kansan drifts are often grouped with the Illinoian glacier as pre-Wisconsin drift. The Illinoian glacier did not advance as far as Sac County.

Other soils at lower elevations on the Cary till plain formed in till, in sediment washed from nearby areas of till, or in both. These include Nicollet, Webster, Canisteo, and Harps soils. Soils in depressions such as Okoboji, Rolfe, and Wacousta soils, generally developed entirely in sediment from adjacent slopes (*15*, *16*).

Loess, or wind-deposited silt, ranges from as thick as 15 to 20 feet on summits in the southwestern part of the county to 4 feet or less near the border of the Cary drift. No loess is in the eastern part of the county on the surface of the Cary drift. The major soils that formed in loess are in the Marshall, Monona, Galva, and Ida series. Primghar, Marcus, and Afton soils also developed in loess or mainly in loess. Some areas of these soils are in drainageways and receive alluvial sediment from upslope. In those places the upper part of the profile may have formed in this sediment, which is very similar to the loess in composition. Sac and Everly soils formed in a thin layer of loess and in the underlying glacial till, which is Tazewell or Kansan in age. Two phases of Sac soils are mapped. The loam substratum phase is in friable Tazewell till, and the clay loam substratum phase is in firm Kansan till.

The loess was calcareous silt loam or light clay loam when it was deposited. In the Ida soils there has been only a small alteration of the parent material, mainly the addition of organic matter in the surface layer and the segregation of some of the lime into concretions or soft accumulations. The other soils that formed in loess have been leached of carbonates in the upper part of the profile. Also, some of the silt-sized particles have weathered to clay size.

Alluvium consists of sediment deposited by water. Alluvium derived mostly from glacial till has a higher sand content than that derived from loess. Some alluvium that came from loess has a sand content of 5 percent or less. The Coland, Terril, and Spillville soils, which are high in sand, are associated with soils in the Cary drift area. Alluvial soils with a lower content of sand that are mainly in the loess mantled part of the county include Ackmore, Calco, Colo, Ely, Judson, Kennebec, Nishna, and Zook soils.

Some of these soils formed in alluvium that has been washed from adjacent slopes and has been moved only a short distance. This is local alluvium, or colluvium. Terril, Ely, and Judson soils and some areas of Ackmore, Kennebec, and Spillville soils are among those that formed in this kind of parent material. Most areas are on foot slopes at the base of areas of moderately sloping to moderately steep soils.

On many stream benches, moderately coarse textured to moderately fine textured alluvium is underlain by sand and gravel that is presumed to have washed from the Wisconsin drift as it retreated. Biscay, Cylinder, Flagler, Salida, Talcot, and Wadena soils formed in this kind of parent material. A few areas of these soils also are on uplands in the Cary drift area. In places, localized sorting of glacial material by water has resulted in finer textured alluvium overlying sand and gravel.

Lacustrine deposits make up a small part of the Cary drift area. These are in places where ponds or lakes were formed by the temporary blocking of the flow of water by glacial ice or debris. The sediment deposited in the pond or on lake bottoms is generally finer textured than till. Collinwood, Lanyon, and Waldorf soils formed in lacustrine parent material.

Organic deposits occur in a few depressions on the Cary drift. Palms muck is the major soil that formed in this parent material, but other soils such as Blue Earth and Okoboji soils have high organic matter content in the upper part of their profile.

Eolian sand is a minor parent material. It is intermingled with loess in the western part of the county. Bolan and Sparta soils formed in this material.

Climate

The soils in Sac County, according to recent evidence (*15*), formed under variable climatic conditions. During the post-Cary glaciation period, from 13,000 to 10,500 years ago, the climate was cool and conifers were the dominant vegetation. Between 8,000 and 10,400 years ago, there was a warming trend and the vegetation changed from conifers to a mixed hardwood forest. About 8,000 years ago, the climate became warmer and drier and herbaceous prairie vegetation became dominant. Studies of the forest-prairie transition area of central Iowa (*4*) indicate that a late change in postglacial climate from relatively dry prai-

rie to more moist conditions has taken place. This change may have started about 3,000 years ago. The present climate is midcontinental subhumid.

A nearly uniform climate prevails throughout the county. The influence of the general climate is modified by local conditions in or near the developing soil. For example, areas on south-facing slopes have a microclimate that is warmer and less humid than the climate of nearby areas. Areas on north- and east-facing slopes tend to be cooler and more moist than those on south-facing slopes, and in a climate like that in Sac County, natural stands of trees are more likely to grow well. The hot, dry areas on south-facing slopes tend to have sparse vegetation, which allows more natural erosion to occur than on north-facing slopes. Ida soils, which are very young in terms of soil development, are typically in areas on south-facing slopes. Low-lying or depressional, poorly drained or very poorly drained soils are wetter and cooler than those in most surrounding areas.

Plant and animal life

Many kinds of living organisms are important in the formation of soils. The activities of burrowing animals, worms, crayfish, and micro-organisms, for example, are reflected in soil properties. However, differences in the kind of vegetation commonly cause the most marked differences in soils (*5*). The dominant kinds of plant life have changed with time. The soils in Sac County have been influenced in recent times mainly by prairie vegetation. The Lester and Le Sueur soils near the Raccoon River also show the influence of a mixture of trees and grasses.

Because grasses have many roots and tops that have decayed in or on the soil, soils that formed under prairie vegetation typically have a thicker, darker colored surface layer than soils that formed under trees or under both trees and grass. Under trees, the organic matter, derived principally from leaves, was deposited mainly on the surface of the soil. Soils that have been influenced by trees generally are more acid and have had more downward movement of bases and clay in their profiles.

