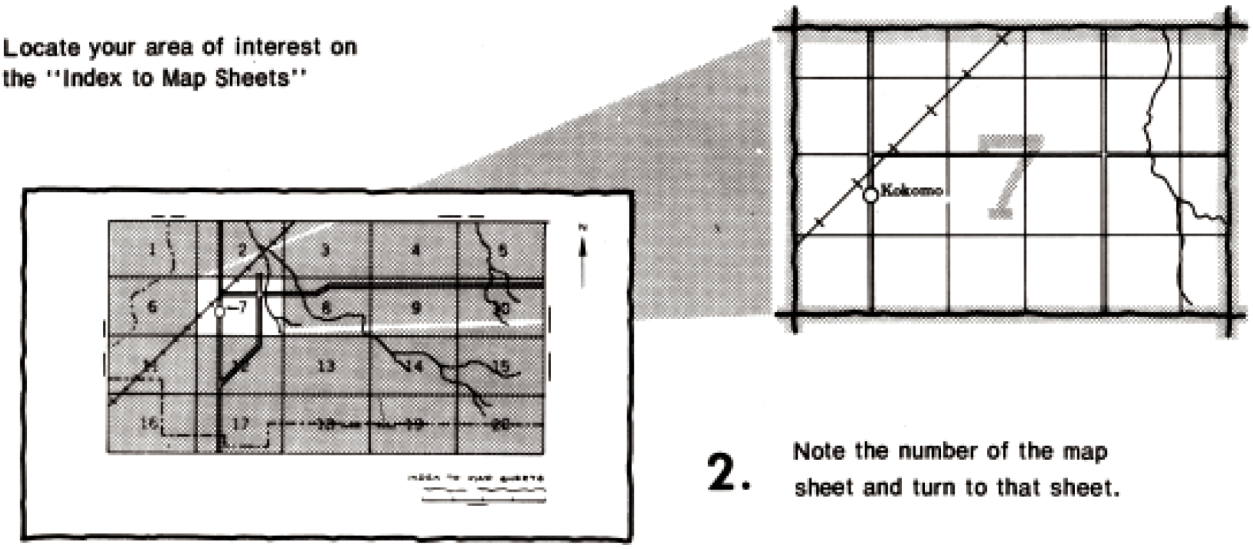
SOIL SURVEY OF

Calhoun County, Iowa

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

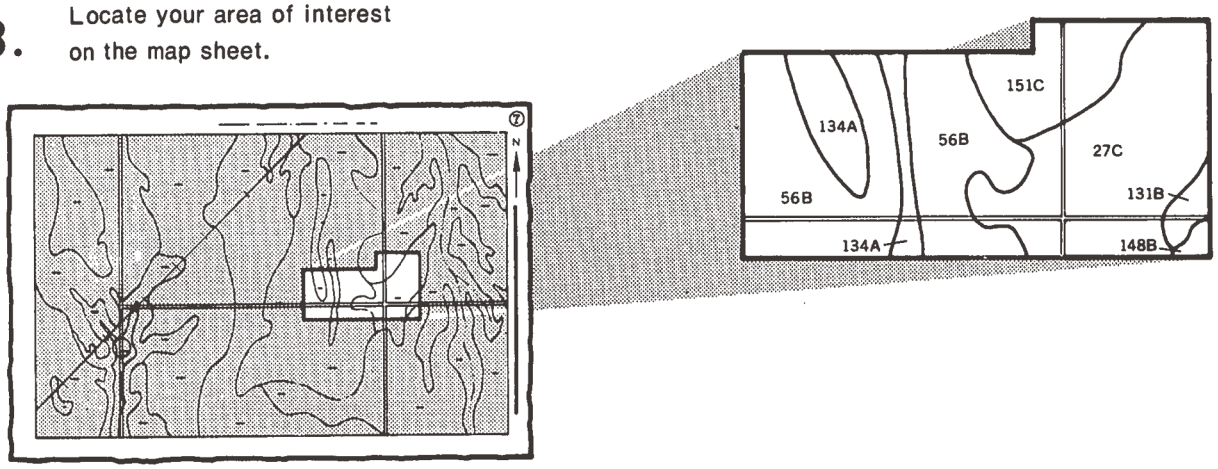
HOW TO USE

1. Locate your area of interest on the "Index to Map Sheets"

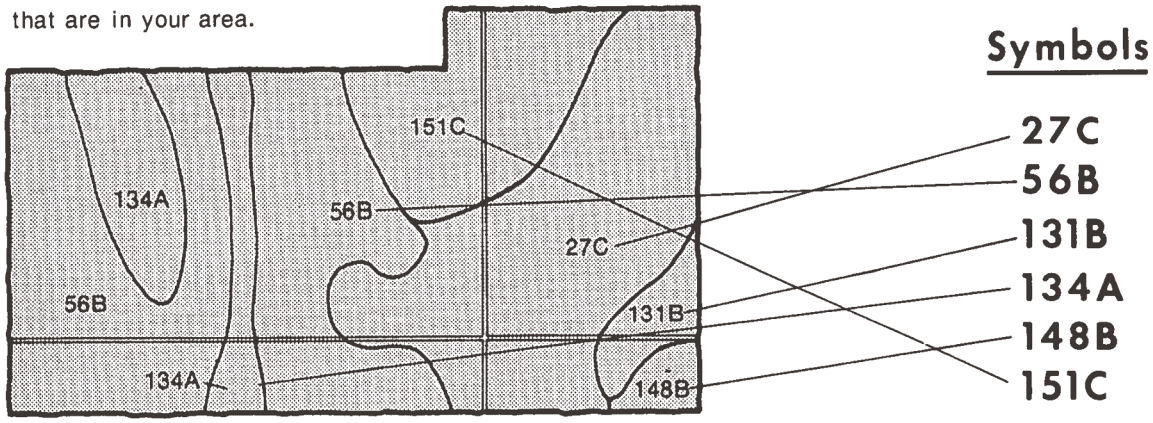


2. Note the number of the map sheet and turn to that sheet.

3. Locate your area of interest on the map sheet.

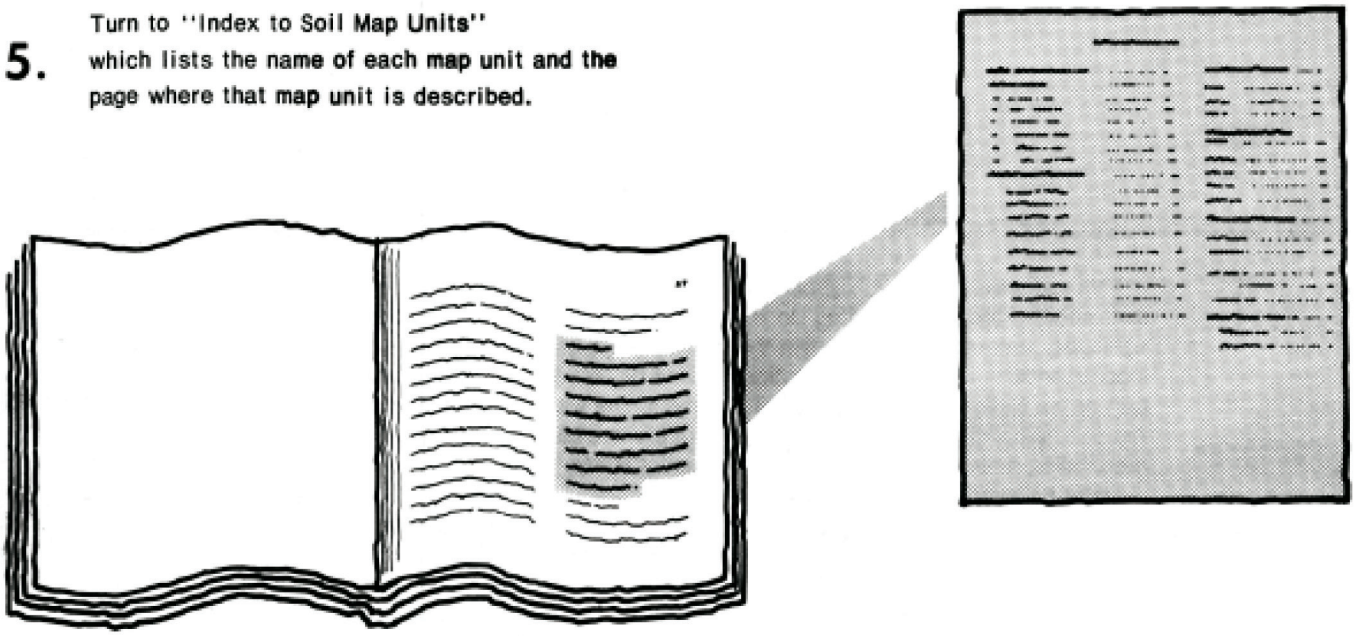


4. List the map unit symbols that are in your area.

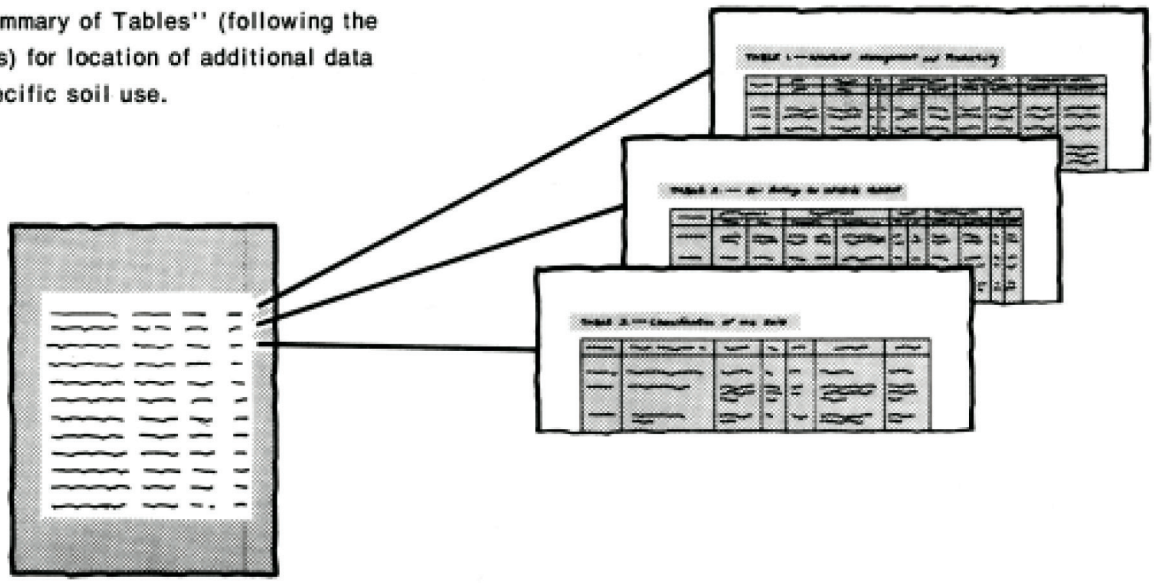


THIS SOIL SURVEY

5. Turn to "Index to Soil Map Units" which lists the name of each map unit and the page where that map unit is described.



6. See "Summary of Tables" (following the Contents) for location of additional data on a specific soil use.



7. Consult "Contents" for parts of the publication that will meet your specific needs. This survey contains useful information for farmers or ranchers, foresters or agronomists; for planners, community decision makers, engineers, developers, builders, or homebuyers; for conservationists, recreationists, teachers, or students; to specialists in wildlife management, waste disposal, or pollution control.

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other federal agencies, state agencies including the Agricultural Experiment Stations, and local agencies. 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, regardless of race, color, national origin, sex, religion, marital status, or age.

This survey was made cooperatively by the Soil Conservation Service; the Iowa Agriculture and Home Economics Experiment Station; the Cooperative Extension Service, Iowa State University; and the Department of Soil Conservation, State of Iowa. It is part of the technical assistance furnished to the Calhoun County Soil Conservation District. Funds appropriated by Calhoun County and the State of Iowa were used to pay for part of the cost of the survey. Major fieldwork was performed in the period 1973-77. Soil names and descriptions were approved in 1979. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1979.

Soil maps in this survey may be copied without permission. Enlargement of these maps, however, could cause misunderstanding of the detail of mapping. If enlarged, maps do not show the small areas of contrasting soils that could have been shown at a larger scale.

Cover: Grassed back slope terraces on gently sloping Clarion soils.

contents

soil series

Issued December 1981

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preface

This soil survey contains information that can be used in land-planning programs in Calhoun County, Iowa. It contains predictions of soil behavior for selected land uses. The survey also highlights limitations inherent in the soil or hazards that adversely affect the soil, improvements needed to overcome the limitations or reduce the hazards, and the impact of selected land uses on the environment.

This soil survey is designed for many different users. Farmers, ranchers, foresters, and agronomists can use it to evaluate the potential of the soil and the management needed for maximum food and fiber production. Planners, community officials, engineers, developers, builders, and home buyers can use the survey to plan land use, select sites for construction, and identify special practices needed to insure proper performance. Conservationists, teachers, students, and specialists in recreation, wildlife management, waste disposal, and pollution control can use the survey to help them understand, protect, and enhance the environment.

Great differences in soil properties can occur within short distances. Some soils are seasonally wet or subject to flooding. Some are shallow to gravel. Some are too unstable to be used as a foundation for buildings or roads. Clayey or wet soils are poorly suited to use as septic tank absorption fields. A high water table makes a soil poorly suited to basements or underground installations.

These and many other soil properties that affect land use are described in this soil survey. Broad areas of soils are shown on the general soil map. The location of each soil is shown on the detailed soil maps. Each soil in the survey area is described. Information on specific uses is given for each soil. Help in using this publication and additional information are available at the local office of the Soil Conservation Service or the Cooperative Extension Service.

soil survey of
Calhoun County, Iowa

By Maynard P. Koppen, Soil Conservation Service

Fieldwork by Maynard P. Koppen, Edwin G. Crocker, Richard D. Finley
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United States Department of Agriculture, Soil Conservation Service
in cooperation with the Iowa Agriculture and Home Economics
Experiment Station; the Cooperative Extension Service, Iowa State
University; and the Department of Soil Conservation, State of Iowa

general nature of the county

CALHOUN COUNTY is in north-central Iowa (fig. 1). It has an area of 366,080 acres, or 572 square miles. Rockwell City, the county seat, is about 75 miles by air from Des Moines, the state capital.

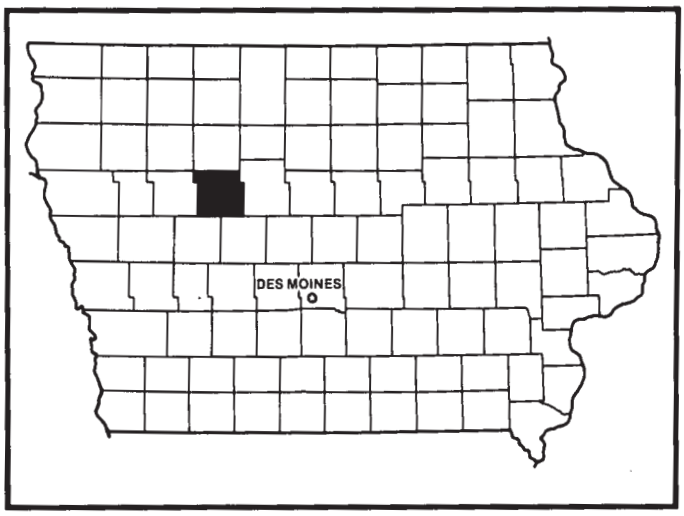

Figure 1.—Location of Calhoun County in Iowa.

The county is chiefly agricultural. The principal crops are corn, soybeans, and small acreages of oats and hay. Corn and soybeans are the most important cash crops. Some of the corn and most of the hay and oats are fed to livestock. Beef cattle, hogs, and a small number of sheep are raised on some farms.

This survey updates the soil survey of Calhoun County published in 1930 (*9*). It provides additional information and larger maps, which show the soils in greater detail.

climate

Prepared by the National Climatic Center, Asheville, North Carolina.

Table 1 gives data on temperature and precipitation for the survey area as recorded at Rockwell City in the period 1951 to 1973. Table 2 shows probable dates of the first freeze in fall and the last freeze in spring. Table 3 provides data on length of the growing season.

In winter the average temperature is 21 degrees F, and the average daily minimum temperature is 12 degrees. The lowest temperature on record, which occurred at Rockwell City on January 21, 1970, is minus 26 degrees. In summer the average temperature is 72 degrees, and the average daily maximum temperature is 84 degrees. The highest recorded temperature, which occurred at Rockwell City on July 31, 1955, is 106 degrees.

Growing degree days are shown in table 1. They are equivalent to "heat units." During the month, growing

degree days accumulate by the amount that the average temperature each day exceeds a base temperature (50 degrees F). The normal monthly accumulation is used to schedule single or successive plantings of a crop between the last freeze in spring and the first freeze in fall.

The total annual precipitation is about 31 inches. Of this, 23 inches, or 74 percent, usually falls in April through September, which includes the growing season for most crops. In 2 years out of 10, the rainfall in April through September is less than 17 inches. The heaviest 1-day rainfall during the period of record was 5 inches at Rockwell City on June 21, 1954. Thunderstorms occur on about 41 days each year, and most occur in summer.

Average seasonal snowfall is about 39 inches. The greatest snow depth at any one time during the period of record was 23 inches. On an average of 36 days, at least 1 inch of snow is on the ground. The number of such days varies greatly from year to year.

The average relative humidity in midafternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 84 percent. The sun shines 72 percent of the time possible in summer and 54 percent in winter. The prevailing wind is from the northwest. Average windspeed is highest, 13 miles per hour, in April.

Tornadoes and severe thunderstorms occur occasionally. They are usually of local extent and of short duration, and the resulting damage is sparse and in narrow belts. Hailstorms occur occasionally during the warmer part of the year. The hail falls in irregular patterns and in small areas.

physiography, relief, and drainage

Most of the soils in Calhoun County are nearly level to gently rolling and are on glacial drift plains. Near the Raccoon River and its major tributaries, the soils are rolling to steep. The elevation is about 1,100 feet above sea level throughout most of the county. It is 1,115 feet above sea level near the county courthouse.

Most of the streams and dredged ditches flow south into the Raccoon River. Lizard Creek flows generally east across the northeast corner of the county. It drains into the Des Moines River near Fort Dodge, in Webster County. On about 23 percent of the acreage in Calhoun County, the soils are well drained; on 21 percent, somewhat poorly drained; on 48 percent, poorly drained; and on 8 percent, very poorly drained.

history and development

The first settlement in Calhoun County was at Lake City in 1854. The county was organized in 1855. The population in 1880 was 5,595, all classed as rural. In 1930, the population was 17,605, and in 1970, it was 14,292 (*12*).

Between 1880 and 1890, many people from Illinois who had experience in land drainage moved to Calhoun County (*12*). They organized county drainage districts. These districts contracted with private companies to dredge drainage ditches and to install a network of large tile, 12 to 36 inches in diameter. These ditches and tile were financed and are maintained by county funds. The tile installed by private owners generally is 4 to 12 inches in diameter. The private drainage systems outlet into the county tile drainage system.

Most county roads have been surfaced. One Federal highway, several state highways, and several railroads cross the county.

how this survey was made

Soil scientists made this survey to learn what soils are in the survey area, where they are, and how they can be used. They observed the steepness, length, and shape of slopes; the size of streams and the general pattern of drainage; the kinds of native plants or crops; and the kinds of rock. They dug many holes to study 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, which has been changed very little by leaching or by plant roots.

The soil scientists recorded the characteristics of the profiles they studied and compared those profiles with others in nearby counties and in more distant places. They classified and named the soils according to nationwide uniform procedures. They drew the boundaries of the soils on aerial photographs. These photographs show trees, buildings, fields, roads, and other details that help in drawing boundaries accurately. The soil maps at the back of this publication were prepared from aerial photographs.

The areas shown on a soil map are called map units. Most map units are made up of one kind of soil. Some are made up of two or more kinds. The map units in this survey area are described under "General soil map units" and "Detailed soil map units."

While a soil survey is in progress, samples of some soils are taken for laboratory measurements and for engineering tests. All soils are field tested to determine their characteristics. Interpretations of those characteristics may be modified during the survey. Data are assembled from other sources, such as test results, records, field experience, and state and local specialists. For example, data on crop yields under defined management are assembled from farm records and from field or plot experiments on the same kinds of soil.

But only part of a soil survey is done when the soils have been named, described, interpreted, and delineated on aerial photographs and when the laboratory data and other data have been assembled. The mass of detailed information then needs to be organized so that it can be used by farmers, engineers, planners, developers and builders, home buyers, and others.

general soil map units

The general soil map at the back of this publication shows the soil associations in this survey area. Each association has a distinctive pattern of soils, relief, and drainage. Each is a unique natural landscape. Typically, an association consists of one or more major soils and some minor soils. It is named for the major soils. The soils making up one association can occur in another but in a different pattern.

The general soil map can be used to compare the suitability of large areas for general land uses. Areas of suitable soils can be identified on the map. Likewise, areas where the soils are not suitable can be identified.

Because of its small scale, the map is not suitable for planning the management of a farm or field or for selecting a site for a road or building or other structure. The soils in any one association differ from place to place in slope, depth, drainage, and other characteristics that affect management.

soil descriptions

1. Webster-Nicollet-Clarion association

Nearly level to moderately sloping, poorly drained, somewhat poorly drained, and well drained soils formed in glacial till on uplands

This association includes all of the county, except for a small area in the southwest corner. It consists of nearly level soils on flats and in swales and very gently sloping to moderately sloping soils on rises, knolls, and low hills (fig. 2). Some areas are undulating.

This association makes up about 97 percent of the county. It is about 25 percent Webster soils, 18 percent Nicollet soils, 18 percent Clarion soils, and 39 percent soils of minor extent (fig. 3).

Figure 2.—An area of the Webster-Nicollet-Clarion association. Clarion and Nicollet soils are on convex slopes and Webster soils in waterways.

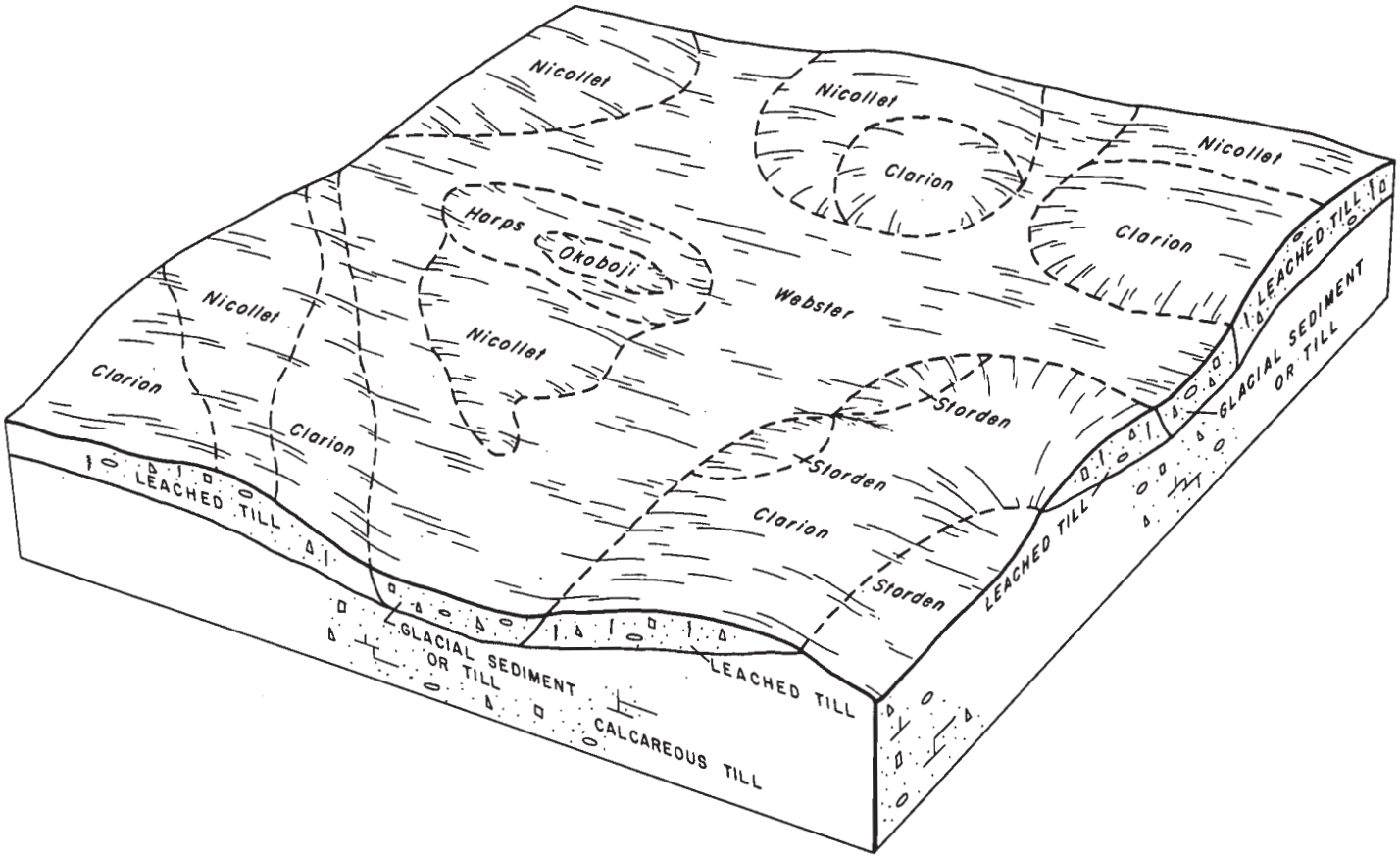

Figure 3.—Pattern of soils and parent material in the Webster-Nicollet-Clarion association.