Poorly drained or very poorly drained soils, such as Marcus, Afton, Webster, Canisteo, and Okoboji soils, formed under a native vegetation of water-tolerant grasses and sedges.

Relief

Relief refers to the lay of the land. Relief is an important factor in soil formation because of its effect on drainage, runoff, the height of the water table, and erosion. It is the main reason for the differing properties of some soils in the county. The influence of relief can be seen in a number of ways in Sac County, where slopes range from nearly level to very steep.

The thickness and color of the A horizon and the thickness of the solum are related to slope. Slope has an effect on erosion and on the amount of water that runs off and percolates through the soil. For example, the thickness and color of the A horizon of Storden, Clarion, and Nicollet soils, which formed in similar parent material, is related to their topography. Thickness of the A horizon increases and the color darkens as slope decreases. Most areas of Storden soils are strongly sloping to steep; Clarion soils are mainly gently sloping or moderately sloping; and Nicollet soils are mostly nearly level. Likewise, the thickness of the solum increases and depth to carbonates decreases from the Storden to the thicker Clarion and Nicollet soils. In soils that have a wide range of slopes, such as the gently sloping to strongly sloping Marshall soils, the depth to carbonates and the thickness of the solum decrease as the percentage of slope increases and as the slopes become more convex.

Time

The passage of time enables the factors of relief, climate, and plant and animal life to bring about changes in parent material. If these factors continue to operate for long periods of time, very similar kinds of soil are formed from widely different kinds of parent material. Soil formation, however, is generally interrupted by geologic events that expose new material. In Sac County, new parent material has been added to the uplands at least four times (*11*). The bedrock was covered by glacial drift from two glaciers; then loess was deposited. During the period of loess deposition, the Tazewell substage of the Wisconsin glacier advanced and covered most of the county. The last increments of loess were deposited on that surface. The last glacial substage covered the eastern part of Sac County. This drift is exposed at the surface. Older parent material has been exposed by geologic erosion, especially along the Raccoon River valley and other deeply cut valleys. Steinauer and Shelby soils formed in older drift that is presumed to have been covered by loess and then reexposed by erosion.

The radiocarbon technique for determining the age of carbonaceous material in loess and till has been useful in dating late Pleistocene events. Radiocarbon dating of material from the base of the Cary glacial drift in the southern part of the Des Moines Lobe indicates that the drift was deposited about 14,000 years ago (*6*); thus, all soils that formed in the Cary drift are not more than 14,000 years old. In much of Iowa, including parts of Sac County, geologic erosion has beveled and, in places, removed material from side slopes and deposited new sediment downslope (*7*). The surfaces of nearly level areas on upland divides are older than slopes that bevel and ascend to the divides. The side slopes in the Cary drift area, therefore, are less than 14,000 years old. In Sac County, the Clarion, Storden, and Lester soils are among those soils on side slopes.

Some sediment washed from side slopes has accumulated to form local alluvium. The age of the side slopes was determined by dating the alluvium at the base of these slopes. Some of the alluvium is less than 3,000 years old (*15*). Because sediment from the side slopes accumulated to form the alluvium, the surfaces of the side slopes in these areas are not more than 3,000 years old. In Sac County, the Terril, Spillville, and Coland soils are among the soils that formed in this kind of alluvium.

Processes of soil horizon differentiation

Horizon differentiation is considered to be the result of additions, removals, transfers, and transformations

in the soil (*9*). Each of these four kinds of change affects many substances that make up soils. For example, there may be additions, removals, transfers, or transformations of organic matter, soluble salts, carbonates, sesquioxides, or silicate clay minerals, all of which generally promote horizon differentiation. Some processes offset or retard differentiation. The combination of processes and the resulting changes take place simultaneously in soils. The ultimate nature of the profile is governed by the balance of these changes within the profile. The addition of organic matter, the removal of substances from parts of the soil profile, and the translocation of clay have been important in the horizon differentiation of the soils of Sac County.

The addition of organic matter is an early step in the process of horizon differentiation in most soils. The amount of organic matter that has accumulated in the A1 horizon of the soils in Sac County ranges from high to very low. Ida and Storden soils, for example, have a thin A1 horizon and have low organic matter content. Webster and Colo soils have a thick A1 horizon and have high organic matter content. Some soils that had high organic matter content now have low content because of erosion.

The downward movement of calcium carbonates and bases in soils is an example of the removal of substances from parts of the soil profile. Most soils in the county have been leached free of calcium carbonates in the upper parts of their profile. A few have been so strongly leached that they are medium acid or strongly acid in some horizons.

Several kinds of transfer of substances from one horizon to another are evident in the soils of Sac County. For example, phosphorus is removed from the subsoil by plant roots and transferred to those parts of the plant growing above the surface. It is then added to the surface layer in the plant residue. This process affects the forms and distribution of phosphorus in the profile.

The translocation of clay takes place when it is carried downward, suspended in percolating water, from the A horizon to the B horizon, where it accumulates in pores and root channels and in clay films on ped faces. The clay is made up mainly of silicate clay minerals in this area. This process occurs in Lester and Le Sueur soils. In other soils, the clay content in the A and B horizons is not markedly different and only a minimal movement of clay is indicated.

Another kind of transfer that is minimal in most soils, but which occurs to some extent in very clayey soils, is that brought about by shrinking and swelling. This causes cracks that allow some material from the surface layer to be incorporated into lower parts of the profile. The Waldorf series is one of the few in Sac County that has soils with the potential for this kind of physical transfer.

Transformations are physical and chemical. The weathering of soil particles to smaller sizes is an example of a physical transformation. The reduction of iron by a process called gleying, which involves the saturation of the soil with water for long periods in the presence of organic matter is an example of a chemical transformation. This process is characterized by the presence of ferrous iron and gray colors. Reductive, extractable iron, or free iron, is commonly less abundant in poorly drained soils, such as the Webster soils, than in such soils as the Nicollet and Clarion soils (*14*).

Another kind of transformation is the weathering of the primary apatite mineral in parent material to secondary phosphorus compounds. Studies indicate that the pH value of the soil must decline to about 7 before appreciable weathering takes place. Storden and Clarion soils are examples of soils that illustrate this type of transformation. Storden soils, which are calcareous, are very low in available phosphorus in the subsoil. Clarion soils, which are leached and are about neutral, have more available phosphorus, although it is also very low.

Classification

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Readers interested in further details about the system should refer to the latest literature available (*10, 13*).

The system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the bases for classification are the different soil properties that are observable or measurable. The properties selected for the higher categories are the result of soil genesis or of factors that affect soil genesis. In table 13 the soils of the survey area are classified according to the system. Classes of the system are briefly discussed in the following paragraphs.

ORDER. Ten orders are recognized. The properties used to differentiate among orders are those that reflect the kind and degree of dominant soil-forming processes that have taken place. Each order is identified by a word ending in *sol*. An example is Entisol.

SUBORDER. Each order is divided into suborders based primarily on properties that influence soil genesis and that are important to plant growth or that were selected to reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Aquent (*Aqu*, meaning water, plus *ent*, from Entisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of expression of pedogenic horizons; soil moisture and temperature regimes; and base status. The name of a great group ends with the name of a suborder. A prefix added to the name suggests something about the soil properties. An example is Haplaquents (*Hapl*, meaning simple horizons, plus *aquent*, the suborder of Entisols that have an aquic moisture regime).

SUBGROUP. Each great group is divided into three subgroups: the central (typic) concept of the great groups, which is not necessarily the most extensive subgroup; the intergrades, or transitional forms to other orders, suborders, or great groups; and the extragrades that have some properties that are representative of the great groups but do not indicate transitions to any other known kind of soil. The names of subgroups are derived by placing one or more adjectives before the name of the great group. The adjective *Typic* is used for the subgroup that is thought to

TABLE 13.—*Classification of the soils*

[An asterisk in the first column indicates a taxadjunct to the series. See text for a description of those characteristics of this taxadjunct that are outside the range of the series]

Soil name	Family or higher taxonomic class
*Ackmore	Fine-silty, mixed, nonacid, mesic Aeric Fluvaquents
Afton	Fine-silty, mixed, mesic Cumulic Haplaquolls
Alluvial land	Loamy, mixed, nonacid, mesic Udifluvents
*Biscay	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Haplaquolls
Blue Earth	Fine-silty, mixed (calcareous), mesic Mollic Fluvaquents
Bolan	Coarse-loamy, mixed, mesic Typic Hapludolls
Calco	Fine-silty, mixed (calcareous), mesic Cumulic Haplaquolls
Canisteo	Fine-loamy, mixed (calcareous), mesic Typic Haplaquolls
*Clarion	Fine-loamy, mixed, mesic Typic Hapludolls
Coland	Fine-loamy, mixed, mesic Cumulic Haplaquolls
*Collinwood	Fine, montmorillonitic, mesic Aquic Hapludolls
Colo	Fine-silty, mixed, mesic Cumulic Haplaquolls
Cylinder	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Aquic Hapludolls
Ely	Fine-silty, mixed, mesic Cumulic Hapludolls
Everly	Fine-loamy, mixed, mesic Typic Hapludolls
Flagler	Coarse-loamy, mixed, mesic Typic Hapludolls
Galva	Fine-silty, mixed, mesic Typic Hapludolls
Harps	Fine-loamy, mesic Typic Calciaquolls
Ida	Fine-silty, mixed (calcareous), mesic Typic Udorthents
*Judson	Fine-silty, mixed, mesic Cumulic Hapludolls
*Kennebec	Fine-silty, mixed, mesic Cumulic Hapludolls
Lanyon	Fine, montmorillonitic, mesic Typic Haplaquolls
*Le Sueur	Fine-loamy, mixed, mesic Aquic Argiudolls
Lester	Fine-loamy, mixed, mesic Mollic Hapludalfs
*Letri	Fine-loamy, mixed, mesic Typic Haplaquolls
Marcus	Fine-silty, mixed, mesic Typic Haplaquolls
Marsh	Aquolls
Marshall	Fine-silty, mixed, mesic Typic Hapludolls
*Monona	Fine-silty, mixed, mesic Typic Hapludolls
Nicollet	Fine-loamy, mixed, mesic Aquic Hapludolls
Nishna	Fine, montmorillonitic (calcareous), mesic Cumulic Haplaquolls
Okoboji	Fine, montmorillonitic, mesic Cumulic Haplaquolls
Palms	Loamy, mixed, euic, mesic Terric Medisaprists
Primghar	Fine-silty, mixed, mesic Aquic Hapludolls
Rolfe	Fine, montmorillonitic, mesic Typic Argialbolls
Sac	Fine-silty, mixed, mesic Typic Hapludolls
Salida	Sandy-skeletal, mixed, mesic Entic Hapludolls
*Shelby	Fine-loamy, mixed, mesic Typic Argiudolls
Sparta	Sandy, mixed, mesic Entic Hapludolls
Spillville	Fine-loamy, mixed, mesic Cumulic Hapludolls
Steinauer	Fine-loamy, mixed (calcareous), mesic Typic Udorthents
Storden	Fine-loamy, mixed (calcareous), mesic Typic Udorthents
Talcot	Fine-loamy over sandy or sandy-skeletal, mixed (calcareous), mesic Typic Haplaquolls
Terril	Fine-loamy, mixed, mesic Cumulic Hapludolls
Wacousta	Fine-silty, mixed, mesic Typic Haplaquolls
Wadena	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Hapludolls
Waldorf	Fine, montmorillonitic, mesic Typic Haplaquolls
Webster	Fine-loamy, mixed, mesic Typic Haplaquolls
Zook	Fine, montmorillonitic, mesic Cumulic Haplaquolls

TABLE 13.— *Classification of the soils*—Continued

typify the great group. In example is Typic Haplaquents.