The poorly drained, nearly level Webster soils are in swales and slightly concave draws and in some areas on flats. Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is about 11 inches of black and very dark gray silty clay loam and clay loam. The subsoil is friable clay loam about 18 inches thick. It is very dark gray in the upper part and dark gray and olive gray in the lower part. The substratum to a depth of about 60 inches is olive gray and dark gray clay loam and loam.

The somewhat poorly drained, very gently sloping Nicollet soils are on knolls and swells. Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is black and very dark grayish brown clay loam about 14 inches thick. The subsoil is friable clay loam about 15 inches thick. It is dark grayish brown in the upper part and grayish brown in the lower part. The substratum to a depth of about 60 inches is olive gray and yellowish brown clay loam.

The well drained Clarion soils are on knolls and rises. They are dominantly gently sloping, but in some areas they are steeper. Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is very dark gray loam about 5 inches thick. The subsoil is about 27 inches thick. It is dark brown, friable loam in the upper part, brown and dark yellowish brown, friable clay loam in the next part, and dark yellowish brown, friable loam in the lower part. The substratum to a depth of about 60 inches is light olive brown loam.

Minor in this association are the poorly drained Canisteo and Harps soils, the very poorly drained Okoboji soils, and the well drained Storden soils. Canisteo and Harps soils are calcareous. They are in positions on the landscape similar to those of the Webster soils. Okoboji soils are in the closed depressions. Storden soils are calcareous. They are moderately sloping to steep.

Erosion is a hazard on the more sloping soils in this association. Even though slopes are short and irregularly shaped, contour farming (fig. 4) and terraces are used to control erosion. In the poorly drained and very poorly drained areas, artificial drainage is needed. Tile lines and drainage ditches are used.

Most of the acreage in this association is used for row crops. Some areas are used for permanent pasture. Corn and soybeans are the main crops grown on the nearly level to moderately sloping soils. Oats and hay are grown in some areas on bottom land and on

livestock farms. The hay is generally alfalfa, a mixture of alfalfa and grass, or clover.

A large amount of grain is sold for cash. Some farms are diversified and raise livestock. On these farms part of the grain and most of the forage is fed to the livestock. Raising and fattening and feeding beef cattle are the most important livestock enterprises. Raising cow-calf herds, dairying, and raising sheep or poultry are less important. On a few farms raising turkeys is a major enterprise.

The trees on this association are grown mainly as windbreaks and ornamentals around farmsteads. A few grow along fence lines or in small stream valleys.

Small deposits of sand and gravel are mined along the small stream valleys. Generally, those in the uplands cannot be mined because they are too stratified or because they occur as layers that are too thin.

2. Wadena-Storden-Coland association

Nearly level to very steep, well drained and poorly drained soils formed in alluvial sediments and glacial till on stream benches, uplands, and bottom land

This association is along the Raccoon River and parts of some of the larger tributaries, including Lake Creek and Camp Creek. It consists mainly of nearly level to moderately sloping soils on benches, moderately sloping to very steep soils on valley sides, and nearly level to gently sloping soils on bottom land. A distinct feature of the association is the contrast in relief between the valley sides and the adjacent benches and bottom land.

This association makes up about 3 percent of the county. It is about 24 percent Wadena soils, 20 percent Storden soils, 14 percent Coland soils, and 42 percent soils of minor extent (fig. 5).

The well drained, nearly level to moderately sloping Wadena soils are on benches along rivers and streams. Typically, the surface layer is very dark brown loam about 8 inches thick. The subsurface layer is very dark grayish brown loam about 5 inches thick. The subsoil is about 27 inches thick. It is dark brown and brown, friable loam in the upper part and dark yellowish brown, very friable loamy coarse sand in the lower part. The substratum to a depth of about 60 inches is grayish brown sand and gravel.

Figure 4.—Contour farming in an area of the Webster-Nicollet-Clarion association.

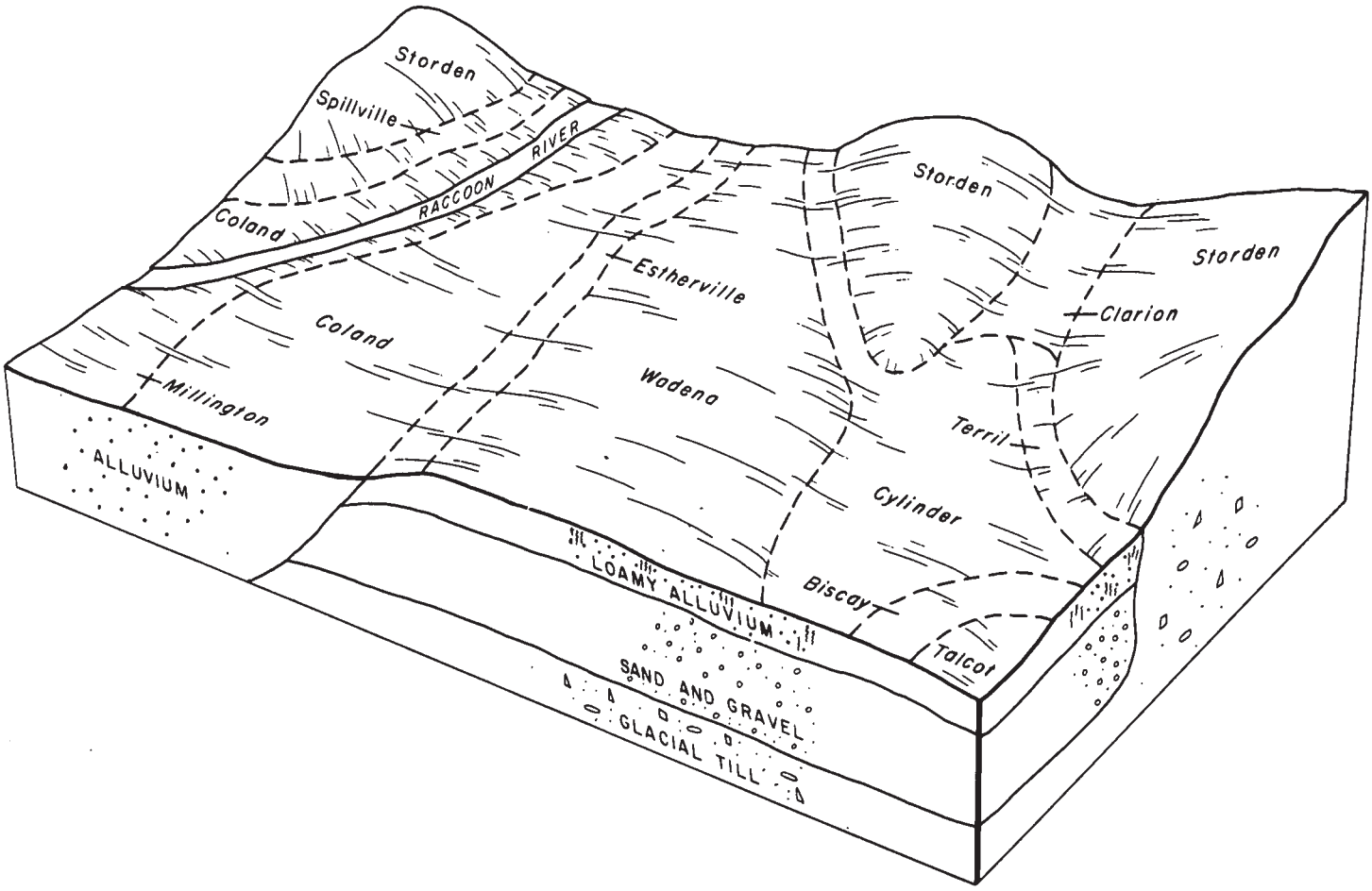

Figure 5.—Pattern of soils and parent material in the Wadena-Storden-Coland association.

Minor in this association are the poorly drained Biscay, Millington, and Talcot soils, the somewhat poorly drained Cylinder soils, the moderately well drained and somewhat poorly drained Spillville soils, the moderately

The well drained, moderately sloping to very steep Storden soils are on most of the valley sides. They are calcareous throughout. Typically, the surface layer is very dark grayish brown and yellowish brown loam about 6 inches thick. The substratum to a depth of about 60 inches is light olive brown, light yellowish brown, and yellowish brown loam.

The poorly drained, nearly level to gently sloping Coland soils are on bottom land. They are subject to flooding. Typically, the surface layer is black clay loam about 9 inches thick. The subsurface layer is friable clay loam about 35 inches thick. It is black in the upper part and very dark gray in the lower part. The upper part of the substratum is dark gray clay loam. The lower part to a depth of about 60 inches is olive gray loam.
well drained Terril soils, the well drained Clarion soils, and the somewhat excessively drained Estherville soils. Millington soils are in about the same position on the landscape as the Coland soils but are closer to streams. Biscay, Cylinder, and Talcot soils are on low benches or in swales on benches. Spillville and Terril soils are on low benches and foot slopes. Clarion soils are on short, irregular slopes adjacent to the steeper Storden soils. Estherville soils are in convex areas on benches.

Erosion is a severe hazard on the more sloping soils. It generally is controlled by a conservation tillage system that leaves a protective amount of crop residue on the surface, by contour farming, and, in places, by terraces. A drainage system and flood protection are needed in areas of the poorly drained Coland soils. Tile lines and drainage ditches are used. In many of the soils on benches, available water capacity is low or moderate because of the limited depth to the underlying sand and gravel.

Mining sand and gravel and raising livestock are the main enterprises on this association. Some areas are

used for row crops. Corn and soybeans are the main crops grown on the nearly level to gently sloping soils. Crop production on the more sloping soils and on the droughty soils underlain by sand and gravel is severely restricted. The more sloping soils are used for pasture or woodland or for oats and hay. The hay is generally alfalfa, a mixture of alfalfa and grass, or clover.

Many of the farms on this association raise beef cattle or cow-calf herds. The pastured areas provide forage on these farms. Other farms raise hogs, poultry, sheep, or dairy cattle.

Large deposits of sand and gravel are mined along the stream valleys. Many of the parks and recreation and wildlife areas in the county are on this association.

detailed soil map units

The map units on the detailed soil maps at the back of this survey represent the soils in the survey area. The map unit descriptions in this section, along with the soil maps, can be used to determine the suitability and potential of a soil for specific uses. They also can be used to plan the management needed for those uses. More information on each map unit, or soil, is given under "Use and management of the soils."

Each map unit on the detailed soil maps represents an area on the landscape and consists of one or more soils for which the unit is named.

A symbol identifying the soil precedes the map unit name in the soil descriptions. Each description includes general facts about the soil and identifies the principal hazards and limitations to be considered in planning for specific uses.

Soils that have profiles that are almost alike make up a *soil series*. Except for differences in texture of the surface layer or of the substratum, all the soils of a series have major horizons that are similar in composition, thickness, and arrangement.

Soils of one series can differ in texture of the surface layer or of the substratum. They also can differ in slope, stoniness, salinity, wetness, degree of erosion, and other characteristics that affect their use. On the basis of such differences, a soil series is divided into *soil phases*. Most of the areas shown on the detailed soil maps are phases of soil series. The name of a soil phase commonly indicates a feature that affects use or management. For example, Clarion loam, 2 to 5 percent slopes, is one of several phases in the Clarion series.

Some map units are made up of two or more major soils. These map units are called soil complexes. A *soil complex* consists of two or more soils that occur as areas so intricately mixed or so small that they cannot be shown separately on the soil maps. The pattern and proportion of the soils are somewhat similar in all areas. Coland-Spillville complex, 2 to 5 percent slopes, is an example.

Most map units include small scattered areas of soils other than those for which the map unit is named. Some of these included soils have properties that differ substantially from those of the major soil or soils. Such differences could significantly affect use and management of the soils in the map unit. These dissimiliar soils are described in each map unit. Also, some of the more unusual or strongly contrasting soils are identified by a special symbol on the soil maps.

This survey includes some *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Orthents, loamy, is an example. Some miscellaneous areas are large enough to be delineated on the soil maps. Some that are too small to be delineated are identified by a special symbol on the soil maps.

Table 4 gives the acreage and proportionate extent of each map unit. Other tables (see "Summary of tables") give properties of the soils and the limitations, capabilities, and potentials for many uses. The Glossary defines many of the terms used in describing the soils.

soil descriptions

4—Knoke silty clay loam, 0 to 1 percent slopes. This level, very poorly drained, calcareous soil is in upland depressions. It is subject to ponding. Areas dominantly are 2 to 10 acres in size but range to 50 acres. They are elliptical.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is black silty clay loam about 28 inches thick. The subsoil is black, friable silty clay loam about 18 inches thick. The substratum to a depth of about 60 inches is black, very dark gray, and dark gray, mottled silty clay loam. In some areas it is olive gray silty clay loam and is as shallow as 24 inches. In other areas it is stratified and is dominantly loam or silt loam.

Included with this soil in mapping are small areas of soils that have lenses of sand and loamy sand. These soils make up less than 5 percent of the unit. They are in positions on the landscape similar to those of the Knoke soil.

The Knoke soil is moderately slowly permeable. It has a seasonal high water table. Surface runoff is ponded. Available water capacity is very high. The content of organic matter is about 9 to 12 percent in the surface layer. The soil typically is moderately alkaline and calcareous throughout. The subsoil generally has a very low or low supply of available phosphorus and potassium.

Most areas are cultivated. If adequately drained, this soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Surface drains remove ponded water. Tile drains remove excess subsurface water. Even if the soil is drained, special care generally is needed to maintain good tilth in

the surface layer. The availability of plant nutrients is adversely affected by the excess amount of lime in the soil. Soil structure tends to be weak and breaks down if the soil is cultivated when too wet. Puddling results from the breakdown of the soil structure. In some areas where soybeans are grown, applications of ferrous sulfate or other iron compounds are needed.

The wetness and the excess lime are the main limitations if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. A drainage system is needed. The species that can withstand the wetness should be selected for planting. Applications of phosphorus, potassium, and minor nutrients are needed in most areas.

This soil is in capability subclass IIIw.

6—Okoboji silty clay loam, 0 to 1 percent slopes. This level, very poorly drained soil is in upland depressions. It is subject to ponding. Areas dominantly are 2 to 10 acres in size but range to 50 acres. They are elliptical.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is black silty clay loam about 14 inches thick. The subsoil is black, friable silty clay loam about 23 inches thick. The substratum to a depth of about 60 inches is black and light gray, mottled silty clay loam. In some areas it is dark gray or olive gray silty clay loam and is as shallow as 24 inches. In other areas it is dominantly loam or silt loam.

Included with this soil in mapping are some small areas of soils that have lenses of sandy loam, loamy sand, or sand. These soils make up less than 5 percent of the unit. They are in positions on the landscape similar to those of the Okoboji soil.

The Okoboji soil is moderately slowly permeable. It has a seasonal high water table. Surface runoff is ponded. Available water capacity is very high. The content of organic matter is about 9 to 12 percent in the surface layer. Reaction typically is neutral in the surface layer and neutral or mildly alkaline in the subsurface layer and subsoil. The subsoil generally has a very low supply of available phosphorus and a very low or low supply of available potassium.

Most areas are cultivated. If adequately drained, this soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Surface drains remove ponded water. Tile drains remove excess subsurface water. Special care generally is needed to maintain good tilth in the surface layer. Chisel plowing increases the infiltration rate by making the surface more pervious to water. Cultivating when the soil is too wet causes surface compaction and cloddiness.

The wetness is the main limitation if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. A drainage system is needed. The species that can withstand the wetness should be selected for planting.

This soil is in capability subclass IIIw.

27B—Terril loam, 1 to 5 percent slopes. This very gently sloping and gently sloping, moderately well drained soil is on upland foot slopes and convex alluvial fans. Slopes generally are short. Areas are irregularly shaped or are long and narrow. Most are 2 to 5 acres in size, but a few are somewhat larger.

Typically, the surface layer is black loam about 7 inches thick. The subsurface layer is black, very dark gray, and very dark grayish brown loam about 16 inches thick. The subsoil extends to a depth of 60 inches or more. It is dark brown, brown, and dark yellowish brown, friable loam in the upper part and dark yellowish brown, mottled, friable clay loam in the lower part. In places the upper part of the subsoil is very dark grayish brown.

Included with this soil in mapping are small areas of soils that have stratified loamy sand and sand within a depth of 36 inches. These soils are in positions on the landscape similar to those of the Terril soil. They make up about 5 percent of the unit.

The Terril soil is moderately permeable. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 4 or 5 percent in the surface layer. The soil typically is slightly acid or neutral throughout. The subsoil generally has a very low supply of available phosphorus and a very low or low supply of available potassium.

Most areas are cultivated. Some are pastured. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard. A conservation tillage system that leaves a protective amount of crop residue on the surface and grassed waterways help to prevent excessive soil loss. In places contour farming and terracing are difficult because slopes are short and irregular. Generally, good tilth can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to prevent surface crusting, and increases the infiltration rate.

If this soil is used for windbreaks or ornamental plantings, erosion is a moderate hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

This soil is in capability subclass IIe.

34B—Estherville sandy loam, 2 to 5 percent slopes. This gently sloping, somewhat excessively drained soil is on knolls and on the sides of benches and ridges. Slopes typically are short and convex. Areas generally are 2 to 10 acres in size. They are irregularly shaped.

Typically, the surface layer is very dark grayish brown sandy loam about 7 inches thick. The subsurface layer is very dark grayish brown sandy loam about 5 inches thick. The subsoil is brown, very dark grayish brown, and dark yellowish brown, friable sandy loam about 16 inches thick. The substratum to a depth of about 60 inches is

brown, calcareous sand and gravel. In some areas it is at a depth of more than 36 inches. In other areas it is dominantly loamy sand or sand in which the content of gravel is less than 10 percent.

Permeability is moderately rapid in the surface soil and subsoil and rapid in the substratum. Surface runoff is slow or medium. Available water capacity is low. The content of organic matter is about 3 to 4 percent in the surface layer. The surface layer, the subsurface layer, and the upper part of the subsoil typically are slightly acid or neutral. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are used as wildlife habitat. Some are cultivated. Some are used for pasture. This soil is poorly suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It is droughty because of the sandy and gravelly substratum. A conservation tillage system that leaves a protective amount of crop residue on the surface conserves moisture and helps to prevent excessive soil loss. In places contour farming helps to control erosion. The soil is not suitable for terracing because sand and gravel are too close to the surface. Returning crop residue to the soil or regularly adding other organic material improves fertility and conserves moisture. Overgrazing reduces the extent of the protective plant cover and increases the runoff rate and the susceptibility to erosion. Good tilth can be easily maintained.

If this soil is used for windbreaks, ornamental plantings, or plantings for wildlife, drought is a severe hazard. Also, erosion is a slight hazard before the trees and shrubs are established. Only the species that can grow well in droughty soils should be selected for planting. A permanent plant cover helps to control erosion.

This soil is in capability subclass IIIs.

34C2—Estherville sandy loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, somewhat excessively drained soil is on knolls and on convex side slopes on benches and uplands. Slopes typically are short. Areas generally are 2 to 5 acres in size. They are irregularly shaped.

Typically, the surface layer is very dark grayish brown sandy loam about 6 inches thick. Plowing has mixed part of the subsoil with the surface soil. The subsoil is about 14 inches thick. It is dark yellowish brown, very friable sandy loam in the upper part and loose sand and gravel in the lower part. The substratum to a depth of about 60 inches is brown, calcareous sand and gravel. In some areas it is at a depth of more than 36 inches. In other areas it is dominantly loamy sand and sand in which the content of gravel is less than 10 percent.

Permeability is moderately rapid in the surface layer and subsoil and rapid in the substratum. Surface runoff is slow or medium. Available water capacity is low. The content of organic matter is about 2 or 3 percent in the surface layer. The surface layer and the upper part of the subsoil typically are slightly acid or neutral. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are used as wildlife habitat. Some are cultivated. Some are used for pasture. This soil is poorly suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It is droughty because of the sandy and gravelly substratum. A conservation tillage system that leaves a protective amount of crop residue on the surface conserves moisture and helps to prevent excessive soil loss. In places contour farming helps to control erosion. The soil is not suitable for terracing because sand and gravel are too close to the surface. Returning crop residue to the soil or regularly adding other organic material improves fertility, conserves moisture, and helps to control erosion. Overgrazing reduces the extent of the protective plant cover and increases the runoff rate and the susceptibility to erosion. Good tilth can be easily maintained.

Drought is a severe hazard if this soil is used for the trees and shrubs grown as windbreaks, ornamental plantings, or plantings for wildlife. Only the species that can grow well in droughty soils should be selected for planting. A permanent plant cover helps to control erosion.

This soil is in capability subclass IVs.

48—Knoke mucky silt loam, 0 to 1 percent slopes. This level, very poorly drained, calcareous soil is in large upland depressions, many of which formerly were shallow lakes. It is subject to ponding. Areas range from 5 to more than 50 acres in size. They are irregularly shaped.

Typically, the surface layer is black mucky silt loam about 8 inches thick. The subsurface layer is about 25 inches thick. It is very dark gray mucky silty clay loam in the upper part, black mucky silty clay loam in the next part, and black silty clay loam in the lower part. The subsoil is black, friable silty clay loam about 13 inches thick. The substratum to a depth of about 60 inches is gray, very dark gray, and dark gray, mottled silty clay loam.

This soil is moderately slowly permeable. It has a seasonal high water table. Surface runoff is ponded. Available water capacity is very high. The content of organic matter is about 12 to 18 percent in the surface layer. The soil typically is moderately alkaline or mildly alkaline throughout. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. If adequately drained, this soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay or pasture. An adequate subsurface and surface drainage system is needed. The availability of plant nutrients is limited by the excess amount of lime in the soil, as commonly is evidenced by stunted soybeans that have yellow leaves. Applications of phosphorus and potassium fertilizer are needed. In some areas applications of ferrous sulfate or

other iron compounds also are needed. Special care generally is needed to maintain good tilth in the surface layer. Cultivating when the soil is wet hastens the breakdown of the soil structure.

The wetness and the excess lime are the main limitations if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. A drainage system is needed; and the species that can withstand the wetness should be selected for planting. Applications of phosphorus, potassium, and minor nutrients are needed in most areas.

This soil is in capability subclass IIIw.

52B—Bode clay loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on knolls and on convex side slopes along upland drainageways. Slopes typically are short. Areas are 2 to 5 acres in size. They are irregularly shaped.

Typically, the surface layer is black clay loam about 6 inches thick. The subsurface layer is very dark grayish brown clay loam about 5 inches thick. The subsoil is friable clay loam about 17 inches thick. It is dark brown in the upper part and brown in the lower part. The substratum to a depth of about 60 inches is mottled dark yellowish brown, grayish brown, and yellowish brown loam. In places plowing has mixed part of the subsoil with the surface soil.

This soil is moderately permeable. Surface runoff is rapid or medium. Available water capacity is high. The content of organic matter is about 3 or 4 percent in the surface layer. The surface layer and the upper part of the subsoil typically are slightly acid or neutral. The subsoil generally has a very low or low supply of available phosphorus and a very low supply of available potassium.

Most areas are cultivated. If erosion is controlled, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. A conservation tillage system that leaves a protective amount of crop residue on the surface and grassed waterways help to prevent excessive soil loss. Contour farming and terracing are practical in some areas but are not feasible in undulating areas where slopes are short. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to control erosion and prevent surface crusting, and increases the infiltration rate. Good tilth generally can be easily maintained.

If this soil is used for windbreaks or ornamental plantings, erosion is a slight hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

This soil is in capability subclass IIe.

55—Nicollet loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on knolls and swells in the uplands. Areas generally are 2 to 15 acres in size and are oblong, but some are 50 acres or more and are irregularly shaped.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is black and very dark grayish brown clay loam about 14 inches thick. The subsoil is friable clay loam about 15 inches thick. It is dark grayish brown in the upper part and grayish brown and mottled in the lower part. The substratum to a depth of about 60 inches is olive gray, mottled clay loam. In places the surface layer is clay loam.

Included with this soil in mapping are small areas of sandy or gravelly soils on knobs. These soils make up less than 5 percent of the unit. Also included are some small areas of wet soils in depressions or on other low lying parts of the landscape and some areas of wet, calcareous soils, which are lower on the landscape than the Nicollet soil. The wet soils make up about 10 percent of the unit.

The Nicollet soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 5 to 6 percent in the surface layer. The surface soil and the upper part of the subsoil typically are slightly acid or neutral. The subsoil generally has a very low supply of available phosphorus and a very low or low supply of available potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. The seasonal wetness can delay fieldwork, but it can be overcome by installing tile drains. Good tilth generally can be easily maintained. Cultivating or grazing when the soil is too wet, however, causes surface compaction. Wind erosion is a hazard if large areas of the soil are plowed in the fall. Returning crop residue to the soil or regularly adding other organic material helps to control wind erosion and prevent surface crusting and increases the infiltration rate.