FAMILY. Families are established within a subgroup on the basis of similar physical and chemical properties that affect management. Among the properties considered in horizons of major biological activity below plow depth are particle-size distribution, mineral content, temperature regime, thickness of the soil penetrable by roots, consistence, moisture equivalent, soil slope, and permanent cracks. A family name consists of the name of a subgroup and a series of adjectives. The adjectives are the class names for the soil properties used as family differentiae. An example is fine-loamy, mixed, nonacid, mesic, Typic Haplaquents.

SERIES. The series consists of a group of soils that are formed from a particular kind of parent material. They have horizons that, except for texture of the surface soil, are similar in differentiating characteristics and in arrangement in the soil profile. Among these characteristics are color, texture, structure, reaction, consistence, and mineralogical and chemical composition.

General nature of the county

This section is mainly for those not familiar with the county. It discusses the early history; climate; topography and drainage; transportation, industries, and markets; and farming of the county.

The first settlement in Sac County was in 1854 in Big Grove, which was on the Raccoon River in the southeastern part of the county. The town of Sac City was laid out in 1855, and the county was organized in 1856. Farming has been and still is the primary industry. Population has ranged from 15,000 to 20,000 in the past 50 years. Sac City, the county seat and largest town, had a population of 3,268 in 1970.

Climate [3]

Climatic data for Sac County were recorded at Sac City. Data on temperature and precipitation are given in table 14. The average annual precipitation at Sac City is 28.6 inches; it ranges from just under 28 inches in the western part of the county to almost 29 inches in the southeast corner. The wettest month is June, and the next wettest month is May. Precipitation averages less than 1 inch per month from November

[3] This section was prepared by ROBERT H. SHAW, climatologist, Iowa State University.

TABLE 14.—*Temperature and precipitation*

[Data for Sac City, Sac County, Iowa]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Average highest maximum	Average lowest minimum	Average total	1 year in 10 will have—		Number of days with snow cover of 1 inch or more	Average depth of snow on days with snow cover
						Less than—	More than—		
	°F	°F	°F	°F	In	In	In		In
January	28	9	47	−16	0.7	0.2	1.8	20	6
February	33	13	52	− 8	1.0	.2	2.3	15	6
March	44	24	68	2	1.8	.6	3.4	11	7
April	61	37	84	23	2.7	1.0	4.3	0	2
May	73	49	90	33	4.1	1.4	7.1	0	0
June	82	59	95	45	4.9	2.2	7.9	0	0
July	88	64	98	52	3.4	1.0	5.7	0	0
August	86	62	97	49	3.5	1.3	7.1	0	0
September	78	53	91	35	3.1	.4	8.2	0	0
October	66	41	85	24	1.8	.1	3.9	0	0
November	46	26	68	7	1.0	.1	3.0	3	4
December	33	16	53	− 7	.9	.2	1.9	10	5
Year	60	38	100	−18	28.6	17.0	38.9	59	6

through February. Precipitation extremes for each month (1 year in 10) are given in table 14. During the 1951–60 period, Sac City averaged 18 days per year with 0.5 inch or more of rainfall and 49 days with 0.10 inch or more of rainfall.

Most of the heavy showers occur during the warm half of the year. About 65 percent of the annual precipitation occurs as showers during the warm season of April through September. Individual showers may very widely in intensity over the county. An inch or more of rain falls in a 1-week period about 4 years out of 10 in June and a little more than 2 years out of 10 in July and August. Well-developed crops use over an inch of water a week during the summer.

Temperature data for Sac City are representative of those for the rest of Sac County, particularly maximum temperatures. An average of 37 days per year have a maximum temperature equal to or greater than 90° F. This is too warm for optimum crop production because water demand is excessive on those days. Minimum temperatures tend to vary more. Low areas, relative to the immediate surrounding area, have a lower minimum temperature on clear, calm nights than urban or upland areas.

Frost, or freezing temperature, data for Sac City are given in table 15. The average date of the last 32° temperature in spring is May 2, and the average date of the first 32° temperature in fall is October 7. The average frost-free period is 158 days.

Soil moisture reserves are an important part of the moisture supply for crops. A 5-inch reserve early in spring is considered to be a critically low level. This area has about a 25 percent chance that less than 5 inches of water will be available to plants in the top 5 feet of soil on April 14. The average amount of water available at this time of year is 7.0 inches. There is less than a 25 percent chance that more than 9 inches will be present.

Topography and drainage

The soils in the eastern part of the county are dominantly nearly level to undulating. In the western part, except in the southwest corner, they are dominantly undulating. In the southwest corner of the county, they are mainly gently rolling to hilly. The prevailing slope is to the south and east. Elevation ranges from about 1,000 feet at the low point in the southeastern part of the county to about 1,400 feet near the northwest corner.