The seasonal high water table is a moderate limitation if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. It generally can be overcome, however, by selecting the species that can withstand occasional wetness or by installing a drainage system.

This soil is in capability class I.

62C2—Storden loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained, calcareous soil is on knolls and convex side slopes along streams and upland drainageways. Slopes generally are short. Areas are irregularly shaped or are long and narrow. Most are 2 to 10 acres in size, but some are somewhat larger.

Typically, the surface layer is mixed very dark grayish brown and yellowish brown loam about 6 inches thick. The substratum to a depth of about 60 inches is light olive brown, yellowish brown, and light yellowish brown, mottled loam. In some areas it has strata of silt loam and sandy loam.

Included with this soil in mapping are some areas where the slope is less than 5 or more than 9 percent.

These areas make up about 10 percent of the unit. Also included are some small areas of sandy or gravelly soils on knobs. These soils make up less than 5 percent of the unit.

The Storden soil is moderately permeable. Surface runoff is rapid. Available water capacity is high. The content of organic matter is about 1 percent in the surface layer. The soil typically is moderately alkaline throughout. Below the surface layer, the supply of available phosphorus and potassium generally is very low.

Most areas are cultivated (fig. 6). If erosion is controlled and fertility improved, this soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Erosion is a severe hazard. A conservation tillage system that leaves a protective amount of crop residue on the surface and grassed waterways help to prevent excessive soil loss. Contour farming and terracing are practical in some areas but are not feasible in areas where slopes are short. Applications of a large amount of phosphorus and potassium fertilizer are needed because of the high content of lime in the soil. In some areas where soybeans are grown, applications of iron compounds are needed. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to control erosion and prevent surface crusting, and increases the infiltration rate.

If this soil is used for windbreaks or ornamental plantings, erosion is a severe hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

This soil is in capability subclass IIIe.

62D2—Storden loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained, calcareous soil is on convex side slopes along streams and upland drainageways. Slopes generally are short. Areas are long and narrow. Most are 2 to 10 acres in size, but a few, mainly along the major streams, are 25 acres or more.

Typically, the surface layer is mixed very dark grayish brown and yellowish brown loam about 6 inches thick. The substratum to a depth of about 60 inches is light olive brown, yellowish brown, and light yellowish brown, mottled loam. In some areas it has strata of silt loam and sandy loam.

Included with this soil in mapping are some areas where the slope is less than 9 or more than 14 percent. These areas make up about 10 percent of the unit. Also included are some small areas of sandy or gravelly soils on knobs. These soils make up less than 5 percent of the unit.

The Storden soil is moderately permeable. Surface runoff is rapid. Available water capacity is high. The content of organic matter is about 0.5 to 1 percent in the surface layer. The soil typically is moderately alkaline throughout. Below the surface layer, the supply of

Figure 6.—A cultivated area of Storden loam, 5 to 9 percent slopes, moderately eroded. This light colored soil is on the crest of the knoll.

available phosphorus and potassium generally is very low.

Some areas are cultivated. Some are pastured. If erosion is controlled and fertility improved, this soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Erosion is a severe hazard. Much of the precipitation from intense rainfall runs off unless a plant cover protects the surface. A conservation tillage system that leaves a protective amount of crop residue on the surface and grassed waterways help to prevent excessive soil loss. Contour farming and terracing are practical in some areas but are not feasible in areas where slopes are short and irregular. Good tilth generally can be easily maintained. In some areas where soybeans are grown, applications of iron compounds are needed. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to control erosion and prevent surface crusting, and increases the infiltration rate.

Pastures commonly are renovated by planting a cultivated crop one year and reestablishing the pasture the next year. Stands can be maintained for a period of years if grazing is controlled, the pasture is reseeded, and fertilizer is applied as needed.

If this soil is used for windbreaks or ornamental plantings, erosion is a severe hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

This soil is in capability subclass IIIe.

62E—Storden loam, 14 to 18 percent slopes. This moderately steep, well drained, calcareous soil is on convex side slopes along streams and upland drainageways. Slopes generally are short. Areas are long and narrow. Most are 2 to 10 acres in size, but a few, mainly along the major streams, are 25 acres or more.

Typically, the surface layer is very dark gray loam about 5 inches thick. The substratum to a depth of about 60 inches is light olive brown, yellowish brown, light yellowish brown, and olive gray loam. In some areas it has strata of silt loam and sandy loam.

Included with this soil in mapping are some areas where the slope is less than 14 or more than 18 percent. These areas make up about 10 percent of the unit.

This soil is moderately permeable. Surface runoff is rapid. Available water capacity is high. The content of organic matter is about 1 to 2 percent in the surface layer. The soil typically is moderately alkaline throughout. Below the surface layer, the supply of available phosphorus and potassium generally is very low.

Most areas are used for pasture. A few are used for cultivated crops. This soil is poorly suited to corn and soybeans. It is moderately suited to small grain and to grasses and legumes for hay and pasture. Erosion is a severe hazard if cultivated crops are grown or if pastures are overgrazed. A protective plant cover is needed because rainfall runs off rapidly. A conservation tillage system that leaves a protective amount of crop residue on the surface and grassed waterways help to prevent excessive soil loss. In many areas contour farming and terracing are difficult because the slopes are too steep and too short. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to control erosion and prevent surface crusting, and increases the infiltration rate.

This soil is suited to row crops grown occasionally to renovate pastures. The pastures commonly are renovated by planting the row crop one year and reestablishing the pasture the next year. Stands can be maintained for a period of years if grazing is controlled, the pasture is reseeded, and fertilizer is applied as needed.

If this soil is used for windbreaks or ornamental plantings, erosion is a severe hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

This soil is in capability subclass IVe.

62F—Storden loam, 18 to 25 percent slopes. This steep, well drained, calcareous soil is on convex side slopes along streams and upland drainageways. Slopes generally are short. Areas are long and narrow. Most are 2 to 10 acres in size, but a few along the major streams are 25 acres or more.

Typically, the surface layer is very dark gray loam about 4 inches thick. The substratum to a depth of about 60 inches is light olive brown, yellowish brown, light yellowish brown, and olive gray loam. In some areas it has strata of silt loam and sandy loam.

Included with this soil in mapping are some areas where the slope is less than 18 or more than 25 percent. These areas make up about 10 percent of the unit. Also included are areas of soils in which the substratum has stratified lenses of loamy sand and sand. These soils are in positions on the landscape similar to those of the Storden soil. They make up less than 5 percent of the unit.

The Storden soil is moderately permeable. Surface runoff is rapid. Available water capacity is high. The content of organic matter is about 1 to 2 percent in the surface layer. The soil typically is moderately alkaline throughout. Below the surface layer, the supply of available phosphorus and potassium generally is very low.

Most areas are used for pasture. Some support bluegrass or native grasses. This soil is generally unsuitable for cultivated crops because erosion is a severe hazard. It is better suited to grasses and legumes for hay and pasture, but it is too erodible for unlimited grazing. Operating farm machinery is hazardous because of the steep slope. In the areas where farm machinery can be used, fertilizer can be applied and pastures renovated.

If this soil is used for windbreaks or ornamental plantings, erosion is a severe hazard before the trees

and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch. Planting is difficult because of the steep slope.

This soil is in capability subclass VIe.

62G—Storden loam, 25 to 40 percent slopes. This very steep, well drained, calcareous soil is on convex side slopes along streams. Slopes are short. Areas are long and narrow or irregularly shaped. Most are 2 to 10 acres in size, but a few are 25 acres or more.

Typically, the surface layer is very dark gray loam about 4 inches thick. The substratum to a depth of about 60 inches is light olive brown, yellowish brown, light yellowish brown, and olive gray loam. In places it has lenses of silt loam and sandy loam. In some areas the slope is more than 40 percent.

This soil is moderately permeable. Surface runoff is rapid. Available water capacity is high. The content of organic matter is about 1 to 2 percent in the surface layer. The soil typically is moderately alkaline throughout. Below the surface layer, the supply of available phosphorus and potassium generally is very low.

Most areas are used for pasture. This soil is generally unsuitable for cultivated crops or unlimited grazing because it is very steep and highly susceptible to erosion. It is poorly suited to hay because the slopes generally are too steep for the use of farm machinery. Controlled grazing is important because renovating pastures is very difficult.

Trees or shrubs can be planted by hand but generally cannot be planted by machine because of the equipment limitation.

This soil is in capability subclass VIIe.

90—Okoboji mucky silt loam, 0 to 1 percent slopes. This level, very poorly drained soil is in upland depressions, generally in the middle of large depressions. It is subject to ponding. Areas are irregularly shaped. Most are 5 to 20 acres in size, but some are 40 acres or more.

Typically, the surface layer is black mucky silt loam about 13 inches thick. The subsurface layer is black silty clay loam about 19 inches thick. The subsoil is black, friable silty clay loam about 10 inches thick. The substratum to a depth of about 60 inches is dark gray silty clay loam. In places the surface layer is muck.

Included with this soil in mapping are small areas of soils in which the substratum has lenses of sandy loam, loamy sand, or sand. These soils make up about 5 percent of the unit. They are in positions on the landscape similar to those of the Okoboji soil.

The Okoboji soil is moderately slowly permeable. It has a seasonal high water table. Surface runoff is slow to ponded. Available water capacity is very high. The content of organic matter is about 12 to 18 percent in the surface layer. Reaction typically is strongly acid or medium acid in the mucky surface layer and neutral or mildly alkaline in the subsurface layer and subsoil. The subsoil generally has a very low supply of available phosphorus and a very low or low supply of available potassium.

Most areas are cultivated. If adequately drained, this soil is moderately suited to corn, soybeans, small grain, and grasses. Surface drains remove excess ponded water. Tile drains remove excess subsurface water. In many areas deep cuts are needed to provide suitable outlets. In the adequately drained areas, good tilth generally can be easily maintained.

The wetness is the main limitation if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. A drainage system is needed. The species that can withstand the wetness should be selected for planting.

This soil is in capability subclass IIIw.

95—Harps loam, 0 to 2 percent slopes. This nearly level, poorly drained, calcareous soil is in plane or slightly convex areas, typically on the rims of the larger upland depressions. Areas generally are 2 to 10 acres in size. They are elliptical.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is about 14 inches thick. It is black loam in the upper part and black and very dark gray, mottled clay loam in the lower part. The subsoil is olive gray, mottled, friable loam about 7 inches thick. The substratum to a depth of about 60 inches is olive gray and yellowish brown, mottled loam. In places the subsoil has thin lenses of sandy loam.

Included with this soil in mapping are spots of highly calcareous, sandy soils. Also included are areas where the substratum has stratified lenses of loamy sand and sand. Included soils make up about 5 percent of the unit. They are in positions on the landscape similar to those of the Harps soil.

The Harps soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 4 to 5 percent in the surface layer. The soil is moderately alkaline throughout. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated (fig. 7). If adequately drained, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Tile drains remove excess subsurface water. Cultivating when the soil is too wet causes surface compaction and cloddiness. Chisel plowing increases the infiltration rate by making the surface more pervious to water. Returning crop residue to the soil and regularly adding other organic material help to control wind erosion and prevent surface crusting and increase the infiltration rate. The availability of plant nutrients is adversely affected by the excess amount of lime in the soil. In some areas where soybeans are grown, applications of iron compound are needed.

Figure 7.—A cultivated area of Harps loam, 0 to 2 percent slopes.

The seasonal high water table and the excess lime are the main limitations if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. Only the species that can withstand a wet, calcareous soil should be selected for planting.

This soil is in capability subclass IIw.

107—Webster silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is in swales or slightly convex areas on uplands. Most areas are 5 to 15 acres in size and are long and narrow, but some are as large as 100 acres and are irregularly shaped.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is about 11 inches thick. It is black silty clay loam in the upper part and very dark gray, mottled clay loam in the lower part. The subsoil is friable clay loam about 18 inches thick. The upper part is very dark gray and mottled, and the lower part is mottled dark gray and olive gray. The upper part of the substratum is olive gray and dark gray, mottled clay loam. The lower part to a depth of about 60 inches is olive gray loam mottled with yellowish brown. In places the surface layer is clay loam.

Included with this soil in mapping are some small areas of Harps soils in similar positions on the landscape and Okoboji soils in depressions. These soils make up about 10 percent of the unit.

The Webster soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 6 to 7 percent in the surface layer. This layer typically is neutral. The subsoil is mildly alkaline. It generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. If adequately drained, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Tile drains remove excess water. Special care generally is needed to maintain good tilth in the surface layer. Cultivating when the soil is too wet causes surface compaction and cloddiness. Chisel plowing increases the infiltration rate by making the surface more pervious to water. Returning crop residue to the soil or regularly adding other organic material helps to control wind erosion and prevent surface crusting and increases the infiltration rate.

The wetness is the main limitation if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. A drainage system is needed. The species that can withstand the wetness should be selected for planting.

This soil is in capability subclass IIw.

108—Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, well drained soil dominantly is on slightly convex slopes on benches, but in a few areas it is on uplands. Areas are irregularly shaped. Generally, those on benches are 5 to 20 acres in size and those on uplands 2 to 3 acres.

Typically, the surface layer is very dark brown loam about 8 inches thick. The subsurface layer is very dark grayish brown loam about 5 inches thick. The subsoil is about 27 inches thick. It is dark brown, friable loam in the upper part, brown, friable loam in the next part, and dark yellowish brown, very friable loamy coarse sand in the lower part. The substratum to a depth of about 60 inches is grayish brown sand and gravel. In some areas loamy sand or sand and gravel is as shallow as 18 inches. In other areas the lower part of the subsoil is sandy loam or sandy clay loam.

Included with this soil in mapping are some areas of sandy and gravelly soils on small knobs and some small areas of poorly drained soils on the low lying parts of the landscape. Included soils make up less than 10 percent of the unit.

Permeability is moderate in the surface layer, subsurface layer, and subsoil of the Wadena soil and very rapid in the substratum. Surface runoff is medium. Available water capacity is low. The content of organic matter is about 3 to 4 percent in the surface layer. The surface layer, the subsurface layer, and the upper part of the subsoil typically are slightly acid or neutral. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It is seasonally droughty because of the sandy and gravelly substratum. Returning crop residue to the soil or regularly adding other organic material improves fertility, conserves moisture, and helps to control wind erosion. Overgrazing reduces the extent of the protective plant cover and increases the susceptibility to wind erosion. Good tilth generally can be easily maintained.

The seasonal droughtiness is the main limitation if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. The species that can withstand the droughtiness should be selected for planting, or irrigation water should be applied if practical.

This soil is in capability subclass IIs.

108B—Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes. This gently sloping, well drained soil dominantly is on convex slopes on benches, but in a few areas it is on uplands. Areas are irregularly shaped. Generally, those on benches are 2 to 10 acres in size and those on uplands 2 to 3 acres.

Typically, the surface layer is very dark brown loam about 8 inches thick. The subsurface layer is very dark grayish brown loam about 5 inches thick. The subsoil is about 27 inches thick. It is dark brown, friable loam in the upper part, brown, friable loam in the next part, and dark yellowish brown, very friable loamy coarse sand in the lower part. The substratum to a depth of about 60 inches is grayish brown sand and gravel. In some small areas, the surface layer is sandy loam and the slope is more than 5 percent.

Permeability is moderate in the surface layer, subsurface layer, and subsoil and very rapid in the substratum. Surface runoff is medium. Available water capacity is low. The content of organic matter is about 3 to 4 percent in the surface layer. The surface layer, the subsurface layer, and the upper part of the subsoil typically are slightly acid or neutral. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard. Also, the soil is seasonally droughty because of the sandy and gravelly substratum. A conservation tillage system that leaves a protective amount of crop residue on the surface helps to prevent excessive soil loss. Returning crop residue to the soil or regularly adding other organic material improves fertility, conserves moisture, and helps to control erosion. Overgrazing pastures reduces the extent of the protective plant cover and increases the runoff rate and the susceptibility to erosion. Good tilth generally can be easily maintained.

If this soil is used for windbreaks or ornamental plantings, erosion is a slight hazard before the trees and shrubs are established. Also, the soil is seasonally droughty. A permanent plant cover or surface mulch helps to control erosion and conserves moisture. The species that can withstand the droughtiness should be selected for planting, or irrigation water should be applied if practical.

This soil is in capability subclass IIe.

108C2—Wadena loam, 24 to 32 inches to sand and gravel, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil dominantly is on convex slopes on the more sloping parts of benches, but in a few areas it is on uplands near stream valleys. Typically, areas are 2 to 10 acres in size and are irregularly shaped.

Typically, the surface layer is about 7 inches thick. It is very dark grayish brown loam mixed with some of the dark brown subsoil material. The subsoil is about 24 inches thick. It dominantly is dark brown and brown, friable loam, but in the lower few inches it is yellowish brown, very friable loamy coarse sand. The substratum to a depth of about 60 inches is grayish brown sand and gravel. In some areas the depth to calcareous gravelly loamy coarse sand is only about 15 inches. In other areas the surface layer and the subsoil are sandy loam or sandy clay loam.

Permeability is moderate in the surface layer and subsoil and very rapid in the substratum. Surface runoff

is medium. Available water capacity is low. The content of organic matter is about 2 to 3 percent in the surface layer. The surface layer and the upper part of the subsoil typically are slightly acid or neutral. The subsoil generally has a very low supply of available phosphorus and potassium.

Some areas are cultivated, and some are pastured. This soil is poorly suited to corn and soybeans. It is moderately suited to small grain and to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard. Also, the soil is seasonally droughty because of the sandy and gravelly substratum. A conservation tillage system that leaves a protective amount of crop residue on the surface helps to prevent excessive soil loss. If terraces are built, the cuts should not expose the sand and gravel substratum and as much topsoil as possible should be returned to the site. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, conserves moisture, and helps to control erosion. Overgrazing pastures reduces the extent of the protective plant cover and increases the runoff rate and the susceptibility to erosion.

If this soil is used for windbreaks or ornamental plantings, erosion is a slight hazard before the trees and shrubs are established. Also, the soil is seasonally droughty. A permanent plant cover or surface mulch helps to control erosion and conserves moisture. The species that can withstand the droughtiness should be selected for planting, or irrigation water should be applied if practical.

This soil is in capability subclass IIIe.

135—Coland clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on bottom land and low benches. It is subject to flooding. Typically, areas range from 10 to 50 acres in size. They are long and narrow.

Typically, the surface layer is black clay loam about 9 inches thick. The subsurface layer is clay loam about 35 inches thick. It is black in the upper part and very dark gray in the lower part. The upper part of the substratum is dark gray clay loam. The lower part to a depth of about 60 inches is gray loam. In places the surface soil is only about 18 inches thick. In some areas the surface layer is silty clay loam. In other areas it is calcareous.

Included with this soil in mapping are small areas of sandy soils, generally at the slightly higher elevations. These soils make up about 10 percent of the unit.

The Coland soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 5 to 7 percent in the surface layer. Reaction typically is neutral in the surface layer and subsurface layer, but in places it is mildly alkaline throughout the soil. Below the surface layer, the supply of available phosphorus is low and the supply of available potassium generally is very low.

Most areas are cultivated. Some areas that are not protected from flooding or that are isolated by a meandering stream are used for pasture (fig. 8). This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture if it is adequately drained and if flooding is controlled. Special care generally is needed to maintain good tilth in the surface layer. Chisel plowing increases the infiltration rate by making the surface more pervious to water. Cultivating when the soil is too wet causes surface compaction and cloddiness. Returning crop residue to the soil or regularly adding other organic material helps to control wind erosion and prevent surface crusting and increases the infiltration rate. Water tolerant grasses and legumes are the best pasture plants.

The seasonal high water table and the flooding are the main limitations if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. Only the species that can withstand the wetness and the flooding should be selected for planting.

This soil is in capability subclass IIw.

135B—Coland clay loam, 2 to 4 percent slopes. This gently sloping, poorly drained soil is in narrow drainageways on bottom land or on foot slopes and alluvial fans. It is subject to flooding. Areas generally are 2 to 5 acres in size and are long and narrow.

Typically, the surface layer is black clay loam about 8 inches thick. The subsurface layer is clay loam about 29 inches thick. It is black in the upper part and very dark gray and mottled in the lower part. The upper part of the substratum is dark gray, mottled clay loam. The lower part to a depth of about 60 inches is gray, mottled loam. In places the substratum has lenses of silt loam or sandy loam. In some small areas, the surface layer is loam and the slope is more than 4 percent.

This soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 5 to 7 percent in the surface layer. Reaction typically is neutral in the surface layer and subsurface layer, but in places it is mildly alkaline in the subsurface layer. Below the surface layer, the supply of available phosphorus generally is low and the supply of available potassium generally is very low.

Most areas are cultivated. Some areas that are not protected from flooding or that are isolated by a meandering stream are used for pasture. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture if it is adequately drained and if flooding is controlled. Special care generally is needed to maintain good tilth in the surface layer. Chisel plowing increases the infiltration rate by making the surface more pervious to water. Cultivating when the soil is too wet causes surface compaction and cloddiness. Returning crop residue to the soil or regularly adding other organic material helps to control wind erosion and prevent surface crusting and increases the infiltration rate. The grasses and legumes that can

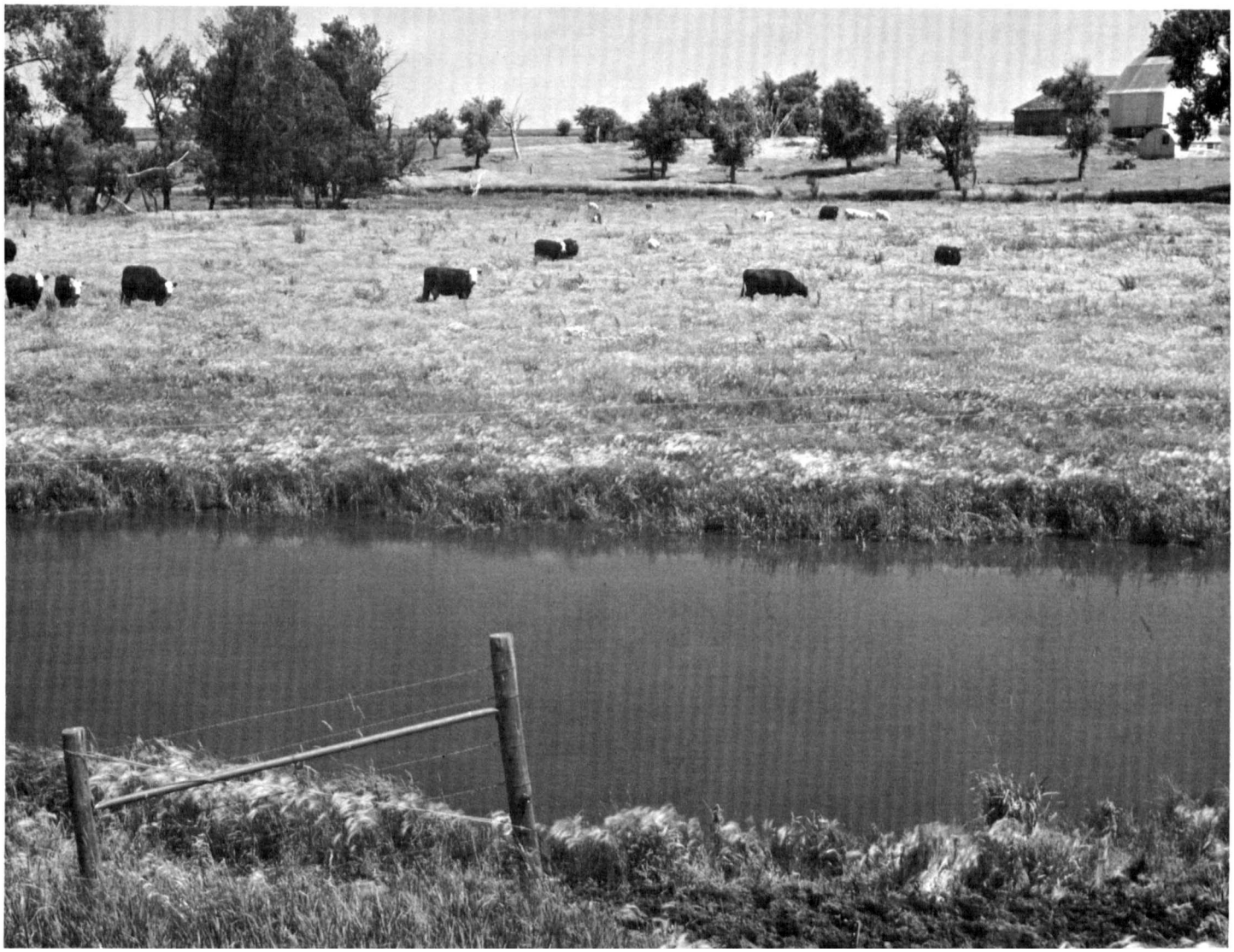

Figure 8.—A pastured area of Coland clay loam, 0 to 2 percent slopes, on bottom land.

withstand the wetness are the best pasture plants. Weed control is important in areas that are flooded because weed seeds are carried in by the floodwater.

The wetness and the flooding are the main limitations if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. Only the species that can withstand the wetness and the flooding should be selected for planting.

This soil is in capability subclass IIw.