The North Raccoon River and its tributaries drain the eastern part of the county. This river originates in Buena Vista County about 25 miles north of the Sac County line and enters Sac County at the northern

TABLE 15.—*Probabilities of last freezing temperatures in spring and first in fall*

[Data are from Sac City, Sac County, Iowa]

Probability	Dates for given probability and temperature				
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower
Spring:					
1 year in 10 later than	Apr. 5	Apr. 14	Apr. 23	May 4	May 17
2 years in 10 later than	Mar. 30	Apr. 8	Apr. 18	Apr. 29	May 12
5 years in 10 later than	Mar. 20	Mar. 28	Apr. 7	Apr. 19	May 2
Fall:					
1 year in 10 earlier than	Oct. 27	Oct. 19	Oct. 13	Oct. 8	Sept. 22
2 years in 10 earlier than	Nov. 1	Oct. 24	Oct. 19	Oct. 13	Sept. 27
5 years in 10 earlier than	Nov. 12	Nov. 4	Oct. 30	Oct. 24	Oct. 7

border in the eastern half of the county. It flows southeast and leaves the county to the east, about 6 miles north of the southern border. The eastern part of the county has a poorly integrated drainage system, and drainage ditches have been dug to connect with or to improve natural drainageways.

The Boyer River and its tributaries drain the west-central part of Sac County. It originates near Storm Lake in Buena Vista County about 5 miles from the Sac County border. It enters from the north near the center of the county, flows to the south, and leaves the county about 6 miles east of the western border. The west-central part of the county has a well integrated drainage system. Some artificial drainage systems have been installed, mainly to drain wet soils in drainageways. Tiling is used, and the outlets are normally natural streams.

Part of the western edge of the county is drained by tributaries of the Maple River. The tributaries flow west into that river, which is about 4 to 8 miles west of the county. This part of the county also has a well integrated natural drainage system and an artificial drainage system that consists mainly of tile in wet drainageways.

The boundary between the watersheds of the North Raccoon and the Boyer Rivers marks the divide between the Missouri River drainage system and the Mississippi River drainage system. It is thought that the Boyer River was part of the Mississippi River system before its channel was diverted by glacial action. A marshy area, known locally as the Old Goose Pond, is presumed to have been part of the Boyer River flood plain.

Transportation, industries, and markets

Two Federal highways intersect in Sac County—U.S. 20, an east-west highway, and U.S. 71, a north-south highway. Iowa Highway 175 crosses the southern part of the county. Three other State highways connect towns in the county with main highways. Approximately 135 miles of county roads are surfaced with asphalt or concrete. Most others are graveled. Less than 1 percent of the county roads are unimproved. Three railroad companies, three truck companies, and two buslines operate in the county. Small aircraft service is available at the towns of Sac City and Wall Lake.

Industry in the county is mainly concerned with farm service and processing farm products. The processing of popcorn is an important industry. Sac County is one of the largest producers of popcorn in the world. Out-of-county markets for farm produce include Sioux City, Storm Lake, Spencer, Denison, and Ft. Dodge, all of which are in Iowa, and Omaha, Chicago, and Minneapolis.

Farming[4]

Farming is the main enterprise in Sac County. The farming is diversified and includes crop production and livestock raising. About 98 percent of the county, or 363,836 acres, is in farms. The average size of the farms is 276 acres. In 1970, 39.3 percent of the area was farmed by the owners; the rest was operated by tenants. The trend for a number of years has been for the farm population and the number of farms to decrease and for the size of the farms to increase.

Corn is the most extensive crop. Most corn is fed to livestock, and the rest is sold. Other crops include soybeans, hay, oats, popcorn, sorghum, and wheat. Hay and oats are grown mostly in rotation with corn and soybeans. Hay crops are mainly mixtures of alfalfa and grasses. The permanent pastures are generally unimproved, and the vegetation is mainly Kentucky bluegrass. Renovated pastures consist mostly of grass-legume mixtures. Bromegrass or orchardgrass and alfalfa or red clover are commonly used in the mixtures.

In recent years, the acreage in corn has decreased slightly and the acreage in oats and hay has also decreased. The acreage in soybeans has greatly increased. The yields of crops have been steadily increasing because of the use of more fertilizer and lime, more productive facilities, better erosion control, and improved management. The acreage of crops in Sac

[4] Data given in this section are from the 1970 Statistical Profile of Iowa, compiled by the Iowa Development Commission, and the Iowa Annual Farm Census of 1972, published in the U.S. Department of Agriculture Statistical Reporting Service Bulletin.

County in 1972 was as follows: corn, 154,005; soybeans 69,923; all hay, 16,255; oats, 14,038; popcorn, 2,476; sorghum, 130; wheat, 22; and all pasture, 40,052.

The feeding of beef cattle and hogs is the most important livestock enterprise. Many beef cattle are bought out of State and trucked into the county for feeding. Hogs are mostly farrowed and fed on the same farm, but some feeder pigs are brought in. The beef cattle and hogs are marketed at packing plants in the Midwest.

The number of beef cattle and hogs fed in the county is increasing. Dairy cows and heifers on hand are decreasing, but beef cows and heifers on hand are increasing. The production of chickens has decreased. Turkey production has been variable, but the general trend is to increased numbers.

The numbers of the principal kinds of livestock raised and sold or on hand in 1972 were as follows: grain-fed cattle marketed, 108,276; grain-fed sheep and lambs marketed, 4,677; sows farrowed, 13,735; hogs marketed, 237,450; milk cows, 2,592; beef cows, 15,521; hens and pullets of laying age, 74,959; commercial broilers produced, 6,490; and turkeys raised, 10,285.

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Glossary

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Alluvium, local. Soil material that has been moved a short distance and deposited at the base of slopes and along small drainageways. It includes the poorly sorted material near the base of slopes that has been moved by gravity, frost action, soil creep, and local wash.

Area reclaim. An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

	Inches
Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	More than 9

Bench. A high, shelflike landform.

Bottom land. The normal flood plain of a stream, subject to frequent flooding.

Bottom, first. The normal flood plain of a stream; land along a stream subject to flooding.

Bottom, second. An old alluvial plain, generally flat or smooth, that borders a stream but is seldom flooded.

Calcareous soil. A soil containing enough calcium carbonate (commonly with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid. A soil having measurable amounts of calcium carbonate or magnesium carbonate.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Colluvium. Soil material, rock fragments, or both moved by creep, slide, or local wash and deposited at the bases of steep slopes.

Complex slope. Irregular or variable slope. Planning or constructing terraces, diversions, and other water-control measures is difficult.

Compressible. Excessive decrease in volume of soft soil under load.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard; little affected by moistening.

Contour tillage. Cultivation that follows the contour of the land, generally almost at right angles to the slope.

Cutbanks cave. Unstable walls of cuts made by earthmoving equipment. The soil sloughs easily.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained.—Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained.—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained.—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically for long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained.—Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained.—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients, as for example in "hillpeats" and "climatic moors."

Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

Erosion. The wearing away of the land surface by running water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature, for example. fire, that exposes a bare surface.

Excess fines. Excess silt and clay. The soil does not provide a source of gravel or sand for construction purposes.

Flooding. The temporary covering of soil with water from overflowing streams, runoff from adjacent slopes, and tides. Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, occasional, and frequent. None means that flooding is not probable; rare that it is unlikely but possible under unusual weather conditions; occasional that it occurs on an average of once or less in 2 years; and frequent that it occurs on an average of more than once in 2 years. Duration is expressed as very brief if less than 2 days, brief if 2 to 7 days, and long if more than 7 days. Probable dates are expressed in months; November–May, for example, means that flooding can occur during the period November through May. Water standing for short periods after rainfall or commonly covering swamps and marshes is not considered flooding.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Frost action. Freezing and thawing of soil moisture. Frost action can damage structures and plant roots.

Glacial drift (geology). Pulverized and other rock material transported by glacial ice and then deposited. Also the assorted and unassorted material deposited by streams flowing from glaciers.

Glacial outwash (geology). Gravel, sand, and silt, commonly stratified, deposited by melt water as it flows from glacial ice.

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Gleyed soil. A soil having one or more neutral gray horizons as a result of waterlogging and lack of oxygen. The term "gleyed" also designates gray horizons and horizons having yellow and gray mottles as a result of intermittent waterlogging.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. The major horizons of mineral soil are as follows:

O horizon.—An organic layer, fresh and decaying plant residue, at the surface of a mineral soil.

A horizon.—The mineral horizon, formed or forming at or near the surface, in which an accumulation of humified organic matter is mixed with the mineral material. Also, a plowed surface horizon most of which was originally part of a B horizon.

A2 horizon.—A mineral horizon, mainly a residual concentration of sand and silt high in content of resistant minerals as a result of the loss of silicate clay, iron, aluminum, or a combination of these.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or a combination of these; (2) by prismatic or blocky structure; (3) by redder or browner colors than those in the A horizon; or (4) by a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the A or B horizon. The material of a C horizon may be either like or unlike that from which the solum is presumed to have formed. If the material is known to differ from that in the solum the Roman numeral II precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock commonly underlies a C horizon, but can be directly below an A or a B horizon.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered, but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Leaching. The removal of soluble material from soil or other material by percolating water.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess. Fine grained material, dominantly of silt-sized particles, deposited by wind.

Low strength. Inadequate strength for supporting loads.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: abundance—few, common, and many; size—fine, medium, and coarse; and contrast—faint, distinct, and prominent. The size measurements are of the diameter along the greatest dimension. Fine indicates less than 5 millimeters (about 0.2 inch); medium, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and coarse, more than 15 millimeters (about 0.6 inch).

Parent material. The great variety of unconsolidated organic and mineral material in which soil forms. Consolidated bedrock is not yet parent material by this concept.

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Percolation. The downward movement of water through the soil.

Percs slowly. The slow movement of water through the soil adversely affecting the specified use.

Permeability. The quality that enables the soil to transmit water or air, measured as the number of inches per hour that water moves through the soil. Terms describing permeability are very slow (less than 0.06 inch), slow (0.06 to 0.20 inch), moderately slow (0.2 to 0.6 inch), moderate (0.6 to 2.0 inches), moderately rapid (2.0 to 6.0 inches), rapid (6.0 to 20 inches), and very rapid (more than 20 inches).

Piping. Moving water forms subsurface tunnels or pipelike cavities in the soil.

Poor outlets. Surface or subsurface drainage outlets difficult or expensive to install.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

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

Relief. The elevations or inequalities of a land surface, considered collectively.

Rooting depth. Shallow root zone. The soil is shallow over a layer that greatly restricts roots. See Root zone.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Seepage. The rapid movement of water through the soil. Seepage adversely affects the specified use.

Series, soil. A group of soils, formed from a particular type of parent material, having horizons that, except for the texture of the A or surface horizon, are similar in all profile characteristics and in arrangement in the soil profile. Among these characteristics are color, texture, structure, reaction, consistence, and mineralogical and chemical composition.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Slow intake. The slow movement of water into the soil.

Slow refill. The slow filling of ponds, resulting from restricted permeability in the soil.

Soil. A natural, three-dimensional body at the earth's surface that is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in mature soil consists of the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristics of the soil are largely confined to the solum.