138B—Clarion loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on knolls in the uplands. Areas generally are 2 to 10 acres in size and are long and narrow, but a few are more than 50 acres in size and are irregularly shaped.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is very dark gray loam about 5 inches thick. The subsoil is about 27 inches thick. It is dark brown and brown, friable loam and clay loam in the upper part, dark yellowish brown, friable clay loam in the next part, and dark yellowish brown, friable loam in the lower part. The substratum to a depth of about 60 inches is light olive brown loam. In some areas plowing has mixed part of the dark brown subsoil with the surface soil. In other areas the substratum has lenses of loamy sand or sand.

Included with this soil in mapping are some areas of the somewhat poorly drained Nicollet soils at the lower elevations. Also included are some small areas of sandy or gravelly soils on knobs and some areas of Storden

soils, which are higher on the landscape than the Clarion soil. Included soils make up less than 15 percent of the unit.

The Clarion soil is moderately permeable. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 3 to 4 percent in the surface layer. The surface soil and the upper part of the subsoil typically are slightly acid or neutral. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard. A conservation tillage system that leaves a protective amount of crop residue on the surface and grassed waterways help to prevent excessive soil loss. Contour farming and terracing are practical in most areas but are not feasible in undulating areas where slopes are short. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to control erosion and prevent surface crusting, and increases the infiltration rate.

If this soil is used for windbreaks or ornamental plantings, erosion is a slight hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

This soil is in capability subclass IIe.

138C—Clarion loam, 5 to 9 percent slopes. This moderately sloping, well drained soil is on knolls in the uplands and on convex side slopes along streams and upland drainageways. Slopes generally are short. Areas are irregularly shaped or are long and narrow. Most are 2 to 10 acres in size, but some near streams are somewhat larger.

Typically, the surface layer is very dark gray loam about 8 inches thick. The subsurface layer is very dark grayish brown, friable loam about 4 inches thick. The subsoil is friable loam about 16 inches thick. It is brown in the upper part and dark yellowish brown and yellowish brown in the lower part. The substratum to a depth of about 60 inches is light olive brown loam. In some concave areas near the base of the slopes, the dark surface layer is as much as 24 to 30 inches thick. In other areas the substratum has lenses of loamy sand and sand.

Included with this soil in mapping are some small areas of sandy or gravelly soils on knobs and areas of Storden soils at the higher elevations. Included soils make up less than 10 percent of the unit.

The Clarion soil is moderately permeable. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 3 to 4 percent in the surface layer. The surface layer, the subsurface layer, and the upper part of the subsoil typically are slightly acid or neutral. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard. A conservation tillage system that leaves a protective amount of crop residue on the surface and grassed waterways help to prevent excessive soil loss. Contour farming and terracing are practical in some areas but are not feasible in undulating areas where slopes are short. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to control erosion and prevent surface crusting, and increases the infiltration rate.

If this soil is used for windbreaks or ornamental plantings, erosion is a moderate hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

This soil is in capability subclass IIIe.

138C2—Clarion loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on knolls in the uplands and on convex side slopes along upland drainageways. Slopes typically are short. Areas range from 5 to 35 acres in size and are irregularly shaped.

Typically, the surface layer is very dark grayish brown loam about 8 inches thick. Plowing has mixed part of the brown subsoil with the surface layer. The subsoil is friable loam about 20 inches thick. The upper part is dark brown, the next part is brown, and the lower part is dark yellowish brown. The substratum to a depth of about 60 inches is yellowish brown and light olive brown loam.

Included with this soil in mapping are some small areas of Storden soils, mainly on the steepest parts of the slopes. These soils make up about 5 percent of the unit.

The Clarion soil is moderately permeable. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 2 to 3 percent in the surface layer. The surface layer and the upper part of the subsoil typically are slightly acid or neutral. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay or pasture. If cultivated crops are grown, further erosion is a hazard. A conservation tillage system that leaves a protective amount of crop residue on the surface helps to prevent excessive soil loss, and grassed waterways help to prevent gully erosion. Contour farming and terracing are practical in some areas but are not feasible in undulating areas where slopes are short. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to control erosion and prevent surface crusting, and increases the infiltration rate. A cover of pasture

plants or hay also helps to control erosion. Overgrazing, however, results in surface compaction and a poor stand and increases the runoff rate.

If this soil is used for windbreaks or ornamental plantings, erosion is a moderate hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

This soil is in capability subclass IIIe.

138D2—Clarion loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is on convex side slopes along streams and drainageways in the uplands. Slopes generally are short. Areas are long and narrow. Typically, they are 2 to 10 acres in size, but a few are larger.

Typically, the surface layer is very dark grayish brown loam about 6 inches thick. Plowing has mixed part of the brown subsoil with the surface layer. The subsoil is friable loam about 14 inches thick. It is brown in the upper part and dark yellowish brown and yellowish brown in the lower part. The substratum to a depth of about 60 inches is light olive brown loam. In some areas the surface layer is thicker and darker. In other areas the substratum has lenses of loamy sand or sand.

This soil is moderately permeable. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 2 to 3 percent in the surface layer. The surface layer and the upper part of the subsoil typically are slightly acid or neutral. The subsoil generally has a very low supply of available phosphorus and potassium.

Some areas are cultivated. Some are used for pasture. This soil is moderately suited to corn and soybeans. It is well suited to small grain and to grasses and legumes for hay and pasture. Erosion is a severe hazard if cultivated crops are grown. A conservation tillage system that leaves a protective amount of crop residue on the surface and grassed waterways help to prevent excessive soil loss. Contour farming and terracing are practical in some areas but are not feasible in areas where slopes are short. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to control erosion and prevent surface crusting, and increases the infiltration rate. Farm machinery can be used to renovate pastures as needed. Overgrazing results in a poor plant cover and increases the runoff rate.

If this soil is used for windbreaks or ornamental plantings, erosion is a severe hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

This soil is in capability subclass IIIe.

202—Cylinder loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is on stream benches and in outwash areas on uplands. Slopes generally are plane or convex but in places are slightly concave. Areas are 2 to 10 acres in size and are irregularly shaped.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is very dark gray loam about 10 inches thick. The subsoil is about 18 inches thick. It is dark grayish brown, mottled, friable loam in the upper part and dark yellowish brown sand and gravel in the lower part. The substratum to a depth of about 60 inches is dark grayish brown sand and gravel. In some areas it is loamy sand or sand in which the content of gravel is less than 5 percent. In other areas the sand and gravel is underlain by medium textured soil material at a depth of 40 to 60 inches.

This soil is moderately permeable in the upper part and very rapidly permeable in the lower part of the subsoil and in the substratum. It has a seasonal high water table. Surface runoff is slow. Available water capacity is low or moderate. The content of organic matter is about 4 to 5 percent in the surface layer. The surface soil and the upper part of the subsoil typically are slightly acid or neutral. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It has a high water table during wet periods but becomes droughty after brief dry periods. Tile drains generally are not needed because of the droughtiness during most of the growing season. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, conserves moisture, and helps to control wind erosion.

Drought is a hazard if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. Generally, the trees and shrubs that can withstand the seasonal wetness as well as the droughtiness should be selected for planting. A surface mulch conserves moisture. Almost any species suited to the climate can be grown if a drainage system is installed to reduce the wetness and if irrigation water is applied as needed to overcome the droughtiness.

This soil is in capability subclass IIs.

203—Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is on stream benches and in outwash areas on uplands. Slopes generally are plane or concave but in places are slightly convex. Areas range from 2 to 15 acres in size and are irregularly shaped.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is black and very dark gray loam about 15 inches thick. The subsoil is dark grayish brown, friable loam about 10 inches thick. The substratum to a depth of about 60 inches is dark yellowish brown, dark grayish brown, and grayish brown sand and gravel. In some areas it is loamy sand or sand in which the content of gravel is less than 5 percent. In

other areas the sand and gravel is underlain by medium textured soil material at a depth of 50 to 60 inches.

This soil is moderately permeable in the upper part and very rapidly permeable in the substratum. It has a seasonal high water table. Surface runoff is slow. Available water capacity is moderate. The content of organic matter is about 4 to 5 percent in the surface layer. The surface soil and subsoil typically are slightly acid or neutral. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to legumes for hay and pasture. It has a high water table during wet periods but becomes droughty after fairly brief dry periods. Tile drains generally are not needed because of the droughtiness during much of the growing season. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, conserves moisture, and helps to control wind erosion.

Drought is a hazard if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. Generally, the trees and shrubs that can withstand the seasonal wetness as well as the droughtiness should be selected for planting. A surface mulch conserves moisture. Almost any species suited to the climate can be grown if a drainage system is installed to reduce the wetness and if irrigation water is applied as needed to overcome the droughtiness.

This soil is in capability class I.

236B—Lester loam, 2 to 6 percent slopes. This gently sloping, well drained soil is on knolls and convex sides slopes along streams and drainageways in the uplands. Areas are irregularly shaped. Typically, they are 2 to 5 acres in size, but a few are larger than 20 acres.

Typically, the surface layer is very dark gray loam about 5 inches thick. The subsurface layer is very dark gray and dark grayish brown loam about 6 inches thick. The subsoil is dark yellowish brown and yellowish brown clay loam about 32 inches thick. It dominantly is firm, but in the upper few inches it is friable. The substratum to a depth of about 60 inches is light olive brown, mottled loam. In places it is clay loam or has thin lenses of sandy loam.

Included with this soil in mapping are some areas of nearly level, somewhat poorly drained soils. These soils make up about 5 percent of the unit.

The Lester soil is moderately permeable. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 2 to 3 percent in the surface layer. The surface layer, subsurface layer, and subsoil typically are medium acid or slightly acid. The subsoil generally has a medium supply of available phosphorus and a very low supply of available potassium.

Some areas are used for wooded pasture. Some are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard. A conservation tillage system that leaves a protective amount of crop residue on the surface and grassed waterways help to prevent excessive soil loss. Contour farming and terracing are practical in most areas but are not feasible in undulating areas where slopes are short. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to control erosion and prevent surface crusting, and increases the infiltration rate.

This soil is well suited to pasture or trees. Most areas used for pasture also support some scattered trees. Some support a dense stand of trees. Removing the trees generally improves the quality of the pasture, and restricting the grazing improves the quality of the woodland.

If this soil is used for windbreaks or ornamental plantings, erosion is a slight hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch.

This soil is in capability subclass IIe.

259—Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, poorly drained soil generally is in low lying areas on benches. In a few areas, however, it is on uplands. Areas generally are 5 to 20 acres in size and are irregularly shaped, but some range to 100 acres or more and are long and narrow.

Typically, the surface layer is black clay loam about 7 inches thick. The subsurface layer is black and very dark gray, mottled clay loam about 16 inches thick. The subsoil is about 15 inches thick. It dominantly is dark gray and olive gray, mottled, friable loam, but in the lower few inches it is olive gray, mottled gravelly sandy loam. The substratum to a depth of about 60 inches is gray and olive gray, mottled gravelly loamy sand. In some small areas the soil is calcareous. In other small areas it is in depressions.

This soil is moderately permeable in the upper part and rapidly permeable in the lower few inches of the subsoil and in the substratum. It has a seasonal high water table. Surface runoff is slow. Available water capacity is moderate. The content of organic matter is about 5 to 7 percent in the surface layer. This layer typically is neutral. The subsoil is mildly alkaline. It generally has a very low supply of available phosphorus and a very low or low supply of available potassium.

Most areas are cultivated. If adequately drained, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It not only is seasonally wet but also is slightly droughty during some periods because of the gravelly substratum. Tile drains remove excess water. In some years, however, the drainage system removes the water that the crop needs later in the growing season. Good tilth generally

can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, conserves moisture, and helps to control wind erosion.

The seasonal high water table is the main limitation if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings, but the droughtiness also is a limitation in some years. Almost any species suited to the climate can be grown if a drainage system is installed to reduce the wetness and irrigation water is applied as needed to overcome the droughtiness.

This soil is in capability subclass IIw.

274—Rolfe silt loam, 0 to 1 percent slopes. This level, very poorly drained soil is in small upland depressions. It is subject to ponding. Areas generally are 1 or 2 acres in size and are nearly round or oblong.

Typically, the surface layer is black silt loam about 8 inches thick. The subsurface layer is dark gray silt loam about 13 inches thick. The subsoil is about 39 inches thick. The upper part is very dark gray and dark gray, mottled, firm or very firm silty clay, and the lower part is dark gray, gray, and olive gray, mottled, firm or friable clay loam. In places the subsoil is friable silty clay loam.

This soil is slowly permeable. It has a seasonal high water table. Surface runoff is ponded. Available water capacity is high. The content of organic matter is about 3 to 5 percent in the surface layer. Reaction typically is slightly acid in the surface layer and subsurface layer and neutral or slightly acid in the upper part of the subsoil. The subsoil generally has a very low supply of available phosphorus and a very low or low supply of available potassium.

Most areas are cultivated. If adequately drained, this soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Tile drains remove excess subsurface water. Because of the slowly permeable subsoil, tile ditches commonly are backfilled with porous material. Surface drains commonly help to remove ponded water. Maintaining good tilth generally is difficult. Cultivating when the soil is wet causes cloddiness and a poor seedbed. Returning crop residue to the soil or regularly adding other organic material helps to prevent surface crusting and increases the infiltration rate.

The seasonal high water table is the main limitation if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. The species that can withstand the wetness should be selected for planting, especially if no drainage system is installed.

This soil is in capability subclass IIIw.

288—Ottosen silty clay loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on slightly convex knolls in the uplands. Areas are irregularly shaped. They generally are 2 to 10 acres in size, but a few are 25 acres or more.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is black silty clay loam about 12 inches thick. The subsoil is about 28 inches thick. It is dark grayish brown and mottled. The upper part is firm silty clay loam, and the lower part is friable clay loam. The substratum to a depth of about 60 inches is olive gray, mottled clay loam.

Included with this soil in mapping are some areas of soils in which the subsoil has thin layers of silty clay. These soils are in positions on the landscape similar to those of the Ottosen soil. They make up about 5 percent of the unit.

The Ottosen soil is moderately slowly permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 5 to 6 percent in the surface layer. The surface soil and the upper part of the subsoil typically are slightly acid. The subsoil generally has a very low or low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. The seasonal wetness can delay fieldwork, but it can be overcome by installing tile drains. Good tilth generally can be easily maintained. Cultivating or grazing when the soil is wet, however, causes surface compaction. Returning crop residue to the soil or regularly adding other organic material helps to control erosion and prevent surface crusting and increases the infiltration rate.

The wetness is the main limitation if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. It generally is a slight limitation, and most of the commonly grown trees and shrubs can be planted.

This soil is in capability class I.

308—Wadena loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, well drained soil dominantly is on slightly convex to slightly concave slopes on benches, but in a few areas it is on uplands. Areas are irregularly shaped. Generally, those on benches are 2 to 10 acres in size and those on uplands 2 to 3 acres.

Typically, the surface layer is very dark brown loam about 8 inches thick. The subsurface layer is very dark grayish brown loam about 5 inches thick. The subsoil is dark brown and brown, friable loam about 20 inches thick. The substratum to a depth of about 60 inches is grayish brown sand and gravel.

Included with this soil in mapping are some areas of Wadena soils in which the underlying sand and gravel is as shallow as 24 inches. These soils generally are at the slightly higher elevations. They make up about 5 percent of the unit. Also included are some areas of soils in which the underlying sand and gravel is as deep as 48 inches. These soils are in positions on the landscape similar to those of the Wadena soil. They make up about 5 percent of the unit.

Permeability is moderate in the upper part of the Wadena soil and very rapid in the substratum. Surface runoff is medium. Available water capacity is moderate. The content of organic matter is about 3 to 4 percent in the surface layer. The surface soil and the upper part of the subsoil typically are slightly acid or neutral. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It is seasonally droughty because of the sandy and gravelly substratum. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, conserves moisture, and helps to control wind erosion.

Drought is a slight hazard if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. A surface mulch conserves moisture.

This soil is in capability subclass IIs.

308B—Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes. This gently sloping, well drained soil dominantly is on moderately convex to moderately concave slopes on benches. In a few areas, however, it is on uplands. Areas generally are 2 to 5 acres in size and are irregularly shaped.

Typically, the surface layer is very dark brown loam about 8 inches thick. The subsurface layer is very dark brown loam about 6 inches thick. The subsoil is about 20 inches thick. It is dark brown, friable loam in the upper part and dark yellowish brown, very friable sandy loam in the lower part. The substratum to a depth of about 60 inches is grayish brown sand and gravel. On some foot slopes the surface layer is as much as 24 inches thick. In some areas the substratum is loamy sand or sand in which the content of gravel is less than 5 percent. In other areas the sand and gravel is underlain by medium textured soil material within a depth of 60 inches.

Permeability is moderate in the upper part of this soil and very rapid in the substratum. Surface runoff is medium. Available water capacity is moderate. The content of organic matter is about 4 to 5 percent in the surface layer. The surface soil and the upper part of the subsoil typically are slightly acid or neutral. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard. Also, the soil is seasonally droughty because of the gravelly or sandy substratum. A conservation tillage system that leaves a protective amount of crop residue on the surface helps to prevent excessive soil loss. If terraces are built, the cuts should not expose the underlying sand and gravel and as much topsoil as possible should be returned to the site. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, conserves moisture, and helps to control erosion.

If this soil is used for windbreaks or ornamental plantings, erosion is a slight hazard before the trees and shrubs are established. Also, the soil is seasonally droughty. A surface mulch helps to control erosion and conserves moisture.

This soil is in capability subclass IIe.

388—Kossuth silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on slightly convex to slightly concave upland slopes. Areas generally are 2 to 10 acres in size and are long and narrow, but a few are 50 acres or more and are irregularly shaped.

Typically, the surface layer is black silty clay loam about 6 inches thick. The subsurface layer is black silty clay loam about 18 inches thick. The subsoil is about 22 inches thick. The upper part is very dark gray, dark gray, and olive gray, mottled, firm silty clay loam, and the lower part is olive gray, mottled, firm and friable clay loam. The substratum to a depth of about 60 inches is olive gray and light olive gray, mottled clay loam.

Included with this soil in mapping are some small areas of the very poorly drained Rolfe and Okoboji soils in depressions. These soils make up less than 5 percent of the unit.

The Kossuth soil is moderately slowly permeable. It has a seasonal high water table. Surface runoff is slow Available water capacity is high. The content of organic matter is about 6 to 7 percent in the surface layer. The surface soil and the upper part of the subsoil typically are slightly acid or neutral. The subsoil generally has a low or very low supply of available phosphorus and potassium.

Most areas are cultivated. If adequately drained, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Tile drains remove excess subsurface water. Special care generally is needed to maintain good tilth in the surface layer. Cultivating when the soil is too wet causes surface compaction and cloddiness. Chisel plowing increases the infiltration rate. Returning crop residue to the soil or regularly adding other organic material helps to control wind erosion and prevent surface crusting and increases the infiltration rate.

The wetness is the main limitation if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. The species that can withstand the wetness should be selected for planting, or a drainage system should be installed.

This soil is in capability subclass IIw.

485—Spillville loam, 0 to 2 percent slopes. This nearly level, moderately well drained and somewhat poorly drained soil is on bottom land. It is subject to flooding. Most areas are 2 to 10 acres in size and are irregularly shaped.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is black and very dark gray loam about 25 inches thick. The substratum to a depth of about 60 inches is very dark gray loam. In some areas it has lenses of loamy sand and sand.

This soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high or very high. The content of organic matter is about 4 to 6 percent in the surface layer. The soil typically is neutral or slightly acid throughout. Below the surface layer, the supply of available phosphorus generally is low and the supply of available potassium is very low.

Some areas are cultivated, and some are pastured. If flooding is controlled, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. In some small areas isolated by a meandering stream, growing cultivated crops is not practical. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material helps to control wind erosion and prevent surface crusting and increases the infiltration rate. In most areas farm machinery can be used to renovate pastures as needed. Weed control is important because weed seeds are carried in by floodwater.

The wetness and the flooding are the main limitations if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. Unless flooding is controlled, only the trees that can withstand the wetness should be planted.

This soil is in capability subclass IIw.

485B—Spillville loam, 2 to 5 percent slopes. This gently sloping, moderately well drained and somewhat poorly drained soil is on foot slopes and alluvial fans. It is subject to flooding. Areas are long and narrow. Most are 2 to 5 acres in size, but a few are more than a mile long and several hundred feet wide.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is black loam about 17 inches thick. The subsoil is very dark grayish brown and dark brown, friable loam about 24 inches thick. The substratum to a depth of about 60 inches is yellowish brown and olive gray loam. In some areas it has lenses of loamy sand and sand.

This soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high or very high. The content of organic matter is about 4 to 6 percent in the surface layer. The soil typically is neutral or slightly acid throughout. Below the surface layer, the supply of available phosphorus generally is low and the supply of available potassium is very low.

Some areas are cultivated, and some are pastured. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture if floodwater or runoff from adjacent soils is controlled. Erosion is a hazard in areas where excess water runs across the soil. Some small areas isolated by a meandering stream are best suited to pasture. In places diversion terraces are used to divert runoff water from the adjacent hillsides. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material helps to control erosion and prevent surface crusting and increases the infiltration rate. In most areas farm machinery can be used to renovate pastures as needed.

If this soil is used for windbreaks or ornamental plantings, erosion is a slight hazard before the trees and shrubs are established. It can be controlled, however, by a permanent plant cover or surface mulch. Unless flooding is controlled, only the species that can withstand the wetness should be planted.

This soil is in capability subclass IIe.

506—Wacousta silty clay loam, 0 to 1 percent slopes. This level, very poorly drained soil is in upland depressions. It is subject to ponding. Areas are irregularly shaped. They generally are 5 to 10 acres in size, but a few are as large as 50 acres.

Typically, the surface layer is black silty clay loam about 6 inches thick. The subsurface layer is black and very dark gray silty clay loam about 10 inches thick. The subsoil is olive gray and light olive gray, mottled, friable silty clay loam about 8 inches thick. The upper part of the substratum dominantly is olive gray, mottled silty clay loam and clay loam. The lower part to a depth of about 60 inches is gray, mottled loam. In some areas the surface layer is mucky silty clay loam. In other areas the substratum has lenses of loamy sand and sand.

This soil is moderately permeable. It has a seasonal high water table. Surface runoff is ponded. Available water capacity is high. The content of organic matter is about 8 to 10 percent in the surface layer. The surface layer is neutral. The subsurface layer is neutral or mildy alkaline. The subsoil is neutral to moderately alkaline. It generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. If adequately drained, this soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Surface drains remove excess ponded water. Tile drains remove excess subsurface water. In many areas deep cuts are needed to provide suitable outlets. Maintaining good tilth generally is difficult. Cultivating when the soil is too wet causes cloddiness and a poor seedbed. Returning crop residue to the soil or regularly adding other organic material helps to prevent surface crusting and increases the infiltration rate.

The seasonal high water table is the main limitation if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. Only the species that can withstand the wetness should be selected for planting, or drainage tile should be installed.

This soil is in capability subclass IIIw.

507—Canisteo silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained, calcareous soil typically is in shallow swales on uplands. Areas generally range from 2 to 100 acres in size and are irregularly shaped.

Typically, the surface layer is black silty clay loam about 6 inches thick. The subsurface layer is about 11 inches thick. It is black clay loam in the upper part and very dark gray loam in the lower part. The subsoil is olive gray, friable loam about 14 inches thick. The upper part of the substratum is olive gray, mottled loam. The lower part to a depth of about 60 inches is olive gray, mottled clay loam. In places the surface layer is not calcareous.

Included with this soil in mapping are some small areas of the very poorly drained Okoboji soils in depressions. These soils make up about 10 percent of the unit.

The Canisteo soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow to ponded. Available water capacity is high. The content of organic matter is about 6 to 7 percent in the surface layer. The soil typically is mildly alkaline or moderately alkaline throughout. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. If adequately drained, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Tile drains remove excess subsurface water. Special care generally is needed to maintain good tilth in the surface layer. Cultivating when the soil is too wet causes surface compaction and cloddiness. Chisel plowing increases the infiltration rate by making the surface more pervious to water. Returning crop residue to the soil or regularly adding other organic material helps to control wind erosion and prevent surface crusting and increases the infiltration rate. The high content of lime in the soil adversely affects the availability of plant nutrients. In some areas where soybeans are grown, applications of iron compounds are needed.

The wetness and the excess amount of lime are the main limitations if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. Only the species that can tolerate a wet, calcareous soil should be selected for planting.

This soil is in capability subclass IIw.

508—Wacousta Variant silty clay loam, 0 to 1 percent slopes. This level, very poorly drained, calcareous soil is in upland depressions. It is subject to ponding. Areas are irregularly shaped. They generally are 5 to 10 acres in size, but a few are as large as 50 acres.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsoil is dark olive gray and olive gray, friable silty clay loam about 6 inches thick. The substratum to a depth of 60 inches is grayish brown, light brownish gray, and olive gray, mottled, friable stratified silty clay loam, clay loam, and loam. In places it has lenses of fine sandy loam, silt loam, and clay loam.

This soil is moderately permeable. It has a seasonal high water table. Surface runoff is ponded. Available water capacity is high. The content of organic matter is about 8 to 10 percent in the surface layer. The soil typically is moderately alkaline throughout. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes if it is adequately drained and if the proper kind and amount of fertilizer is applied. Surface drains remove ponded water. Tile drains remove excess subsurface water. Because the soil commonly is in the lowest part of depressions, however, a suitable drainage outlet is not available in many places. Special care generally is needed to maintain good tilth in the surface layer. Cultivating when the soil is wet results in puddling. The high content of lime in the soil adversely affects the availability of plant nutrients. In some areas where soybeans are grown, applications of iron compounds are needed.

The seasonal high water table and the excess amount of lime are the main limitations if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. Only the species that can withstand a wet, calcareous soil should be selected for planting.

This soil is in capability subclass IIIw.

559—Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, poorly drained, calcareous soil is in swales in wide upland drainageways and on benches. Areas are 2 to 10 acres in size and are irregularly shaped.

Typically, the surface layer is black clay loam about 7 inches thick. The subsurface layer is black clay loam about 8 inches thick. The subsoil is about 24 inches thick. It is very dark gray, dark gray, and olive, friable clay loam and loam in the upper part and olive gray and gray, very friable, mottled gravelly sandy loam in the lower part. The substratum to a depth of about 60 inches is olive gray gravelly coarse sand.

Included with this soil in mapping are some areas of gently sloping soils in which the substratum is dominated by small stones and cobbles. These soils make up about 5 percent of the unit.

The Talcot soil is moderately permeable in the upper part and rapidly permeable in the substratum. It has a seasonal high water table. Surface runoff is slow. Available water capacity is moderate. The content of organic matter is about 6 to 7 percent in the surface layer. The soil is moderately alkaline throughout. The subsoil generally has a very low supply of available phosphorus and a very low or low supply of available potassium.

Some areas are cultivated, and some are pastured. If adequately drained, this soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It not only is seasonally wet but also

is slightly droughty during some periods because the available water capacity is very low in the sandy and gravelly substratum. Tile drains remove excess subsurface water. In some years, however, the drainage system removes the water that the crop needs later in the growing season. Special care generally is needed to maintain good tilth in the surface layer. Cultivating when the soil is too wet causes surface compaction and cloddiness. The high content of lime in the soil adversely affects the availability of some of the plant nutrients. Chisel plowing increases the infiltration rate by making the surface more pervious to water. Returning crop residue to the soil or regularly adding other organic material helps to control wind erosion and prevent surface crusting and increases the infiltration rate. In some areas where soybeans are grown, applications of iron compounds are needed.

The wetness and the excess amount of lime are the main limitations if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. Only the species that can withstand a wet, calcareous soil should be selected for planting.

This soil is in capability subclass IIw.

585B—Coland-Spillville complex, 2 to 5 percent slopes. This map unit occurs as gently sloping areas of a poorly drained Coland soil and a moderately well drained and somewhat poorly drained Spillville soil. These soils are in small valleys and upland drainageways. They are subject to flooding. Areas generally are 2 to 10 acres in size. They range from about 50 to 70 percent Coland soil and 20 to 40 percent Spillville soil. The two soils occur as areas so intermingled or so small that mapping them separately is not practical.

Typically, the Coland soil has a surface layer of black clay loam about 9 inches thick. The subsurface layer is black and very dark gray clay loam about 35 inches thick. The substratum to a depth of about 60 inches is dark gray and gray clay loam and loam.

Typically, the Spillville soil has a surface layer of black loam about 9 inches thick. The subsurface layer is black and very dark gray loam about 25 inches thick. The substratum to a depth of about 60 inches is very dark gray loam. In places it has thin layers of sandy loam, sandy clay loam, or silt loam.

These soils are moderately permeable. They have a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 4 to 7 percent in the surface layer. The surface layer and subsurface layer typically are slightly acid or neutral. Below the surface layer, the supply of available phosphorus is low and the supply of available potassium very low.

Some areas are cultivated, and some are pastured. If adequately drained, these soils are well suited to corn, soybeans, and small grain and to grasses and legumes for hay or pasture. Wetness and flooding commonly are problems, especially in areas where excess water runs in from adjoining hillsides. Diversion terraces can be built on the upper parts of the landscape, and tile drains have been installed in many places. Grassed waterways help to prevent gully erosion. Special care generally is needed to maintain good tilth in the surface layer of the Coland soil. Cultivating when the soils are too wet causes surface compaction and cloddiness. Chisel plowing increases the infiltration rate by making the surface more pervious to water. Returning crop residue to the soils or regularly adding other organic material helps to control wind erosion and prevent surface crusting and increases the infiltration rate in both soils.

Most areas used for pasture are in narrow valleys. Some are cut by a meandering drainageway. The wetness is the main problem. Diversion terraces and drainage tile reduce the number of days that the pasture is too wet for normal use and increase the number of suitable pasture plants.

The wetness and the flooding are the main limitations if these soils are used for the trees and shrubs grown as windbreaks or ornamental plantings. A drainage system is needed. The species that can withstand the wetness should be selected for planting.

These soils are in capability subclass IIw.

733—Calco silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained, calcareous soil is on bottom land. It is subject to flooding. Areas typically are 2 to 10 acres in size and are irregularly shaped, but some are more than 50 acres and are long and narrow.

Typically, the surface layer is black silty clay loam about 12 inches thick. The subsurface layer is black silty clay loam about 25 inches thick. The subsoil is very dark gray, friable clay loam about 10 inches thick. The substratum to a depth of about 60 inches is very dark gray clay loam. In some areas it has lenses of loamy sand and sand.

This soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 5 to 7 percent in the surface layer. The surface soil and subsoil are moderately alkaline. The subsoil generally has a medium supply of available phosphorus and a very low supply of available potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture if it is adequately drained and if flooding is controlled. Special care generally is needed to maintain good tilth in the surface layer. Cultivating when the soil is too wet causes surface compaction and cloddiness. Because of the excess lime, the soil structure tends to be weak and breaks down easily. Puddling results from the breakdown of the soil structure. Chisel plowing increases the infiltration rate by making the surface more pervious to water. Returning crop residue to the soil and regularly adding other organic material help to control wind erosion and prevent

surface crusting and increase the infiltration rate. The high content of lime in the soil adversely affects the availability of plant nutrients. In some areas where soybeans are grown, applications of iron compounds are needed.

Some areas are used for pasture because they are isolated by a meandering stream, but most are accessible to farm machinery. Pastures can be renovated as needed. Weed control is important because weed seeds are carried in by floodwater.

The wetness, the flooding, and the excess amount of lime are the main limitations if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. Only the species that can withstand a wet, calcareous soil should be selected for planting.

This soil is in capability subclass IIw.

1048—Knoke mucky silt loam, ponded, 0 to 1 percent slopes. This level, very poorly drained, calcareous soil is in upland depressions. It is subject to ponding. The two areas of this soil in the county are 35 and 140 acres in size.

Typically, a few inches of partly decomposed plant residue is at the surface. The surface layer is black mucky silt loam about 10 inches thick. The subsoil is about 13 inches thick. It is very dark gray, friable silt loam in the upper part and very dark gray, friable silty clay loam in the lower part. The substratum to a depth of about 60 inches is very dark gray and olive gray loam.

This soil is moderately slowly permeable. It has a seasonal high water table. Surface runoff is ponded. Available water capacity is very high. The content of organic matter is about 12 to 18 percent in the surface layer. The soil typically is moderately alkaline throughout. The subsoil generally has a very low supply of available phosphorus and potassium.

This soil supports aquatic vegetation. It is suited to wetland wildlife habitat (fig. 9). The trees and shrubs planted in areas of wildlife habitat should be tolerant of an extremely wet soil.

Unless an extensive drainage system is installed, this soil is not suited to cultivated crops or to grasses and legumes for hay and pasture. It also is unsuited to most trees and shrubs.

This soil is in capability subclass VIIw.

1458—Millington loam, channeled, 0 to 2 percent slopes. This nearly level, poorly drained, calcareous soil is on flood plains along the larger streams. It is subject to flooding. Areas range from 2 to more than 100 acres in size and are irregularly shaped.

Figure 9.—Aquatic vegetation and muskrat dens in an area of Knoke mucky silt loam, ponded, 0 to 1 percent slopes.

Typically, the surface layer is black loam about 11 inches thick. The subsurface layer is black sandy loam about 16 inches thick. The subsoil is very dark gray, friable loam about 21 inches thick. The substratum to a depth of about 60 inches is very dark grayish brown. It is loam in the upper part and sandy loam in the lower part.

This soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high or very high. The content of organic matter is about 4 to 6 percent in the surface layer. This layer typically is mildly alkaline or moderately alkaline. The supply of available phosphorus is low in the subsoil and the supply of available potassium very low.

Almost all of the acreage is used for pasture or supports trees. This soil is generally unsuited to corn, soybeans, and small grain and is poorly suited to grasses and legumes for hay and pasture. The frequent flooding is the main hazard. Also, many areas are inaccessible to farm machinery because of the old stream channels. The grasses and legumes planted for hay and pasture should be those that can withstand the wetness and the flooding.

This soil is well suited to wetland wildlife habitat. It is poorly suited to trees. The species planted should be those that are tolerant of the flooding.

This soil is in capability subclass Vw.

1585B—Coland-Spillville complex, channeled, 2 to 5 percent slopes. This map unit occurs as gently sloping areas of a poorly drained Coland soil and a moderately well drained and somewhat poorly drained Spillville soil. These soils are in long, narrow valleys cut by meandering stream channels. They are subject to flooding. Areas generally are 2 to 10 acres in size. They range from about 50 to 60 percent Coland soil and 25 to 40 percent Spillville soil. The two soils occur as areas so intermingled or so small that mapping them separately is not practical.

Typically, the Coland soil has a surface layer of black clay loam about 8 inches thick. The subsurface layer is black and very dark gray clay loam about 29 inches thick. The substratum to a depth of about 60 inches is dark gray and gray clay loam and loam. In places it has thin lenses of sand and sandy loam.

Typically, the Spillville soil has a surface layer of black loam about 9 inches thick. The subsurface layer is black and very dark gray loam about 25 inches thick. The substratum to a depth of about 60 inches is very dark gray loam. In places it has thin layers of sandy loam, sandy clay loam, or silt loam.

These soils are moderately permeable. They have a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 4 to 7 percent in the surface layer. The surface layer and subsurface layer typically are slightly acid or neutral. Below the surface layer, the supply of available phosphorus generally is low and the supply of available potassium very low.

Most areas are used for pasture or woodland. These soils are well suited to wildlife habitat. The wetness and the flooding are the main limitations in the areas used for trees and shrubs. The species planted in areas of wildlife habitat or woodland should be those that can withstand the wetness.

These soils generally are unsuitable for corn, soybeans, and small grain. The use of farm machinery is impractical because a meandering stream dissects most areas.

These soils are in capability subclass Vw.

5010—Pits, gravel. This map unit dominantly is on stream benches but in some areas is on uplands. The pits generally are no longer mined. They range from less than 1 acre to more than 40 acres in size and commonly are square or rectangular.

Typically, available water capacity is low or very low in the soil material. As a result, the material tends to be droughty during much of the growing season. In most areas it has a seasonal high water table. Also, the low lying areas are ponded during wet periods. Stones and cobbles are commonly on the surface. Typically, the content of organic matter is less than 1 percent. Reaction is moderately alkaline.

Most of the inactive pits support weeds and small trees. Some have been used as refuse dumps. The pits can be developed for wildlife or recreational uses. The trees and shrubs that can withstand a high content of lime and the droughtiness should be selected for planting.

No capability class or subclass is assigned.

5040—Orthents, loamy. This map unit occurs as areas that have been developed for various uses, including borrow areas, cut and fill areas, sanitary landfills, and reclaimed gravel pits. These areas are still suitable for plants. They are about 2 to 20 acres in size. They commonly are square or rectangular, but some are irregularly shaped.

The soil material varies but in most areas is derived from loamy glacial till. In many areas it is compacted. Typically, it is moderately alkaline and calcareous and the content of organic matter is less than 1 percent in the surface layer. In areas where topsoil has been replaced, however, the soil material is neutral or slightly acid and the content of organic matter is 2 percent or more.

Most areas that have not been converted to urban use could be used for corn and soybeans. Many areas, however, are better suited to hay or pasture unless tilth and fertility are improved. Also, sloping areas are subject to erosion if they are cultivated.

Some areas are suitable as wildlife habitat or woodland. Special care is needed in selecting species for planting. Only the plants suited to the specific soil conditions at the site should be selected.

No capability class or subclass is assigned.

prime farmland

Prime farmland is one of several kinds of important farmlands defined by the U.S. Department of Agriculture. It is of major importance in providing the Nation's short- and long-range needs for food and fiber. Because the supply of high quality farmland is limited, the U.S. Department of Agriculture recognizes that responsible levels of government, as well as individuals, should encourage and facilitate the wise use of our Nation's prime farmland.

Prime farmland, as defined by the U.S. Department of Agriculture, is the land that is best suited to food, feed, forage, fiber, and oilseed crops. It may be cropland, pasture, woodland, or other land, but it is not urban or built-up land or water areas. It either is used for food or fiber or is available for these uses. The soil qualities, growing season, and moisture supply are those needed for a well managed soil economically to produce a sustained high yield of crops. Prime farmland produces the highest yields with minimal inputs of energy and economic resources, and farming it results in the least damage to the environment.

Prime farmland usually has an adequate and dependable supply of moisture from precipitation or irrigation. The temperature and growing season are favorable. The level of acidity or alkalinity is acceptable. Prime farmland has few or no rocks and is permeable to water and air. It is not excessively erodible or saturated with water for long periods and is not frequently flooded during the growing season. The slope ranges mainly from 0 to 6 percent. More detailed information about the criteria for prime farmland is available at the local office of the Soil Conservation Service.

About 141,000 acres throughout Calhoun County, or about 45 percent of the total acreage, meets the requirements for prime farmland. On an additional 174,000 acres, the soil meets the requirements only in areas where it is drained or protected from flooding, or both. Onsite investigation is needed to determine whether or not a specific area of the soil is adequately drained or is frequently flooded during the growing season. Crops are grown on about 310,000 acres of the prime farmland. They account for an estimated two-thirds of the local agricultural income each year. They are mainly corn and soybeans.

Parts of the county recently have been losing some prime farmland to industrial and urban uses. The loss of prime farmland to other uses puts pressure on marginal lands, which generally are more erodible, droughty, and difficult to cultivate and are less productive.

The map units that meet the requirements for prime farmland in Calhoun County are listed in this section. This list does not constitute a recommendation for a particular land use. The map units that are considered prime farmland are:

27B—Terril loam, 1 to 5 percent slopes
52B—Bode clay loam, 2 to 5 percent slopes
55—Nicollet loam, 1 to 3 percent slopes
95—Harps loam, 0 to 2 percent slopes [1]
107—Webster silty clay loam, 0 to 2 percent slopes [1]
108—Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes
108B—Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes
135—Coland clay loam, 0 to 2 percent slopes [1]
135B—Coland clay loam, 2 to 4 percent slopes [1]
138B—Clarion loam, 2 to 5 percent slopes
202—Cylinder loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes
203—Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes
236B—Lester loam, 2 to 6 percent slopes
259—Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes [1]
288—Ottosen silty clay loam, 1 to 3 percent slopes
308—Wadena loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes
308B—Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes
388—Kossuth silty clay loam, 0 to 2 percent slopes [1]
485—Spillville loam, 0 to 2 percent slopes [2]
485B—Spillville loam, 2 to 5 percent slopes
506—Wacousta silty clay loam, 0 to 1 percent slopes [1]
507—Canisteo silty clay loam, 0 to 2 percent slopes [1]
508—Wacousta Variant silty clay loam, 0 to 1 percent slopes [1]
559—Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes [1]
585B—Coland-Spillville complex, 2 to 5 percent slopes [1] [2]
733—Calco silty clay loam, 0 to 2 percent slopes [1]

[1] Only the areas that are adequately drained are considered prime farmland.

[2] The only areas considered prime farmland are those that are protected from flooding or are flooded during the growing season once or less in 2 years.

use and management of the soils

This soil survey is an inventory and evaluation of the soils in the survey area. It can be used to adjust land uses to the limitations and potentials of natural resources and the environment. Also, it can help avoid soil-related failures in land uses.

In preparing a soil survey, soil scientists, conservationists, engineers, and others collect extensive field data about the nature and behavior characteristics of the soils. They collect data on erosion, droughtiness, flooding, and other factors that affect various soil uses and management. Field experience and collected data on soil properties and performance are used as a basis in predicting soil behavior.

Information in this section can be used to plan the use and management of soils for crops and pasture; as sites for buildings, sanitary facilities, highways and other transportation systems, and parks and other recreation facilities; and for wildlife habitat. It can be used to identify the potentials and limitations of each soil for specific land uses and to help prevent construction failures caused by unfavorable soil properties.

Planners and others using soil survey information can evaluate the effect of specific land uses on productivity and on the environment in all or part of the survey area. The survey can help planners to maintain or create a land use pattern in harmony with the natural soil.

Contractors can use this survey to locate sources of sand and gravel, roadfill, and topsoil. They can use it to identify areas where bedrock, wetness, or very firm soil layers can cause difficulty in excavation.

Health officials, highway officials, engineers, and others may also find this survey useful. The survey can help them plan the safe disposal of wastes and locate sites for pavements, sidewalks, campgrounds, playgrounds, lawns, and trees and shrubs.

crops and pasture

General management needed for crops and pasture is suggested in this section. The crops or pasture plants best suited to the soils, including some not commonly grown in the survey area, are identified; the system of land capability classification used by the Soil Conservation Service is explained; and the estimated yields of the main crops and hay and pasture plants are listed for each soil.

Planners of management systems for individual fields or farms should consider the detailed information given in the description of each soil under "Detailed soil map units." Specific information can be obtained from the local office of the Soil Conservation Service or the Cooperative Extension Service.

About 344,000 acres in Calhoun County, or 94 percent of the total acreage, is used for crops. The main crops are corn and soybeans and some oats and legume and grass-legume hay. Minor crops include sudangrass, which is used for pasture, and sorghum, which is mainly harvested for grain. Barley and wheat are also grown on small acreages but are not grown every year. The pastured acreage has decreased markedly in recent years as grain production has increased.

Extending the latest technology to all of the cropland in the county could increase crop production and the extent of soil conservation. This soil survey, which gives the basic characteristics of each kind of soil, can greatly aid in the application of such technology.

Soil drainage is a major management concern on about 75 percent of the acreage in Calhoun County. Many soils in the county are poorly drained or very poorly drained. A drainage system is needed if these soils are cultivated. The Biscay, Canisteo, Coland, Talcot, and Webster soils are poorly drained, and the Okoboji and Wacousta soils are very poorly drained. Biscay and Talcot soils are underlain by sand and gravel. They are on benches. Coland soils are on bottom land. The nearly level Canisteo and Webster soils are on uplands. Okoboji and Wacousta soils are in depressions.

Subsurface tile is the main method of drainage (fig. 10). The tiles drain excess water into large drainage ditches, which in turn outlet into natural streams. Shallow ditches are also used to drain some of the soils in depressions.

The design of both surface and subsurface drainage systems varies with the kind of soil. A combination of surface drains or a system that controls the runoff from the slopes at the higher elevations and drainage tile is needed in many areas of the somewhat poorly drained and poorly drained soils that are intensively row cropped. Drains should be more closely spaced in moderately slowly permeable or slowly permeable soils than in the more rapidly permeable soils. Finding adequate outlets for tile drainage systems is difficult in many areas.

Soil erosion caused by running water is a hazard on the more sloping soils, such as Clarion, Lester, and Storden soils. Contour farming and terracing or a conservation tillage system that leaves a protective amount of crop residue on the surface helps to control

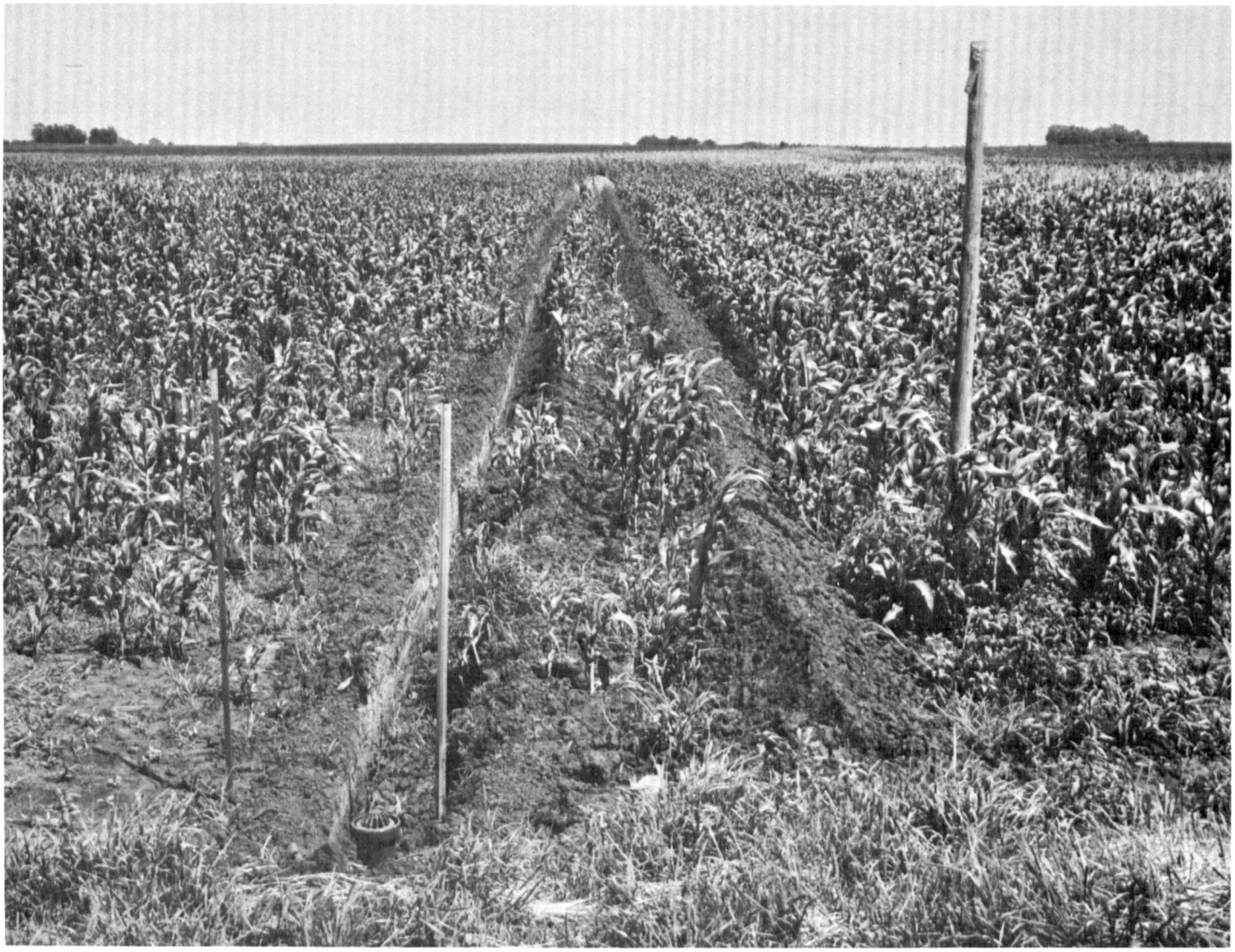

Figure 10.—A subsurface drainage system in Okoboji soils.

erosion. Some slopes are so short, steep, and irregular, however, that contour farming or terracing is not practical. On these soils a cropping system that provides a protective plant cover or a conservation tillage system is needed.

Wind erosion is a hazard on Estherville and other soils unless the surface is protected. It can damage these soils in a few hours if winds are strong and the soils are dry and have no plant cover or surface mulch. Crops on these soils and the adjacent heavier textured soils are often damaged by blowing sand. Many of the nearly level, heavier textured soils, such as Canisteo, Harps, and Webster soils, also are damaged by wind erosion. The damage generally occurs when these soils are cropped to soybeans and then fall tilled. Maintaining a plant cover or a surface mulch and keeping the surface rough through proper tillage minimize the damage caused by wind erosion on all of the soils.

Loss of the surface layer through erosion is damaging for many reasons. Productivity is reduced as the surface layer is lost and part of the subsoil is incorporated into a plow layer. Loss of the surface layer is especially damaging to soils that have a restricted root zone. Estherville and Wadena soils are examples. These soils have a restricted root zone because they are shallow or moderately deep over sand and gravel. Loss of the surface layer can result in pollution of streams by sediment. Control of erosion improves the quality of

water for municipal use, for recreation, and for fish and wildlife by minimizing the pollution of streams.

Erosion control provides a protective plant cover, reduces the runoff rate, and increases the infiltration rate. A cropping system that keeps a plant cover on the surface for extended periods can hold soil losses to an amount that will not reduce the productive capacity of the soils. On livestock farms, where part of the acreage is pasture and hayland, including legumes and grasses in the cropping system not only provides nitrogen and improves tilth for the following crop but also reduces the risk of erosion on the more sloping soils.

A conservation tillage system that leaves a protective amount of crop residue on the surface increases the infiltration rate, reduces the runoff rate, and helps to control erosion. It is effective on many of the tillable soils in the county. If the soils are suitable for growing corn and soybeans year after year, a conservation tillage system is the most effective method of controlling erosion.

Terraces and diversions reduce the length of slopes and the hazards of runoff and erosion. They are most practical on well drained, gently sloping or moderately sloping soils that have smooth slopes. Some areas of Clarion and Lester soils are well suited to terracing. Topsoil should be stockpiled during terrace construction and used to cover the exposed subsoil when the terrace is completed.