Stratified. Arranged in strata, or layers. The term refers to geoglogic material. Layers in soils that result from the processes of soil formation are called horizons; those inherited from the parent material are called strata.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates that are separated from adjoining aggregates. The principal forms of soil structure are—platy (laminated), prismatic (vertical axis of aggregates longer than horizontal), columnar (prisms with rounded tops), blocky (angular or subangular), and granular. Structureless soils are either single grained (each grain by itself, as in dune sand) or massive (the particles adhering without any regular cleavage, as in many hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsoil phosphorus. The relative amount of phosphorus (P) in the soil between depths of 25 and 36 inches. The classes are very low (VL), low (L), medium (M), and high (H).

Subsoil potassium. The relative amount of potassium (K) in the soil between depths of 6 and 12 inches. The classes are very low minus (VL−), very low plus (VL+), low (L), medium (M), and high (H).

Substratum. The part of the soil below the solum.

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 can soak into the soil or flow slowly to a prepared outlet without harm. A terrace in a field is generally built so that the field can be farmed. A terrace intended mainly for drainage has a deep channel that is maintained in permanent sod.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea. A stream terrace is frequently called a second bottom, in contrast with a flood plain, and is seldom subject to overflow. A marine terrace, generally wide, was deposited by the sea.

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 small loamy sand, sandy loam, loam, silt, silt loam. sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay, and clay. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Thin layer. Otherwise suitable soil material too thin for the specified use.

Tilth, soil. The condition of the soil, especially the soil structure, as related to the growth of plants. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Underlying material. Material below the soil. In most soils it is similar to the parent material in which the soil formed.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Water table. The upper limit of this soil or underlying rock material that is wholly saturated with water.

Water table, apparent. A thick zone of free water in the soil. An apparent water table is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil.

Water table, artesian. A water table under hydrostatic head, generally beneath an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole.

Water table, perched. A water table standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

GUIDE TO MAPPING UNITS

Map symbol	Mapping unit	Described on page	Capability unit	
			Symbol	Page
1D3	Ida silt loam, 9 to 14 percent slopes, severely eroded	25	IIIe-2	60
1E3	Ida silt loam, 14 to 20 percent slopes, severely eroded	25	IVe-1	61
1F3	Ida silt loam, 20 to 30 percent slopes, severely eroded	25	VIe-1	62
5B	Kennebec-Ackmore complex, 2 to 5 percent slopes	27	IIw-1	58
C5B	Kennebec-Ackmore complex, channeled, 2 to 5 percent slopes	27	Vw-1	62
6	Okoboji silty clay loam, 0 to 1 percent slopes	36	IIIw-1	60
8C	Judson silty clay loam, 3 to 8 percent slopes	26	IIIe-1	59
9B	Marshall silty clay loam, 2 to 5 percent slopes	32	IIe-1	58
9B2	Marshall silty clay loam, 2 to 5 percent slopes, moderately eroded	32	IIe-1	58
9C	Marshall silty clay loam, 5 to 9 percent slopes	32	IIIe-1	59
9C2	Marshall silty clay loam, 5 to 9 percent slopes, moderately eroded	33	IIIe-1	59
9D2	Marshall silty clay loam, 9 to 14 percent slopes, moderately eroded	33	IIIe-2	60
9D3	Marshall silty clay loam, 9 to 14 percent slopes, severely eroded	33	IIIe-2	60
10D3	Monona silt loam, 9 to 14 percent slopes, severely eroded	34	IIIe-2	60
10E3	Monona silt loam, 14 to 20 percent slopes, severely eroded	34	IVe-1	61
11B	Colo-Ely silty clay loams, 2 to 5 percent slopes	18	IIw-1	58
24C2	Shelby loam, 5 to 9 percent slopes, moderately eroded	43	IIIe-1	59
24D2	Shelby loam, 9 to 14 percent slopes, moderately eroded	43	IIIe-2	60
24E2	Shelby loam, 14 to 18 percent slopes, moderately eroded	43	VIe-1	62
26B	Kennebec silty clay loam, 2 to 5 percent slopes	27	IIe-1	58
27C	Terril loam, 3 to 8 percent slopes	47	IIIe-1	59
31	Afton silty clay loam, 0 to 2 percent slopes	10	IIw-1	58
33E	Steinauer loam, 9 to 18 percent slopes	45	VIe-1	62
33F	Steinauer loam, 18 to 40 percent slopes	45	VIe-1	62
41D	Sparta loamy fine sand, 5 to 14 percent slopes	43	VIs-1	62
54	Zook silty clay loam, 0 to 2 percent slopes	51	IIw-2	59
55	Nicollet loam, 1 to 3 percent slopes	34	I-1	58
62C	Storden loam, 5 to 9 percent slopes	45	IIIe-1	59
62D	Storden loam, 9 to 14 percent slopes	45	IIIe-2	60
62E	Storden loam, 14 to 18 percent slopes	45	IVe-1	61
62F	Storden loam, 18 to 25 percent slopes	46	VIe-1	62
62G	Storden loam, 25 to 40 percent slopes	46	VIIe-1	62
73C	Salida gravelly loamy sand, 5 to 9 percent slopes	42	IVe-2	61
73D	Salida gravelly loamy sand, 9 to 14 percent slopes	42	IVe-2	61
77B	Sac silty clay loam, loam substratum, 2 to 5 percent slopes	39	IIe-1	58
77B2	Sac silty clay loam, loam substratum, 2 to 5 percent slopes, moderately eroded	39	IIe-1	58
77C	Sac silty clay loam, loam substratum, 5 to 9 percent slopes	39	IIIe-1	59
77C2	Sac silty clay loam, loam substratum, 5 to 9 percent slopes, moderately eroded	40	IIIe-1	59
78B	Sac silty clay loam, clay loam substratum, 2 to 5 percent slopes	40	IIe-1	58
78B2	Sac silty clay loam, clay loam substratum, 2 to 5 percent slopes, moderately eroded	40	IIe-1	58
78C	Sac silty clay loam, clay loam substratum, 5 to 9 percent slopes	41	IIIe-1	59
78C2	Sac silty clay loam, clay loam substratum, 5 to 9 percent slopes, moderately eroded	41	IIIe-1	59
91	Primghar silty clay loam, 0 to 3 percent slopes	37	I-1	58
92	Marcus silty clay loam, 0 to 2 percent slopes	31	IIw-1	58
95	Harps loam, 0 to 2 percent slopes	24	IIw-1	58
107	Webster silty clay loam, 0 to 2 percent slopes	50	IIw-1	58
108	Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	49	IIs-1	59
108B	Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes	49	IIe-2	58
108C2	Wadena loam, 24 to 32 inches to sand and gravel, 5 to 9 percent slopes, moderately eroded	49	IIIe-3	60
133	Colo silty clay loam, 0 to 2 percent slopes	18	IIw-2	59
134	Zook silty clay, 0 to 2 percent slopes	51	IIw-2	59
135	Coland clay loam, 0 to 2 percent slopes	16	IIw-2	59
135B	Coland clay loam, 2 to 4 percent slopes	16	IIw-1	58
138B	Clarion loam, 2 to 5 percent slopes	15	IIe-1	58
138C	Clarion loam, 5 to 9 percent slopes	15	IIIe-1	59