Information about the design of erosion-control practices for each kind of soil is contained in the Technical Guide, available in local offices of the Soil Conservation Service.

Soil fertility varies widely in the soils in Calhoun County. Most of the well drained soils on uplands are naturally acid, but the Storden soils are alkaline. The poorly drained soils generally are nearly neutral, but the Harps soils are alkaline. Applications of ground limestone are needed for good plant growth on the acid soils. The supply of available potash and phosphorus varies widely but is particularly low in Calco, Harps, and other wet, alkaline soils. On all soils additions of lime and fertilizer should be based on the results of soil tests, on the need of the crop, and on the expected level of yields. The Cooperative Extension Service can help in determining the kinds and amounts of fertilizer and lime needed.

Soil tilth is an important factor in the germination of seeds and in the infiltration of water into the soil. Soils with good tilth are granular and porous and generally high in content of organic matter. Regular additions of crop residue, manure, and other organic material improve the soil structure and help to prevent surface crusting.

Fall plowing is not suitable on many of the soils in Calhoun County. The more sloping soils and many nearly level soils that have been cropped to soybeans are subject to damaging erosion if they are fall plowed.

The field crops suited to the soils and climate of Calhoun County include many that are not commonly grown. Corn and soybeans are the most commonly grown crops. Oats is the most common close-growing crop. Wheat, grain sorghum, sunflowers, potatoes, sugar beets, popcorn, pumpkins, sugar cane, canning peas, and navy beans can be grown if economic conditions are favorable. Rye, barley, buckwheat, and flax could be grown, and grass seed could be produced from bromegrass, redtop, bluegrass, switchgrass, big bluestem, and indiangrass.

The specialty crops that are grown commercially in Calhoun County are limited in extent. Nursery stock is the only specialty crop grown. Most of the well drained soils in the survey area are suitable for orchards. Soils in low positions where frost is frequent and air drainage is poor, however, generally are poorly suited to early vegetables, small fruits, and orchards.

The latest information and suggestions about growing specialty crops can be obtained from local offices of the Cooperative Extension Service and the Soil Conservation Service.

yields per acre

The average yields per acre that can be expected of the principal crops under a high level of management are shown in table 5. In any given year, yields may be higher or lower than those indicated in the table because of variations in rainfall and other climatic factors.

The yields are based mainly on the experience and records of farmers, conservationists, and extension agents. Available yield data from nearby counties and results of field trials and demonstrations are also considered.

The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate and timely tillage; 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; and harvesting that insures the smallest possible loss.

The estimated yields reflect the productive capacity of each soil for each of the principal crops. Yields are likely to increase as new production technology is developed. The productivity of a given soil compared with that of other soils, however, is not likely to change.

Crops other than those shown in table 5 are grown in the survey area, but estimated yields are not listed because the acreage of such crops is small. The local office of the Soil Conservation Service or of the Cooperative Extension Service can provide information about the management and productivity of the soils.

land capability classification

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops

that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor does it consider possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for engineering purposes.

In the capability system, soils are generally grouped at three levels: capability class, subclass, and unit. Only class and subclass are used in this survey.

Capability classes, the broadest groups, are designated by Roman numerals I through VIII. The numerals indicate progressively greater limitations and narrower choices for practical use. The classes are defined as follows:

Class I soils have slight limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants or that require special conservation practices, or both.

Class IV soils have very severe limitations that reduce the choice of plants or that require very careful management, or both.

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use.

Class VI soils have severe limitations that make them generally unsuitable for cultivation.

Class VII soils have very severe limitations that make them unsuitable for cultivation.

Class VIII soils and miscellaneous areas have limitations that nearly preclude their use for commercial crop production. Calhoun County has no soils in class VIII.

Capability subclasses are soil groups within one class. They are designated by adding a small letter, *e, w, s,* or *c,* to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States, shows that the chief limitation is climate that is very cold or very dry.

In class I there are no subclasses because the soils of this class have few limitations. Class V contains only the subclasses indicated by *w, s,* or *c* because the soils in class V are subject to little or no erosion. They have other limitations that restrict their use to pasture, rangeland, woodland, wildlife habitat, or recreation.

The acreage of soils in each capability class and subclass is shown in table 6. The capability classification of each map unit is given in the section "Detailed soil map units."

windbreaks and environmental plantings

Windbreaks protect livestock, buildings, and yards from wind and snow. They also protect fruit trees and gardens, and they furnish habitat for wildlife. Several rows of low- and high-growing broadleaf and coniferous trees and shrubs provide the most protection.

Field windbreaks are narrow plantings made at right angles to the prevailing wind and at specific intervals across the field. The interval depends on the erodibility of the soil. Field windbreaks protect cropland and crops from wind, keep snow from blowing off the fields, and provide food and cover for wildlife.

Environmental plantings help to beautify and screen houses and other buildings and to abate noise. The plants, mostly evergreen shrubs and trees, are closely spaced. To insure plant survival, a healthy planting stock of suitable species should be planted properly on a well prepared site and maintained in good condition.

Table 7 shows the height that locally grown trees and shrubs are expected to reach in 20 years on various soils. The estimates in table 7 are based on measurements and observation of established plantings that have been given adequate care. They can be used as a guide in planning windbreaks and screens. Additional information on planning windbreaks and screens and planting and caring for trees and shrubs can be obtained from local offices of the Soil Conservation Service or the Cooperative Extension Service or from a nursery.

recreation

The soils of the survey area are rated in table 8 according to limitations that affect their suitability for recreation. The ratings are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewerlines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation are also important. Soils subject to flooding are limited for recreation use by the duration and intensity of flooding and the season when flooding occurs. In planning recreation facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

In table 8, the degree of soil limitation is expressed as slight, moderate, or severe. *Slight* means that soil properties are generally favorable and that limitations are

minor and easily overcome. *Moderate* means that 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 other information in this survey, for example, interpretations for septic tank absorption fields in table 11 and interpretations for dwellings without basements and for local roads and streets in table 10.

Camp areas require site preparation, such as shaping and leveling the 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 some vehicular traffic. The best soils have mild slopes and are not wet or 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 campsites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for picnic areas are firm when wet, are not dusty when dry, are not subject to flooding during the period of use, and do not have slopes or stones or boulders that 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 are not wet or subject to flooding during the season of use. The surface is free of stones and boulders, is firm after rains, and is not dusty when dry. If grading is needed, the depth of the soil over bedrock or a hardpan should be considered.

Paths and trails for hiking, horseback riding, and bicycling should require little or no cutting and filling. The best soils are not wet, are firm after rains, are not dusty when dry, and are not subject to flooding more than once a year during the period of use. They have moderate slopes and few or no stones or boulders on the surface.

Golf fairways are subject to heavy foot traffic and some light vehicular traffic. Cutting or filling may be required. The best soils for use as golf fairways are firm when wet, are not dusty when dry, and are not subject to prolonged flooding during the period of use. They have moderate slopes and no stones or boulders on the surface. The suitability of the soil for tees or greens is not considered in rating the soils.

wildlife habitat

Soils affect the kind and amount of vegetation that is available to wildlife as food and cover. They also affect the construction of water impoundments. The kind and abundance of wildlife depend largely on the amount and distribution of food, cover, and water. Wildlife habitat can be created or improved by planting appropriate vegetation, by maintaining the existing plant cover, or by promoting the natural establishment of desirable plants.

In table 9, the soils in the survey area are rated according to their potential for providing habitat for various kinds of wildlife. This information can be used in planning parks, wildlife refuges, nature study areas, and other developments for wildlife; in selecting soils that are suitable for establishing, improving, or maintaining specific elements of wildlife habitat; and in determining the intensity of management needed for each element of the habitat.

The potential of the soil is rated good, fair, poor, or very poor. A rating of *good* indicates that the element or kind of habitat is easily established, improved, or maintained. Few or no limitations affect management, and satisfactory results can be expected. A rating of *fair* indicates that the element or kind of habitat can be established, improved, or maintained in most places. Moderately intensive management is required for satisfactory results. A rating of *poor* indicates that limitations are severe for the designated element or kind of habitat. Habitat can be created, improved, or maintained in most places, but management is difficult and must be intensive. A rating of *very poor* indicates that restrictions for the element or kind of habitat are very severe and that unsatisfactory results can be expected. Creating, improving, or maintaining habitat is impractical or impossible.

The elements of wildlife habitat are described in the following paragraphs.

Grain and seed crops are domestic grains and seed-producing herbaceous plants. Soil properties and features 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. Examples of grain and seed crops are corn, wheat, oats, and soybeans.

Grasses and legumes are domestic perennial grasses and herbaceous legumes. Soil properties and features that affect the 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. Examples of grasses and legumes are fescue, orchardgrass, bromegrass, clover, and alfalfa.

Wild herbaceous plants are native or naturally established grasses and forbs, including weeds. Soil properties and features 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. Examples of wild herbaceous plants are bluestem, goldenrod, beggarweed, wheatgrass, and grama.

Hardwood trees and woody understory produce nuts or other fruit, buds, catkins, twigs, bark, and foliage. Soil properties and features that affect the growth of hardwood trees and shrubs are depth of the root zone, the available water capacity, and wetness. Examples of these plants are oak, poplar, cherry, apple, hawthorn, dogwood, hickory, and elderberry. Examples of fruit-producing shrubs that are suitable for planting on soils rated *good* are Russian-olive, autumn-olive, and crabapple.

Coniferous plants furnish browse, seeds, and cones. Soil properties and features that affect the growth of coniferous trees, shrubs, and ground cover are depth of the root zone, available water capacity, and wetness. Examples of coniferous plants are pine, spruce, fir, cedar, and juniper.

Wetland plants are annual and perennial wild herbaceous plants that grow on moist or wet sites. Submerged or floating aquatic plants are excluded. Soil properties and features affecting wetland plants are texture of the surface layer, wetness, reaction, salinity, slope, and surface stoniness. Examples of wetland plants are smartweed, wild millet, wildrice, saltgrass, cordgrass, rushes, sedges, and reeds.

Shallow water areas have an average depth of less than 5 feet. Some are naturally wet areas. Others are created by dams, levees, or other water-control structures. Soil properties and features affecting shallow water areas are depth to bedrock, wetness, surface stoniness, slope, and permeability. Examples of shallow water areas are marshes, waterfowl feeding areas, and ponds.

The habitat for various kinds of wildlife is described in the following paragraphs.

Habitat for openland wildlife consists of cropland, pasture, 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 wildlife attracted to these areas include bobwhite quail, pheasant, meadowlark, field sparrow, cottontail, and red fox.

Habitat for woodland wildlife consists of areas of deciduous plants or coniferous plants or both and associated grasses, legumes, and wild herbaceous plants. Wildlife attracted to these areas include wild turkey, ruffed grouse, woodcock, thrushes, woodpeckers, squirrels, gray fox, raccoon, and deer.

Habitat for wetland wildlife consists of open, marshy or swampy shallow water areas. Some of the wildlife attracted to such areas are ducks, geese, herons, shore birds, muskrat, mink, and beaver.

engineering

This section provides information for planning land uses related to urban development and to water management. Soils are rated for various uses, and the most limiting features are identified. The ratings are given in the following tables: Building site development, Sanitary facilities, Construction materials, and Water management. The ratings are based on observed performance of the soils and on the estimated data and test data in the "Soil properties" section.

Information in this section is intended for land use planning, for evaluating land use alternatives, and for planning site investigations prior to design and construction. The information, however, has limitations. For example, estimates and other data generally apply only to that part of the soil within a depth of 5 or 6 feet. Because of the map scale, small areas of different soils may be included within the mapped areas of a specific soil.

The information is not site specific and does not eliminate the need for onsite investigation of the soils or for testing and analysis by personnel experienced in the design and construction of engineering works.

Government ordinances and regulations that restrict certain land uses or impose specific design criteria were not considered in preparing the information in this section. Local ordinances and regulations need to be considered in planning, in site selection, and in design.

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about grain-size distribution, liquid limit, plasticity index, soil reaction, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kind of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

This information can be used to (1) evaluate the potential of areas for residential, commercial, industrial, and recreation uses; (2) make preliminary estimates of construction conditions; (3) evaluate alternative routes for roads, streets, highways, pipelines, and underground cables; (4) evaluate alternative sites for sanitary landfills, septic tank absorption fields, and sewage lagoons; (5) plan detailed onsite investigations of soils and geology; (6) locate potential sources of gravel, sand, earthfill, and topsoil; (7) plan drainage systems, irrigation systems, ponds, terraces, and other structures for soil and water conservation; and (8) predict performance of proposed small structures and pavements by comparing the performance of existing similar structures on the same or similar soils.

The information in the tables, along with the soil maps, the soil descriptions, and other data provided in this survey can be used to make additional interpretations.

Some of the terms used in this soil survey have a special meaning in soil science and are defined in the Glossary.

building site development

Table 10 shows the degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, local roads and streets, and lawns and landscaping. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for basements, graves, utility lines, open ditches, and other purposes. The ratings are based on soil properties, site features, and observed performance of the soils. The ease of digging, filling, and compacting is affected by the depth to bedrock, a cemented pan, or a very firm dense layer; stone content; soil texture; and slope. The time of the year that excavations can be made is affected by the depth to a seasonal high water table and the susceptibility of the soil to flooding. The resistance of the excavation walls or banks to sloughing or caving is affected by soil texture and the depth to the water table.

Dwellings and small commercial buildings are structures built on shallow foundations on undisturbed soil. The load limit is the same as that for single-family dwellings no higher than three stories. Ratings are made for small commercial buildings without basements, for dwellings with basements, and for dwellings without basements. The ratings are based on soil properties, site features, and observed performance of the soils. A high water table, flooding, shrink-swell potential, and organic layers can cause the movement of footings. A high water table, large stones, and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 5 to 6 feet are not considered.

Local roads and streets have an all-weather surface and carry automobile and light truck traffic all year. They have a subgrade of cut or fill soil material, a base of gravel, crushed rock, or stabilized soil material, and a flexible or rigid surface. Cuts and fills are generally limited to less than 6 feet. The ratings are based on soil properties, site features, and observed performance of the soils. Depth to bedrock or to a cemented pan, a high water table, flooding, large stones, and slope affect the ease of excavating and grading. Soil strength (as inferred from the engineering classification of the soil), shrink-swell potential, frost action potential, and depth to a high water table affect the traffic supporting capacity.

Lawns and landscaping require soils on which turf and ornamental trees and shrubs can be established and maintained. The ratings are based on soil properties, site features, and observed performance of the soils. Soil reaction, a high water table, depth to bedrock or to a cemented pan, the available water capacity in the upper 40 inches, and the content of salts, sodium, and sulfidic materials affect plant growth. Flooding, wetness, slope, stoniness, and the amount of sand, clay, or organic matter in the surface layer affect trafficability after vegetation is established.

sanitary facilities

Table 11 shows the degree and kind of soil limitations that affect septic tank absorption fields, sewage lagoons, and sanitary landfills. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required.

Table 11 also shows the suitability of the soils for use as daily cover for landfills. A rating of *good* indicates that soil properties and site features are favorable for the use and good performance and low maintenance can be expected; *fair* indicates that soil properties and site features are moderately favorable for the use and one or more soil properties or site features make the soil less desirable than the soils rated good; and *poor* indicates that one or more soil properties or site features are unfavorable for the use and overcoming the unfavorable properties requires special design, extra maintenance, or costly alteration.

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 and 72 inches is evaluated. The ratings are based on soil properties, site features, and observed performance of the soils. Permeability, a high water table, depth to bedrock or to a cemented pan, and flooding affect absorption of the effluent. Large stones and bedrock or a cemented pan interfere with installation.

Unsatisfactory performance of septic tank absorption fields, including excessively slow absorption of effluent, surfacing of effluent, and hillside seepage, can affect public health. Ground water can be polluted if highly permeable sand and gravel or fractured bedrock is less than 4 feet below the base of the absorption field, if slope is excessive, or if the water table is near the surface. There must be unsaturated soil material beneath the absorption field to filter the effluent effectively. Many

local ordinances require that this material be of a certain thickness.

Sewage lagoons are shallow ponds constructed to hold sewage while aerobic bacteria decompose the solid and liquid wastes. Lagoons should have a nearly level floor surrounded by cut slopes or embankments of compacted soil. Lagoons generally are designed to hold the sewage within a depth of 2 to 5 feet. Nearly impervious soil material for the lagoon floor and sides is required to minimize seepage and contamination of ground water.

Table 11 gives ratings for the natural soil that makes up the lagoon floor. The surface layer and, generally, 1 or 2 feet of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features, and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock or to a cemented pan, flooding, large stones, and content of organic matter.

Excessive seepage due to rapid permeability of the soil or a water table that is high enough to raise the level of sewage in the lagoon causes a lagoon to function unsatisfactorily. Pollution results if seepage is excessive or if floodwater overtops the lagoon. A high content of organic matter is detrimental to proper functioning of the lagoon because it inhibits aerobic activity. Slope, bedrock, and cemented pans can cause construction problems, and large stones can hinder compaction of the lagoon floor.

Sanitary landfills are areas where solid waste is disposed of by burying it in soil. There are two types of landfill—trench and area. In a trench landfill, the waste is placed in a trench. It is spread, compacted, and covered daily with a thin layer of soil excavated at the site. In an area landfill, the waste is placed in successive layers on the surface of the soil. The waste is spread, compacted, and covered daily with a thin layer of soil from a source away from the site.

Both types of landfill must be able to bear heavy vehicular traffic. Both types involve a risk of ground water pollution. Ease of excavation and revegetation needs to be considered.

The ratings in table 11 are based on soil properties, site features, and observed performance of the soils. Permeability, depth to bedrock or to a cemented pan, a high water table, slope, and flooding affect both types of landfill. Texture, stones and boulders, highly organic layers, soil reaction, and content of salts and sodium affect trench type landfills. Unless otherwise stated, the ratings apply only to that part of the soil within a depth of about 6 feet. For deeper trenches, a limitation rated slight or moderate may not be valid. Onsite investigation is needed.

Daily cover for landfill is the soil material that is used to cover compacted solid waste in an area type sanitary landfill. The soil material is obtained offsite, transported to the landfill, and spread over the waste.

Soil texture, wetness, coarse fragments, and slope affect the ease of removing and spreading the material during wet and dry periods. Loamy or silty soils that are free of large stones or excess gravel are the best cover for a landfill. Clayey soils are sticky or cloddy and are difficult to spread; sandy soils are subject to soil blowing.

After soil material has been removed, the soil material remaining in the borrow area must be thick enough over bedrock, a cemented pan, or the water table to permit revegetation. The soil material used as final cover for a landfill should be suitable for plants. The surface layer generally has the best workability, more organic matter, and the best potential for plants. Material from the surface layer should be stockpiled for use as the final cover.

construction materials

Table 12 gives information about the soils as a source of roadfill, sand, gravel, and topsoil. The soils are rated *good, fair,* or *poor* as a source of roadfill and topsoil. They are rated as a probable or improbable source of sand and gravel. The ratings are based on soil properties and site features that affect the removal of the soil and its use as construction material. Normal compaction, minor processing, and other standard construction practices are assumed. Each soil is evaluated to a depth of 5 or 6 feet.

Roadfill is soil material that is excavated in one place and used in road embankments in another place. In this table, the soils are rated as a source of roadfill for low embankments, generally less than 6 feet high and less exacting in design than higher embankments.

The ratings are for the soil material below the surface layer to a depth of 5 or 6 feet. It is assumed that soil layers will be mixed during excavating and spreading. Many soils have layers of contrasting suitability within their profile. The table showing engineering index properties provides detailed information about each soil layer. This information can help determine the suitability of each layer for use as roadfill. The performance of soil after it is stabilized with lime or cement is not considered in the ratings.

The ratings are based on soil properties, site features, and observed performance of the soils. The thickness of suitable material is a major consideration. The ease of excavation is affected by large stones, a high water table, and slope. How well the soil performs in place after it has been compacted and drained is determined by its strength (as inferred from the engineering classification of the soil) and shrink-swell potential.

Soils rated *good* contain significant amounts of sand or gravel or both. They have at least 5 feet of suitable material, low shrink-swell potential, few cobbles and stones, and slopes of 15 percent or less. Depth to the water table is more than 3 feet. Soils rated *fair* are more than 35 percent silt- and clay-sized particles and have a plasticity index of less than 10. They have moderate

shrink-swell potential, slopes of 15 to 25 percent, or many stones. Depth to the water table is 1 to 3 feet. Soils rated *poor* have a plasticity index of more than 10, a high shrink-swell potential, many stones, or slopes of more than 25 percent. They are wet, and the depth to the water table is less than 1 foot. They may have layers of suitable material, but the material is less than 3 feet thick.

Sand and gravel are natural aggregates suitable for commercial use with a minimum of processing. Sand and gravel are used in many kinds of construction. Specifications for each use vary widely. In table 12, only the probability of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are factors that affect excavation of the material.

The properties used to evaluate the soil as a source of sand or gravel are gradation of grain sizes (as indicated by the engineering classification of the soil), the thickness of suitable material, and the content of rock fragments. Kinds of rock, acidity, and stratification are given in the soil series descriptions. Gradation of grain sizes is given in the table on engineering index properties.

A soil rated as a probable source has a layer of clean sand or gravel or a layer of sand or gravel that is up to 12 percent silty fines. This material must be at least 3 feet thick and less than 50 percent, by weight, large stones. All other soils are rated as an improbable source. Coarse fragments of soft bedrock, such as shale and siltstone, are not considered to be sand and gravel.

Topsoil is used to cover an area so that vegetation can be established and maintained. The upper 40 inches of a soil is evaluated for use as topsoil. Also evaluated is the reclamation potential of the borrow area.

Plant growth is affected by toxic material and by such properties as soil reaction, available water capacity, and fertility. The ease of excavating, loading, and spreading is affected by rock fragments, slope, a water table, soil texture, and thickness of suitable material. Reclamation of the borrow area is affected by slope, a water table, rock fragments, bedrock, and toxic material.

Soils rated *good* have friable loamy material to a depth of at least 40 inches. They are free of stones and cobbles, have little or no gravel, and have slopes of less than 8 percent. They are low in content of soluble salts, are naturally fertile or respond well to fertilizer, and are not so wet that excavation is difficult.

Soils rated *fair* are sandy soils, loamy soils that have a relatively high content of clay, soils that have only 20 to 40 inches of suitable material, soils that have an appreciable amount of gravel, stones, or soluble salts, or soils that have slopes of 8 to 15 percent. The soils are not so wet that excavation is difficult.

Soils rated *poor* are very sandy or clayey, have less than 20 inches of suitable material, have a large amount of gravel, stones, or soluble salts, have slopes of more than 15 percent, or have a seasonal water table at or near the surface.

The surface layer of most soils is generally preferred for topsoil because of its organic matter content. Organic matter greatly increases the absorption and retention of moisture and nutrients for plant growth.

water management

Table 13 gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas and embankments, dikes, and levees. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and are easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increase in construction costs, and possibly increased maintenance are required.

This table also gives for each soil the restrictive features that affect drainage, irrigation, terraces and diversions, and grassed waterways.

Pond reservoir areas hold water behind a dam or embankment (fig. 11). Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the permeability of the soil and the depth to fractured bedrock or other permeable material. Excessive slope can affect the storage capacity of the reservoir area.

Embankments, dikes, and levees are raised structures of soil material, generally less than 20 feet high, constructed to impound water or to protect land against overflow. In this table, the soils are rated as a source of material for embankment fill. The ratings apply to the soil material below the surface layer to a depth of about 5 feet. It is assumed that soil layers will be uniformly mixed and compacted during construction.

The ratings do not indicate the ability of the natural soil to support an embankment. Soil properties to a depth even greater than the height of the embankment can affect performance and safety of the embankment. Generally, deeper onsite investigation is needed to determine these properties.

Soil material in embankments must be resistant to seepage, piping, and erosion and have favorable compaction characteristics. Unfavorable features include less than 5 feet of suitable material and a high content of stones or boulders, organic matter, or salts or sodium. A high water table affects the amount of usable material. It also affects trafficability.

Drainage is the removal of excess surface and subsurface water from the soil. How easily and effectively the soil is drained depends on the depth to bedrock, to a cemented pan, or to other layers that affect the rate of water movement; permeability; depth to a high water table or depth of standing water if the soil is

Figure 11.—Farm pond in a deep waterway in an area of Storden loam, 18 to 25 percent slopes.

subject to ponding; slope; susceptibility to flooding; subsidence of organic layers; and potential frost action. Excavating and grading and the stability of ditchbanks are affected by depth to bedrock or to a cemented pan, large stones, slope, and the hazard of cutbanks caving. The productivity of the soil after drainage is adversely affected by extreme acidity or by toxic substances in the root zone, such as salts, sodium, or sulfur. Availability of drainage outlets is not considered in the ratings.

Irrigation is the controlled application of water to supplement rainfall and support plant growth. The design and management of an irrigation system are affected by depth to the water table, the need for drainage, flooding, available water capacity, intake rate, permeability, erosion hazard, and slope. The construction of a system is affected by large stones and depth to bedrock or to a cemented pan. The performance of a system is affected by the depth of the root zone, the amount of salts or sodium, and soil reaction.

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to reduce erosion and conserve moisture by intercepting runoff. Slope, wetness, large stones, and depth to bedrock or to a cemented pan affect the construction of terraces and diversions. A restricted rooting depth, a severe hazard of wind or water erosion, an excessively coarse texture, and restricted permeability adversely affect maintenance.

Grassed waterways are natural or constructed channels, generally broad and shallow, that conduct surface water to outlets at a nonerosive velocity. Large stones, wetness, slope, and depth to bedrock or to a cemented pan affect the construction of grassed waterways. A hazard of wind erosion, low available water capacity, restricted rooting depth, toxic substances, such as salts or sodium, and restricted permeability adversely affect the growth and maintenance of the grass after construction.

soil properties

Data relating to soil properties are collected during the course of the soil survey. The data and the estimates of soil and water features, listed in tables, are explained on the following pages.

Soil properties are determined by field examination of the soils and by laboratory index testing of some benchmark soils. Established standard procedures are followed. During the survey, many shallow borings are made and examined to identify and classify the soils and to delineate them on the soil maps. Samples are taken from some typical profiles and tested in the laboratory to determine grain-size distribution, plasticity, and compaction characteristics.

Estimates of soil properties are based on field examinations, on laboratory tests of samples from the survey area, and on laboratory tests of samples of similar soils in nearby areas. Tests verify field observations, verify properties that cannot be estimated accurately by field observation, and help characterize key soils.

The estimates of soil properties shown in the tables include the range of grain-size distribution and Atterberg limits, the engineering classifications, and the physical and chemical properties of the major layers of each soil. Pertinent soil and water features also are given.

engineering index properties

Table 14 gives estimates of the engineering classification and of the range of index properties for the major layers of each soil in the survey area. Most soils have layers of contrasting properties within the upper 5 or 6 feet.

Depth to the upper and lower boundaries of each layer is indicated. The range in depth and information on other properties of each layer are given for each soil series under "Soil series and their morphology."

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter. "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is as much as 15 or 20 percent, an appropriate modifier is added, for example, "gravelly." Textural terms are defined in the Glossary.

Classification of the soils is determined according to the Unified soil classification system (*2*) and the system adopted by the American Association of State Highway and Transportation Officials (*1*).

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 and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as Pt. Soils exhibiting engineering properties of two groups can have a dual classification, for example, SP-SM.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups 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 fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group 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 A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

Rock fragments larger than 3 inches in diameter are indicated as a percentage of the total soil on a dry-weight basis. The percentages are estimates determined mainly by converting volume percentage in the field to weight percentage.

Percentage (of soil particles) passing designated sieves is the percentage of the soil fraction less than 3 inches in diameter based on an oven-dry weight. The sieves, numbers 4, 10, 40, and 200 (USA Standard Series), have openings of 4.76, 2.00, 0.420, and 0.074 millimeters, respectively. Estimates are based on laboratory tests of soils sampled in the survey area and in nearby areas and on estimates made in the field.

Liquid limit and *plasticity index* (Atterberg limits) indicate the plasticity characteristics of a soil. The estimates are based on test data from the survey area or from nearby areas and on field examination.

physical and chemical properties

Table 15 shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the major layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

Clay as a soil separate consists of mineral soil particles that are less than 0.002 millimeter in diameter. In this table, the estimated clay content of each major soil layer is given as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The amount and kind of clay greatly affect the fertility and physical condition of the soil. They determine the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, permeability, and plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and earth-moving operations.

Moist bulk density is the weight of soil (ovendry) per unit volume. Volume is measured when the soil is at field moisture capacity, that is, the moisture content at 1/3 bar moisture tension. Weight is determined after drying the soil at 105 degrees C. In this table, the estimated moist bulk density of each major soil horizon is expressed in grams per cubic centimeter of soil material that is less than 2 millimeters in diameter. Bulk density data are used to compute shrink-swell potential, available water capacity, total pore space, and other soil properties. The moist bulk density of a soil indicates the pore space available for water and roots. A bulk density of more than 1.6 can restrict water storage and root penetration. Moist bulk density is influenced by texture, kind of clay, content of organic matter, and soil structure.

Permeability refers to the ability of a soil to transmit water or air. The estimates indicate the rate of downward movement of water when the soil is saturated. They are based on soil characteristics observed in the field, particularly structure, porosity, and texture. Permeability is considered in the design of soil drainage systems, septic tank absorption fields, and construction where the rate of water movement under saturated conditions affects behavior.

Available water capacity refers to the quantity of water that the soil is capable of storing for use by plants. The capacity for water storage is given in inches of water per inch of soil for each major soil layer. The capacity varies, depending on soil properties that affect the retention of water and the depth of the root zone. The most important properties are the content of organic matter, soil texture, bulk density, and soil structure. Available water capacity is an important factor in the choice of plants or crops to be grown and in the design and management of irrigation systems. Available water capacity is not an estimate of the quantity of water actually available to plants at any given time.

Soil reaction is a measure of acidity or alkalinity and is expressed as a range in pH values. The range in pH of each major horizon is based on many field tests. For many soils, values have been verified by laboratory analyses. Soil reaction is important in selecting crops and other plants, in evaluating soil amendments for fertility and stabilization, and in determining the risk of corrosion.

Shrink-swell potential is the potential for volume change in a soil with a loss or gain in moisture. Volume change occurs mainly because of the interaction of clay minerals with water and varies with the amount and type of clay minerals in the soil. The size of the load on the soil and the magnitude of the change in soil moisture content influence the amount of swelling of soils in place. Laboratory measurements of swelling of undisturbed clods were made for many soils. For others, swelling was estimated on the basis of the kind and amount of clay minerals in the soil and on measurements of similar soils.

If the shrink-swell potential is rated moderate to very high, shrinking and swelling can cause damage to buildings, roads, and other structures. Special design is often needed.

Shrink-swell potential classes are based on the change in length of an unconfined clod as moisture content is increased from air-dry to field capacity. The change is based on the soil fraction less than 2 millimeters in diameter. The classes are *low*, a change of less than 3 percent; *moderate*, 3 to 6 percent; and *high*, more than 6 percent. *Very high*, greater than 9 percent, is sometimes used.

Erosion factor K indicates the susceptibility of a soil to sheet and rill erosion by water. Factor K is one of six factors used in the Universal Soil Loss Equation (USLE) to predict the average annual rate of soil loss by sheet and rill erosion in tons per acre per year. The estimates are based primarily on percentage of silt, sand, and organic matter (up to 4 percent) and on soil structure and permeability. Values of K range from 0.05 to 0.69. The higher the value, the more susceptible the soil is to sheet and rill erosion by water.

Erosion factor T is an estimate of the maximum average annual rate of soil erosion by wind or water that can occur without affecting crop productivity over a sustained period. The rate is in tons per acre per year.

Wind erodibility groups are made up of soils that have similar properties affecting their resistance to wind erosion in cultivated areas. The groups indicate the susceptibility of soil to wind erosion and the amount of soil lost. Soils are grouped according to the following distinctions:

1. Sands, coarse sands, fine sands, and very fine sands. These soils are generally not suitable for crops. They are extremely erodible, and vegetation is difficult to establish.
2. Loamy sands, loamy fine sands, and loamy very fine sands. These soils are very highly erodible. Crops can be grown if intensive measures to control wind erosion are used.

3. Sandy loams, coarse sandy loams, fine sandy loams, and very fine sandy loams. These soils are highly erodible. Crops can be grown if intensive measures to control wind erosion 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. Crops can be grown if intensive measures to control wind erosion are used.

4. Clays, silty clays, clay loams, and silty clay loams that are more than 35 percent clay. These soils are moderately erodible. Crops can be grown if measures to control wind erosion 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. Crops can be grown if measures to control wind erosion 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. 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. Crops can easily be grown.

8. Stony or gravelly soils and other soils not subject to wind erosion.

Organic matter is the plant and animal residue in the soil at various stages of decomposition.

In table 15, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

The content of organic matter of a soil can be maintained or increased by returning crop residue to the soil. Organic matter affects the available water capacity, infiltration rate, and tilth. It is a source of nitrogen and other nutrients for crops.

soil and water features

Table 16 gives estimates of various soil and water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are assigned to one of four groups. They are grouped according to the intake of water when the soils are thoroughly wet and receive 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 mainly of deep, well drained to excessively drained sands or gravelly sands. 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 or deep, moderately well drained or 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 having a layer that impedes the downward movement of water or soils of moderately fine texture or fine 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 clays 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, the temporary inundation of an area, is caused by overflowing streams or by runoff from adjacent slopes. Water standing for short periods after rainfall or snowmelt and water in swamps and marshes are not considered flooding.

Table 16 gives the frequency and duration of flooding and the time of year when flooding is most likely.

Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, common, occasional, and frequent. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions; *common* that it is likely under normal 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.

The information is based on evidence in the soil profile, namely thin strata of gravel, sand, silt, or clay deposited by floodwater; irregular decrease in organic matter content with increasing depth; and absence of distinctive horizons that form in soils that are not subject to flooding.

Also considered is local information about the extent and levels of flooding and the relation of each soil on the landscape to historic floods. Information on the extent of flooding based on soil data is less specific than that provided by detailed engineering surveys that delineate flood-prone areas at specific flood frequency levels.

High water table (seasonal) is the highest level of a saturated zone in the soil in most years. The depth to a seasonal high water table applies to undrained soils. The estimates are based mainly on the evidence of a saturated zone, namely grayish colors or mottles in the soil. Indicated in table 16 are the depth to the seasonal high water table; the kind of water table—that is, perched, artesian, or apparent; and the months of the year that the water table commonly is high. A water table

that is seasonally high for less than 1 month is not indicated in table 16.

An apparent water table is a thick zone of free water in the soil. It is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil. An artesian water table is under hydrostatic head, generally beneath an impermeable layer. When this layer is penetrated, the water level rises in an uncased borehole. A perched water table is water standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

Only saturated zones within a depth of about 6 feet are indicated. A plus sign preceding the range in depth indicates that the water table is above the surface of the soil. The first numeral in the range indicates how high the water rises above the surface. The second numeral indicates the depth below the surface.

Potential frost action is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, permeability, content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured clayey soils that have a high water table in winter are most susceptible to frost action. Well drained, very gravelly, or very sandy soils are the least susceptible. Frost heave and low soil strength during thawing cause damage mainly to pavements and other rigid structures.

Risk of corrosion pertains to potential soil-induced electrochemical or chemical action that dissolves or weakens uncoated steel or concrete. The rate of corrosion of uncoated steel is related to such factors as soil moisture, particle-size distribution, acidity, and electrical conductivity of the soil. The rate of corrosion of concrete is based mainly on the sulfate and sodium content, texture, moisture content, and acidity of the soil. Special site examination and design may be needed if the combination of factors creates a severe corrosion environment. The steel in installations that intersect soil boundaries or soil layers is more susceptible to corrosion than steel in installations that are entirely within one kind of soil or within one soil layer.

For uncoated steel, the risk of corrosion, expressed as *low, moderate,* or *high,* is based on soil drainage class, total acidity, electrical resistivity near field capacity, and electrical conductivity of the saturation extract.

For concrete, the risk of corrosion is also expressed as *low*, *moderate*, or *high*. It is based on soil texture, acidity, and amount of sulfates in the saturation extract.

classification of the soils

The system of soil classification used by the National Cooperative Soil Survey has six categories (*11*). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. In table 17, the soils of the survey area are classified according to the system. The categories are defined in the following paragraphs.

ORDER. Ten soil orders are recognized. The differences among orders reflect the dominant soil-forming processes and the degree of soil formation. Each order is identified by a word ending in *sol*. An example is Mollisol.

SUBORDER. Each order is divided into suborders primarily on the basis of properties that influence soil genesis and are important to plant growth or properties that reflect the most important variables within the orders. The last syllable in the name of a suborder indicates the order. An example is Aquoll (*Aqu*, meaning water, plus *oll*, from Mollisol).

GREAT GROUP. Each suborder is divided into great groups on the basis of close similarities in kind, arrangement, and degree of development of pedogenic horizons; soil moisture and temperature regimes; and base status. Each great group is identified by the name of a suborder and by a prefix that indicates a property of the soil. An example is Haplaquolls (*Hapl*, meaning minimal horizonation, plus *aquoll*, the suborder of the Mollisols that have an aquic moisture regime).

SUBGROUP. Each great group has a typic subgroup. Other subgroups are intergrades or extragrades. The typic is the central concept of the great group; it is not necessarily the most extensive. Intergrades are transitions to other orders, suborders, or great groups. Extragrades have some properties that are not representative of the great group but do not indicate transitions to any other known kind of soil. Each subgroup is identified by one or more adjectives preceding the name of the great group. The adjective *Typic* identifies the subgroup that typifies the great group. An example is Typic Haplaquolls.

FAMILY. Families are established within a subgroup on the basis of physical and chemical properties and other characteristics that affect management. Mostly the properties are those of horizons below plow depth where there is much biological activity. Among the properties and characteristics considered are particle-size class, mineral content, temperature regime, depth of the root zone, consistence, moisture equivalent, slope, and permanent cracks. A family name consists of the name of a subgroup preceded by terms that indicate soil properties. An example is fine-loamy, mixed, mesic Typic Haplaquolls.

SERIES. The series consists of soils that have similar horizons in their profile. The horizons are similar in color, texture, structure, reaction, consistence, mineral and chemical composition, and arrangement in the profile. The texture of the surface layer or of the substratum can differ within a series.

soil series and their morphology

In this section, each soil series recognized in the survey area is described. The descriptions are arranged in alphabetic order.

Characteristics of the soil and the material in which it formed are identified for each series. The soil is compared with similar soils and with nearby soils of other series. A pedon, a small three-dimensional area of soil, that is typical of the series in the survey area is described. The detailed description of each soil horizon follows standards in the *Soil Survey Manual* (*10*). Many of the technical terms used in the descriptions are defined in *Soil Taxonomy* (*11*). Unless otherwise stated, colors in the descriptions are for moist soil. Following the pedon description is the range of important characteristics of the soils in the series.

The map units of each soil series are described in the section "Detailed soil map units."

Biscay series

The Biscay series consists of poorly drained soils that are moderately permeable in the upper part and rapidly permeable in the lower part of the subsoil and in the substratum. These soils are on benches and uplands. They formed in loamy glacial outwash and in the underlying calcareous sand and gravel. Slope ranges from 0 to 2 percent.

Biscay soils are similar to Cylinder and Talcot soils and are commonly adjacent to Cylinder and Wadena soils. Cylinder soils have higher chroma in the upper part of the B horizon than the Biscay soils. They are

somewhat poorly drained and are at the slightly higher elevations. Talcot soils are calcareous throughout. Wadena soils are well drained and are on the higher lying or more sloping parts of the landscape.

Typical pedon of Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, 21 feet south and 66 feet east of the center of sec. 23, T. 86 N., R. 34 W.

Ap—0 to 7 inches; black (N 2/0) clay loam, black (10YR 2/1) dry; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A12—7 to 13 inches; black (10YR 2/1) clay loam, very dark gray (2.5Y 3/0) dry; common medium faint very dark gray (5Y 3/1) mottles; weak fine granular and weak very fine subangular blocky structure; friable; few fine dark accumulations of oxide; neutral; gradual smooth boundary.

A31—13 to 19 inches; very dark gray (10YR 3/1) clay loam, dark gray (10YR 4/1) dry; common medium faint dark olive gray (5Y 3/2) mottles; weak fine granular and weak very fine subangular blocky structure; friable; few fine dark accumulations of oxide; neutral; gradual smooth boundary.

A32—19 to 23 inches; very dark gray (10YR 3/1) clay loam, gray (10YR 5/1) dry; common medium distinct olive gray (5Y 4/2) mottles; weak very fine subangular blocky structure; friable; mildly alkaline; clear smooth boundary.

B2g—23 to 29 inches; dark gray (5Y 4/1) and olive gray (5Y 4/2) loam; few medium distinct light olive brown (2.5Y 5/4) mottles; weak medium subangular blocky structure; friable; few fine dark accumulations of oxide; mildly alkaline; abrupt smooth boundary.

B31g—29 to 34 inches; olive gray (5Y 5/2) loam; few medium distinct light olive brown (2.5Y 5/4) mottles; weak medium subangular blocky structure; friable; few fine dark accumulations of oxide; mildly alkaline; abrupt smooth boundary.

IIB32g—34 to 38 inches; olive gray (5Y 5/2) gravelly sandy loam; few medium distinct light olive brown (2.5Y 5/6) mottles; weak medium subangular blocky structure; very friable; few fine dark accumulations of oxide; strong effervescence; moderately alkaline; abrupt smooth boundary.

IICg—38 to 60 inches; gray (5Y 5/1) and olive gray (5Y 5/2) gravelly loamy sand; few fine faint olive gray (5Y 4/2) and olive (5Y 4/3) mottles; massive; very friable; few fine soft calcium carbonate accumulations; few fine dark accumulations of oxide; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 26 to 40 inches. The thickness of the mollic epipedon ranges from 16 to 24 inches.

The A horizon is clay loam or loam. The B2 horizon has chroma of 1 to 3. It is loam, clay loam, or sandy clay loam. It is neutral or mildly alkaline. The fine earth part of the C horizon is loamy coarse sand, loamy sand, coarse sand, or sand. The content of gravel in this horizon is 10 to 50 percent. In some pedons the sand and gravel is stratified.

Bode series

The Bode series consists of well drained moderately permeable soils on convex slopes in the uplands. These soils formed in moderately fine textured lacustrine sediments less than 3 feet deep over medium textured glacial till. Slope ranges from 2 to 5 percent.

Bode soils are similar to Clarion soils and are commonly adjacent to Clarion, Kossuth, Nicollet, Ottosen, and Webster soils in the lower lying areas. Clarion, Nicollet, and Webster soils contain less clay and more sand in the A and B horizons than the Bode soils. Kossuth soils are poorly drained. Ottosen soils are somewhat poorly drained.

Typical pedon of Bode clay loam, 2 to 5 percent slopes, 2,040 feet west and 50 feet north of the southeast corner of sec. 2, T. 87 N., R. 33 W.

Ap—0 to 6 inches; black (10YR 2/1) clay loam, dark gray (10YR 4/1) dry; weak very fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

A3—6 to 11 inches; very dark grayish brown (10YR 3/2) clay loam, dark grayish brown (10YR 4/2) dry; dark brown (10YR 3/3) coatings on faces of peds; weak very fine and fine subangular blocky structure; friable; neutral; clear smooth boundary.

B1—11 to 17 inches; dark brown (10YR 3/3) clay loam, brown (10YR 5/3) dry; weak very fine and fine subangular blocky structure; friable; neutral; clear smooth boundary.

B21—17 to 23 inches; brown (10YR 4/3) clay loam, yellowish brown (10YR 5/4) dry; very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) coatings on faces of peds; weak very fine and fine subangular blocky structure; friable; neutral; clear smooth boundary.

B22—23 to 28 inches; brown (10YR 4/3) clay loam; dark brown (10YR 3/3) coatings on faces of peds; weak very fine and fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

IIC1—28 to 42 inches; dark yellowish brown (10YR 4/4) and grayish brown (2.5Y 5/2) loam; weak fine prismatic structure; friable; many soft calcium carbonate accumulations; many fine dark accumulations of oxide; strong effervescence; moderately alkaline; gradual smooth boundary.

IIC2—42 to 52 inches; yellowish brown (10YR 5/6) loam; many medium distinct grayish brown (2.5Y 5/2) mottles; massive; friable; few fine soft calcium carbonate accumulations; common fine dark accumulations of oxide; slightly stratified; strong effervescence; moderately alkaline; gradual smooth boundary.

IIC3—52 to 60 inches; yellowish brown (10YR 5/6) and grayish brown (2.5Y 5/2) loam; massive; friable; common fine dark accumulations of oxide; few fine calcium carbonate accumulations; slightly stratified; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 24 to 40 inches. The thickness of the mollic epipedon ranges from 10 to 20 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly clay loam, but the range includes loam. The B2 horizon has hue of 10YR or 2.5Y and value and chroma of 3 or 4. It is neutral or slightly acid. The content of clay in this horizon ranges from 28 to 35 percent.

Calco series

The Calco series consists of poorly drained, calcareous, moderately permeable soils on bottom land. These soils formed in alluvium. Slope ranges from 0 to 2 percent.

Calco soils are similar to Canisteo and Harps soils and are commonly adjacent to Coland and Spillville soils. Canisteo soils have an A horizon that is less than 20 inches thick and are fine-loamy. Coland soils have a higher content of sand than the Calco soils and are not calcareous. Their position on the landscape is similar to that of the Calco soils. Harps soils have a calcic horizon. Their mollic epipedon is thinner than that of the Calco soils. Spillville soils are moderately well drained and somewhat poorly drained and are at higher elevations than the Calco soils. Also, they have a higher content of sand.

Typical pedon of Calco silty clay loam, 0 to 2 percent slopes, 550 feet east and 2,040 feet south of the northwest corner of sec. 4, T. 88 N., R. 34 W.

A11—0 to 12 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; moderate very fine subangular blocky structure; friable; strong effervescence; moderately alkaline; diffuse smooth boundary.

A12—12 to 24 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; moderate very fine subangular blocky structure; friable; strong effervescence; moderately alkaline; diffuse smooth boundary.

A13—24 to 37 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak very fine subangular blocky structure; friable; strong effervescence; moderately alkaline; diffuse smooth boundary.

Bg—37 to 47 inches; very dark gray (10YR 3/1) clay loam, very dark gray (10YR 3/1) dry; weak fine prismatic structure parting to weak very fine subangular blocky; friable; slight effervescence; moderately alkaline; diffuse smooth boundary.

C1g—47 to 60 inches; very dark gray (5Y 3/1) clay loam, dark gray (10YR 4/1) dry; massive; friable; slight effervescence; mildly alkaline.

The thickness of the A horizon ranges from 30 to 50 inches. The thickness of the mollic epipedon ranges from 40 to 50 inches.

The A horizon is black (N 2/0, 10YR 2/1, or 5Y 2/1). The B horizon has value of 3 or 4 and chroma of 0 or 1. It is loam or clay loam. Some pedons do not have a B horizon. The C horizon dominantly has value of 3 and chroma of 0 or 1 but in some pedons has value of 4 or 5 and chroma of 2. It is dominantly clay loam, but in some pedons it has thin strata of other textures.

Canisteo series

The Canisteo series consists of poorly drained, calcareous, moderately permeable soils in the uplands. These soils formed in glacial till and glacial sediments. Slope ranges from 0 to 2 percent.

Canisteo soils are similar to Webster soils and are commonly adjacent to Nicollet and Webster soils. Both of the adjacent soils have a noncalcareous solum. The somewhat poorly drained Nicollet soils are on the higher parts of the landscape. Webster soils are in positions on the landscape similar to those of the Canisteo soils.

Typical pedon of Canisteo silty clay loam, 0 to 2 percent slopes, 1,520 feet south and 320 feet east of the northwest corner of sec. 22, T. 88 N., R. 32 W.

Ap—0 to 6 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak very fine subangular blocky structure parting to weak very fine granular; friable; strong effervescence; moderately alkaline; clear smooth boundary.

A12—6 to 10 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak fine and very fine subangular blocky structure; friable; strong effervescence; moderately alkaline; clear smooth boundary.

A3g—10 to 17 inches; very dark gray (5Y 3/1) loam; some mixing of dark olive gray (5Y 3/2) and dark gray (10YR 4/1) dry; weak fine and very fine subangular blocky structure; friable; few very fine soft calcium carbonate accumulations; strong effervescence; moderately alkaline; gradual smooth boundary.

B21g—17 to 26 inches; olive gray (5Y 5/2) loam; weak fine and very fine subangular blocky structure; friable; few fine reddish accumulations of oxide; strong effervescence; moderately alkaline; clear smooth boundary.

B22g—26 to 31 inches; olive gray (5Y 5/2) loam; common medium distinct strong brown (7.5YR 5/6) mottles; weak fine and very fine subangular blocky structure; friable; strong effervescence; moderately alkaline; clear smooth boundary.

C1g—31 to 42 inches; olive gray (5Y 5/2) loam; common medium distinct strong brown (7.5YR 5/6) mottles; weak fine and very fine subangular blocky structure; friable; common fine soft calcium carbonate accumulations; strong effervescence; moderately alkaline; clear smooth boundary.
C2g—42 to 57 inches; olive gray (5Y 5/2) clay loam; common medium distinct yellowish brown (10YR 5/8) mottles; massive; friable; many medium soft calcium carbonate accumulations; many dark accumulations of oxide; strong effervescence; moderately alkaline; clear smooth boundary.
C3g—57 to 60 inches; olive gray (5Y 4/2) clay loam; common medium distinct yellowish brown (10YR 5/8) mottles; massive; friable; common medium dark accumulations of oxide; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 20 to 36 inches. The thickness of the mollic epipedon ranges from 14 to 24 inches.

The A horizon has value of 2 or 3 and chroma of 0 or 1. It is clay loam, silty clay loam, or loam. The B2 horizon has value of 4 or 5 and chroma of 1 or 2. It is loam or clay loam. The C horizon has value of 4 to 6 and chroma of 2 to 4. It is loam or clay loam.

Clarion series

The Clarion series consists of well drained, moderately permeable soils on convex slopes in the uplands. These soils formed in glacial till. Slope ranges from 2 to 14 percent.