GUIDE TO MAPPING UNITS--Continued

Map symbol	Mapping unit	Described on page	Capability unit Symbol	Capability unit Page
138C2	Clarion loam, 5 to 9 percent slopes, moderately eroded	16	IIIe-1	59
138D2	Clarion loam, 9 to 14 percent slopes, moderately eroded	16	IIIe-2	60
174B	Bolan loam, 2 to 5 percent slopes	13	IIe-2	58
174C2	Bolan loam, 5 to 9 percent slopes, moderately eroded	13	IIIe-3	60
174D2	Bolan loam, 9 to 14 percent slopes, moderately eroded	13	IVe-2	61
201B	Coland-Spillville complex, 2 to 5 percent slopes	17	IIw-1	58
C201B	Coland-Spillville complex, channeled, 2 to 5 percent slopes	17	Vw-1	62
202	Cylinder loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	19	IIs-1	59
203	Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	19	I-1	58
221	Palms muck, 0 to 1 percent slopes	37	IIIw-1	60
234	Nishna silty clay loam, 0 to 2 percent slopes	35	IIw-2	59
236B	Lester loam, 2 to 7 percent slopes	29	IIe-1	58
259	Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	11	IIw-1	58
274	Rolfe loam, 0 to 1 percent slopes	38	IIIw-1	60
308	Wadena loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	48	I-1	58
308B	Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes	48	IIe-1	58
310	Galva silty clay loam, 0 to 2 percent slopes	23	I-1	58
310B	Galva silty clay loam, 2 to 5 percent slopes	23	IIe-1	58
310B2	Galva silty clay loam, 2 to 5 percent slopes, moderately eroded	23	IIe-1	58
310C	Galva silty clay loam, 5 to 9 percent slopes	23	IIIe-1	59
310C2	Galva silty clay loam, 5 to 9 percent slopes, moderately eroded	23	IIIe-1	59
T310	Galva silty clay loam, benches, 0 to 2 percent slopes	23	I-1	58
T310B	Galva silty clay loam, benches, 2 to 5 percent slopes	24	IIe-1	58
315	Alluvial land	10	Vw-1	62
323B	Terril loam, sandy substratum, 2 to 5 percent slopes	47	IIe-1	58
325	Le Sueur loam, 1 to 3 percent slopes	30	I-1	58
354	Marsh	31	VIIw-1	63
384	Collinwood silty clay loam, 1 to 3 percent slopes	18	I-1	58
390	Waldorf silty clay loam, 0 to 2 percent slopes	50	IIw-1	58
397B	Letri silty clay loam, 1 to 4 percent slopes	31	IIw-1	58
428	Ely silty clay loam, 1 to 3 percent slopes	20	I-1	58
430	Ackmore silt loam, 0 to 2 percent slopes	9	IIw-2	59
430B	Ackmore silt loam, 2 to 5 percent slopes	9	IIe-1	58
485	Spillville loam, 0 to 2 percent slopes	44	IIw-2	59
485B	Spillville loam, 2 to 5 percent slopes	44	IIe-1	58
506	Wacousta silty clay loam, 0 to 1 percent slopes	48	IIIw-1	60
507	Canisteo silty clay loam, 0 to 2 percent slopes	14	IIw-1	58
511	Blue Earth silty clay loam, 0 to 1 percent slopes	12	IIIw-1	60
559	Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	46	IIw-1	58
577C2	Everly clay loam, 4 to 9 percent slopes, moderately eroded	21	IIIe-1	59
577D2	Everly clay loam, 9 to 14 percent slopes, moderately eroded	21	IIIe-2	60
606	Lanyon silty clay loam, 0 to 1 percent slopes	28	IIIw-1	60
733	Calco silty clay loam, 0 to 2 percent slopes	14	IIw-2	59
823B	Flagler sandy loam, calcareous subsoil variant, 2 to 5 percent slopes	22	IIIe-3	60
823C2	Flagler sandy loam, calcareous subsoil variant, 5 to 9 percent slopes, moderately eroded	22	IIIe-3	60

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