Clarion soils are commonly adjacent to the Nicollet, Storden, and Webster soils. Nicollet soils are slightly finer textured than the Clarion soils. They are somewhat poorly drained and are on the less sloping parts of the landscape. Storden soils have carbonates. They are on the more sloping knobs. Webster soils are finer textured than the Clarion soils. They are poorly drained and are on the lower parts of the landscape.

Typical pedon of Clarion loam, 2 to 5 percent slopes, 1,270 feet west and 375 feet north of the southeast corner of sec. 28, T. 86 N., R. 33 W.

A1—0 to 9 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine granular and weak very fine subangular blocky structure; friable; neutral; clear smooth boundary.
A3—9 to 14 inches; very dark gray (10YR 3/1) loam, very dark grayish brown (10YR 3/2) dry; weak fine granular and weak very fine subangular blocky structure; friable; slightly acid; clear smooth boundary.
B1—14 to 18 inches; dark brown (10YR 3/3) loam, brown (10YR 4/3) dry; thin discontinuous very dark gray (10YR 3/1) clay films; brown (10YR 4/3) coatings on faces of peds; weak very fine subangular blocky structure; friable; slightly acid; clear smooth boundary.
B21—18 to 22 inches; brown (10YR 4/3) clay loam; thin discontinuous very dark grayish brown (10YR 3/2) clay films; weak fine prismatic structure parting to weak fine subangular blocky; friable; slightly acid; clear smooth boundary.
B22—22 to 29 inches; dark yellowish brown (10YR 4/4) clay loam; weak fine prismatic structure parting to weak fine subangular blocky; friable; thin discontinuous very dark gray (10YR 3/1) clay films in root channels; slightly acid; clear smooth boundary.
B31—29 to 37 inches; dark yellowish brown (10YR 4/4) clay loam; weak fine prismatic structure parting to weak fine subangular blocky; friable; neutral; abrupt smooth boundary.
B32—37 to 41 inches; dark yellowish brown (10YR 4/4) loam; weak fine subangular blocky structure; friable; few medium calcium carbonate accumulations; mildly alkaline; abrupt smooth boundary.
C1—41 to 50 inches; light olive brown (2.5Y 5/4) loam; massive; friable; few fine calcium carbonate accumulations; common very fine dark accumulations of oxide; strong effervescence; moderately alkaline; abrupt smooth boundary.
C2—50 to 60 inches; light olive brown (2.5Y 5/4) loam high in content of silt; massive; friable; thin light olive gray (5Y 6/2) strata; violent effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 18 to 50 inches. The thickness of the mollic epipedon ranges from 10 to 20 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. The B2 horizon has value and chroma of 3 to 5. It is loam or clay loam. It is neutral or slightly acid. The C horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 3 to 6.

Clarion loam, 5 to 9 percent slopes, moderately eroded, and Clarion loam, 9 to 14 percent slopes, moderately eroded, are taxadjuncts to the Clarion series because their mollic colors extend to a depth of only 4 to 6 inches. This difference, however, does not significantly affect the use or behavior of the soils.

Coland series

The Coland series consists of poorly drained, moderately permeable soils on bottom land and alluvial fans. These soils formed in moderately fine textured alluvium. Slope ranges from 0 to 5 percent.

Coland soils are similar to Calco, Okoboji, and Spillville soils and are commonly adjacent to Biscay, Cylinder, Spillville, and Wadena soils. Biscay, Cylinder, and Wadena soils have contrasting sandy or sandy-skeletal textures within a depth of 40 inches. They are on the higher parts of the landscape. Calco soils have free

carbonates in the solum. Okoboji and Spillville soils contain more clay in the solum than the Coland soils. Also, Spillville soils are slightly lower on the landscape.

Typical pedon of Coland clay loam, 0 to 2 percent slopes, 400 feet west and 2,440 feet south of the northeast corner of sec. 29, T. 89 N., R. 34 W.

Ap—0 to 9 inches; black (N 2/0) clay loam, black (10YR 2/1) dry; moderate fine angular blocky structure; friable; neutral; abrupt smooth boundary.
A12—9 to 20 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak very fine granular structure; friable; neutral; gradual smooth boundary.
A13—20 to 30 inches; black (N 2/0) clay loam, dark gray (10YR 4/1) dry; common medium prominent yellowish brown (10YR 5/6) mottles; weak very fine subangular blocky and granular structure; friable; few very fine dark accumulations of oxide; neutral; gradual smooth boundary.
A14—30 to 44 inches; very dark gray (10YR 3/1) clay loam, dark gray (10YR 4/1) dry; few medium distinct very dark gray (5Y 3/1) and dark gray (5Y 4/1) mottles; weak fine and very fine subangular blocky structure; friable; few very fine reddish accumulations of oxide; neutral; gradual smooth boundary.
C1—44 to 53 inches; dark gray (5Y 4/1) clay loam; common medium prominent yellowish brown (10YR 5/6) mottles; massive; friable; common medium dark and reddish accumulations of oxide; black (5Y 2/1) fillings in crawfish holes; neutral; gradual smooth boundary.
C2—53 to 60 inches; gray (5Y 5/1) loam; many medium prominent yellowish brown (10YR 5/6) mottles; massive; friable; many medium dark and reddish accumulations of oxide; black (5Y 2/1) fillings in crawfish holes; mildly alkaline.

The thickness of the solum ranges from 36 to 48 inches. The A horizon is clay loam or silty clay loam. Some pedons have a B horizon, which has hue of 5Y, value of 3 to 5, and chroma of 0 or 1. The C horizon has hue of 5Y and value of 2 to 5. It dominantly has chroma of 0 or 1 but in some pedons has chroma of 2 and prominent mottles. It is dominantly clay loam or loam but in some pedons has strata of sandy clay loam and sandy loam.

Cylinder series

The Cylinder series consists of somewhat poorly drained soils that are moderately permeable in the solum and very rapidly permeable in the substratum. These soils are on glacial outwash plains and stream benches. They formed in loamy alluvium over sand and gravel. Slope ranges from 0 to 2 percent.

Cylinder soils are similar to Biscay, Nicollet, and Wadena soils and are commonly adjacent to Biscay and Wadena soils. Biscay soils have lower chroma in the upper part of the B horizon than the Cylinder soils. They are poorly drained and are at the slightly lower elevations. Nicollet soils are fine-loamy throughout. Wadena soils are well drained and are on the higher parts of the landscape.

Typical pedon of Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, 12 feet west and 24 feet south of the northeast corner of sec. 26, T. 86 N., R. 34 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; neutral; clear smooth boundary.
A12—8 to 14 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine and very fine subangular blocky structure; friable; neutral; clear smooth boundary.
A3—14 to 23 inches; very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; weak fine and very fine subangular blocky and weak fine granular structure; friable; neutral; clear smooth boundary.
B2—23 to 33 inches; dark grayish brown (10YR 4/2) loam, dark grayish brown (10YR 4/2) dry; common very dark grayish brown (10YR 3/2) coatings on faces of peds in the upper part; few fine faint yellowish brown (10YR 5/6) mottles; weak fine granular structure; friable; few fine red accumulations of oxide; neutral; abrupt smooth boundary.
IIC1—33 to 56 inches; dark yellowish brown (10YR 4/4) sand and gravel; single grained; loose; few red accumulations of oxide; few pebbles; 2-inch cemented sand lens; mildly alkaline; abrupt smooth boundary.
IIC2—56 to 60 inches; mixed dark grayish brown (10YR 4/2) and grayish brown (10YR 5/2) sand and gravel; single grained; loose; few red accumulations of oxide; few pebbles; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 24 to 48 inches. The depth to sand and gravel ranges from 24 to 40 inches. The thickness of the mollic epipedon ranges from 16 to 24 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is loam or clay loam. The B2 horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 or 3. It is loam or clay loam. It is slightly acid or neutral. In some pedons the C horizon is gravelly loamy sand.

Estherville series

The Estherville series consists of somewhat excessively drained soils that are moderately rapidly permeable in the solum and rapidly permeable in the substratum. These soils formed in glacial alluvium on broad outwash plains and valley trains and on kames on glacial moraines. Slope ranges from 2 to 9 percent.

Estherville soils are similar to Wadena soils and are commonly adjacent to Clarion and Wadena soils in the higher lying areas. Both of the adjacent soils are well drained. Clarion soils do not have sand and gravel in the substratum. Wadena soils are 24 to 40 inches deep over sand and gravel.

Typical pedon of Estherville sandy loam, 2 to 5 percent slopes, 800 feet east and 400 feet south of the center of sec. 17, T. 86 N., R. 34 W.

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) sandy loam, dark grayish brown (10YR 4/2) dry; 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) sandy loam, brown (10YR 4/3) dry; weak very fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

B1—12 to 16 inches; mixed brown (10YR 4/3) and very dark grayish brown (10YR 3/2) sandy loam; weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

B2—16 to 28 inches; dark yellowish brown (10YR 4/4) sandy loam; weak medium subangular blocky structure; friable; slightly acid; gradual smooth boundary.

IIC1—28 to 48 inches; brown (10YR 4/3) sand and gravel; single grained; loose; slight effervescence; moderately alkaline; diffuse smooth boundary.

IIC2—48 to 60 inches; brown (10YR 4/3) sand and gravel; single grained; loose; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 15 to 30 inches. The thickness of the mollic epipedon ranges from 10 to 18 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is sandy loam or loam. The B2 horizon has value of 3 or 4 and chroma of 3 to 5. It is sandy loam or loam. It is slightly acid or medium acid. The content of clay in this horizon is less than 18 percent, and the content of sand coarser than very fine sand ranges from 30 to 50 percent. The IIC horizon has chroma of 2 to 6.

Harps series

The Harps series consists of poorly drained, calcareous, moderately permeable soils. These soils formed in glacial till or alluvium derived from till on till plains or outwash plains. They are on narrow rims of depressions, on slight rises within poorly defined swales or flat outwash plains, and, in a few places, in swales or poorly defined drainageways. Slope ranges from 0 to 2 percent.

Harps soils are similar to Canisteo and Talcot soils and are commonly adjacent to Canisteo, Okoboji, Wacousta, and Webster soils. Canisteo and Talcot soils do not have a calcic horizon. They have a lower calcium carbonate equivalent than the Harps soils. Canisteo soils are at the slightly lower elevations. Okoboji soils are cumulic. They are finer textured than the Harps soils and are noncalcareous. They are at the slightly lower elevations. Wacousta and Webster soils are noncalcareous. Wacousta soils are in depressions that are surrounded by the Harps soils. Webster soils are at the slightly lower elevations.

Typical pedon of Harps loam, 0 to 2 percent slopes, 40 feet west and 2,586 feet south of the northeast corner of sec. 25, T. 89 N., R. 34 W.

Apca—0 to 8 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak fine granular structure; friable; violent effervescence; moderately alkaline; abrupt smooth boundary.

A12ca—8 to 14 inches; black (10YR 2/1) loam, gray (10YR 5/1) dry; weak fine granular structure; friable; violent effervescence; moderately alkaline; gradual smooth boundary.

A13ca—14 to 18 inches; black (10YR 2/1) and very dark gray (10YR 3/1) clay loam, gray (10YR 5/1) and light gray (10YR 6/1) dry; weak very fine subangular blocky structure; friable; violent effervescence; moderately alkaline; clear smooth boundary.

A3ca—18 to 22 inches; very dark gray (5Y 3/1) clay loam, light gray (10YR 6/1) dry; few fine distinct gray (5Y 5/1) mottles; weak very fine subangular blocky structure; friable; violent effervescence; moderately alkaline; clear smooth boundary.

B2g—22 to 29 inches; olive gray (5Y 5/2) loam; common medium faint grayish brown (2.5Y 5/2) mottles; weak very fine subangular blocky structure; friable; few medium dark soft accumulations of oxide; strong effervescence; moderately alkaline; gradual smooth boundary.

C1g—29 to 36 inches; olive gray (5Y 5/2) loam; common medium distinct yellowish brown (10YR 5/6) mottles; massive; friable; common medium dark soft accumulations of oxide; common medium soft calcium carbonate accumulations; strong effervescence; moderately alkaline; diffuse smooth boundary.

C2—36 to 48 inches; olive gray (5Y 5/2) loam; many medium distinct yellowish brown (10YR 5/6) mottles; massive; friable; common medium dark and few medium reddish accumulations of oxide; strong effervescence; moderately alkaline; diffuse smooth boundary.

C3—48 to 60 inches; mottled olive gray (5Y 5/2) and yellowish brown (10YR 5/6) loam; massive; friable; dark accumulations of oxide and few medium reddish accumulations of oxide; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 29 to 50 inches. The thickness of the mollic epipedon ranges from 10 to 24 inches.

The A horizon is black or very dark gray (N 3/0, 10YR 2/1, 10YR 3/1, or 5Y 3/1). It is loam or clay loam. The B horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 1 or 2. It is loam or clay loam. The C horizon has colors similar to those of the B horizon. In some pedons, however, high chroma colors are dominant in the upper part.

Knoke series

The Knoke series consists of very poorly drained, calcareous, moderately slowly permeable soils in upland depressions. These soils formed in silty glacial sediments. Slope is 0 to 1 percent.

Knoke soils are similar to Okoboji soils and are commonly adjacent to Wacousta and Wacousta Variant soils. Okoboji and Wacousta soils are noncalcareous. Wacousta and Wacousta Variant soils are in positions on the landscape similar to those of the Knoke soils. Their mollic epipedon is thinner than that of the Knoke soils.

Typical pedon of Knoke mucky silt loam, 0 to 1 percent slopes, 1,440 feet north and 50 feet west of the southeast corner of sec. 3, T. 88 N., R. 33 W.

Ap—0 to 8 inches; black (5Y 2/1) mucky silt loam, dark gray.(10YR 4/1) dry; weak medium platy structure parting to weak fine subangular blocky; friable; many snail shells; violent effervescence; moderately alkaline; abrupt smooth boundary.

A12—8 to 13 inches; very dark gray (5Y 3/1) mucky silty clay loam, gray (10YR 5/1) dry; weak medium platy structure; friable; thin light reddish coatings in fine continuous vertical tubular pores; many snail shells; violent effervescence; moderately alkaline; abrupt smooth boundary.

A13—13 to 18 inches; black (5Y 2/1) mucky silty clay loam, dark gray (10YR 4/1) dry; weak medium platy structure; friable; many snail shells; thin light reddish coatings in fine continuous vertical tubular pores; violent effervescence; moderately alkaline; clear smooth boundary.

A14—18 to 33 inches; black (N 2/0) silty clay loam, dark gray (10YR 4/1) dry; weak very fine and fine subangular blocky structure; friable; slight effervescence; mildly alkaline; gradual smooth boundary.

B2g—33 to 40 inches; black (N 2/0) silty clay loam, dark gray (10YR 4/1) dry; weak fine angular and subangular blocky structure; friable; slight effervescence; mildly alkaline; clear smooth boundary.

B3g—40 to 46 inches; black (N 2/0) silty clay loam, gray (10YR 5/1) dry; common medium prominent olive brown (2.5Y 4/4) mottles; weak fine prismatic structure parting to weak fine subangular blocky; friable; slight effervescence; mildly alkaline; clear smooth boundary.

C1g—46 to 54 inches; gray (5Y 5/1), very dark gray (5Y 3/1), and dark gray (2.5Y 4/1) silty clay loam; weak fine prismatic structure; friable; strong effervescence; moderately alkaline; gradual smooth boundary.

C2g—54 to 60 inches; gray (5Y 5/1) silty clay loam; many medium prominent dark yellowish brown (10YR 4/4) mottles; massive; friable; common medium soft calcium carbonate accumulations; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 24 to 60 inches. The thickness of the mollic epipedon ranges from 24 to 48 inches.

The A horizon has hue of 10YR, 2.5Y, 5Y, or N, value of 2 or 3, and chroma of 0 or 1. It is mucky silt loam, silty clay loam, or mucky silty clay loam in the upper part and silty clay loam, clay loam, or silty clay in the lower part. The B horizon has hue of N, 2.5Y, or 5Y, value of 2 or 3, and chroma of 0 or 1. It is silty clay loam or silty clay. The C horizon has value of 3 to 5 and chroma of 1 or 2.

Kossuth series

The Kossuth series consists of poorly drained, moderately slowly permeable soils on uplands. These soils formed in 2 to 4 feet of moderately fine textured glacial or lacustrine sediments and in the underlying glacial till. Slope ranges from 0 to 2 percent.

Kossuth soils are similar to Webster soils and are commonly adjacent to Bode, Canisteo, Nicollet, Ottosen, and Webster soils. Bode soils are on the higher parts of the landscape and are well drained. Canisteo soils have free carbonates throughout the solum. Their position on the landscape is similar to that of the Kossuth soils. Nicollet and Ottosen soils are on the slightly higher parts of the landscape and are somewhat poorly drained. Webster soils have a lower content of clay in the upper part of the solum than the Kossuth soils. They formed in glacial till and in local alluvium derived from the till. Their position on the landscape is similar to that of the Kossuth soils.

Typical pedon of Kossuth silty clay loam, 0 to 2 percent slopes, 100 feet west and 2,400 feet north of the southeast corner of sec. 12, T. 86 N., R. 31 W.

Ap—0 to 6 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak fine granular and weak fine subangular blocky structure; firm; neutral; clear smooth boundary.

A12—6 to 19 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak fine granular and weak fine and very fine subangular blocky structure; firm; few very fine dark accumulations of oxide; slightly acid; clear smooth boundary.

A3g—19 to 24 inches; black (5Y 2/1) silty clay loam, dark gray (10YR 4/1) dry; common very fine faint dark olive gray (5Y 3/2) mottles; weak very fine subangular blocky structure; firm; many fine dark

accumulations of oxide; neutral; clear smooth boundary.

B1tg—24 to 29 inches; very dark gray (5Y 3/1) and dark gray (5Y 4/1) silty clay loam, gray (10YR 5/1) dry; few fine distinct olive (5Y 4/3) mottles; weak very fine subangular blocky structure; firm; many fine dark accumulations of oxide; thin discontinuous clay films on faces of peds; neutral; clear smooth boundary.

B21tg—29 to 33 inches; dark gray (5Y 4/1) and olive gray (5Y 4/2) silty clay loam; common fine distinct olive (5Y 4/3) mottles; weak fine prismatic structure parting to weak very fine subangular blocky; firm; many very fine dark accumulations of oxide; thin discontinuous clay films; neutral; clear smooth boundary.

IIB22g—33 to 40 inches; olive gray (5Y 5/2) clay loam; common fine faint olive (5Y 4/3) mottles; weak fine prismatic structure parting to weak very fine subangular blocky; firm; many very fine dark accumulations of oxide; neutral; clear smooth boundary.

IIB3g—40 to 46 inches; olive gray (5Y 5/2) clay loam; common fine distinct olive brown (2.5Y 4/4) mottles; weak fine prismatic structure parting to weak very fine subangular blocky; friable; few fine dark accumulations of oxide; few fine soft calcium carbonate accumulations; mildly alkaline; abrupt smooth boundary.

IIC1g—46 to 53 inches; olive gray (5Y 5/2) clay loam; common fine distinct olive brown (2.5Y 4/4) mottles; weak fine prismatic structure parting to weak very fine subangular blocky; friable; few medium reddish accumulations of oxide; strong effervescence; moderately alkaline; clear smooth boundary.

IIC2g—53 to 60 inches; olive gray (5Y 5/2) and light olive gray (5Y 6/2) clay loam; many medium distinct light olive brown (2.5Y 5/6) mottles; friable; common medium dark accumulations of oxide; light gray threads of calcium carbonate; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 24 to 48 inches. The thickness of the mollic epipedon ranges from 18 to 24 inches.

The A horizon is slightly acid or neutral. The Ap and A12 horizons have hue of N or 10YR, value of 2, and chroma of 0 or 1. The A3 horizon has hue of 5Y or 10YR, value of 2 or 3, and chroma of 1.

The B horizon has hue of 5Y or 2.5Y, value of 3 to 5, and chroma of 1 or 2. It is silty clay loam or clay loam. The C horizon dominantly has hue of 5Y or 2.5Y, value of 4 or 5, and chroma of 1 or 2. In some pedons, however, it has chroma of 3 to 6 in part of the matrix.

Lester series

The Lester series consists of well drained, moderately permeable soils on convex slopes in the uplands. These soils formed in calcareous loam glacial till. Slope ranges from 2 to 6 percent.

Lester soils are similar to Clarion soils and are commonly adjacent to those soils. Clarion soils do not have an A2 horizon and contain less clay in the B horizon than the Lester soils. Their position on the landscape is similar to that of the Lester soils.

Typical pedon of Lester loam, 2 to 6 percent slopes, 1,140 feet east and 480 feet south of the center of sec. 5, T. 86 N., R. 34 W.

A1—0 to 5 inches; very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; weak fine granular and weak very fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

A21—5 to 8 inches; very dark gray (10YR 3/1) loam, grayish brown (10YR 5/2) dry; common fine faint dark grayish brown (10YR 4/2) mottles; weak thin platy structure parting to weak fine granular and weak very fine subangular blocky; friable; slightly acid; clear smooth boundary.

A22—8 to 11 inches; dark grayish brown (10YR 4/2) loam, light brownish gray (10YR 6/2) dry; very dark gray (10YR 3/1) coatings on faces of peds; weak thin platy structure parting to weak fine granular and weak very fine subangular blocky; friable; medium acid; clear smooth boundary.

B1t—11 to 14 inches; dark yellowish brown (10YR 4/4) clay loam; brown (10YR 4/3) coatings on faces of peds and, when dry, many gray (5Y 6/1) coatings; moderate fine and very fine subangular blocky structure; friable; medium acid; abrupt smooth boundary.

B21t—14 to 22 inches; dark yellowish brown (10YR 4/4) clay loam; dark brown (10YR 3/3) coatings on faces of peds and, when dry, many light gray (5Y 7/2) coatings; strong fine subangular blocky structure; firm; medium acid; clear smooth boundary.

B22t—22 to 35 inches; dark yellowish brown (10YR 4/4) clay loam; many moderately thick coatings on faces of peds, light gray (5Y 7/2) dry; moderate medium prismatic structure parting to strong fine subangular blocky; firm; dark brown (7.5YR 3/2) iron segregations; medium acid; clear smooth boundary.

B3—35 to 43 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) clay loam; thick dark brown (7.5YR 3/2) coatings on faces of peds; moderate coarse prismatic structure parting to weak medium subangular blocky; firm; few fine dark and reddish accumulations of oxide; thick black (5YR 2/1) coatings on faces of prisms; mildly alkaline; abrupt smooth boundary.

C1—43 to 56 inches; light olive brown (2.5Y 5/6) loam; few dark brown (7.5YR 3/2) coatings on faces of peds; few medium distinct grayish brown (2.5Y 5/2) mottles; weak fine prismatic structure parting to weak medium subangular blocky; friable; many light gray calcium carbonate accumulations; few fine

reddish and many fine dark accumulations of oxide; strong effervescence; moderately alkaline; diffuse smooth boundary.
C2—56 to 60 inches; light olive brown (2.5Y 5/6) loam; few medium distinct olive gray (5Y 5/2) mottles; weak fine prismatic structure parting to weak medium subangular blocky; friable; few fine dark and reddish accumulations of oxide; few threads of calcium carbonate; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 20 to 48 inches. The mollic colors extend to a depth of 7 to 10 inches.

The A horizon is loam or silt loam. The A1 horizon has value of 2 or 3 and chroma of 1 or 2. The A2 horizon has value of 3 to 5 and chroma of 1 or 2.

The B horizon has chroma of 3 to 5 in the upper part and hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 3 or 4 in the lower part. It is clay loam or loam. The C horizon has value of 4 to 6 and chroma of 3 to 6. It is loam or clay loam.

Millington series

The Millington series consists of poorly drained, moderately permeable soils on flood plains. These soils formed in dark stratified alluvium. Slope ranges from 0 to 2 percent.

Millington soils are similar to Coland soils and are commonly adjacent to Coland and Spillville soils. Coland soils are not stratified. They typically have a lower content of sand than the Millington soils. Spillville soils are moderately well drained and somewhat poorly drained. They are not stratified. Their position on the landscape is similar to that of the Millington soils.

Typical pedon of Millington loam, channeled, 0 to 2 percent slopes, 700 feet west and 850 feet south of the center of sec. 36, T. 86 N., R. 34 W.

A11—0 to 11 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure; friable; slight effervescence; mildly alkaline; gradual smooth boundary.
A12—11 to 27 inches; black (10YR 2/1) sandy loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure; very friable; slight effervescence; mildly alkaline; gradual smooth boundary.
B2—27 to 48 inches; very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure; friable; slight effervescence; mildly alkaline; gradual smooth boundary.
C1—48 to 56 inches; very dark grayish brown (10YR 3/2) loam, gray (10YR 5/1) dry; weak fine subangular blocky structure; very friable; slight effervescence; moderately alkaline; gradual smooth boundary.
C2—56 to 60 inches; very dark grayish brown (10YR 3/2) sandy loam, grayish brown (10YR 5/2) dry; massive; very friable; slight effervescence; moderately alkaline.

The thickness of the solum ranges from 36 to 50 inches. The A horizon has value of 2 or 3 and chroma of 1 or 2. It is loam, sandy loam, or silt loam. The C horizon has value of 3 or 4 and chroma of 1 or 2. It is stratified loam, silt loam, and sandy loam.

Nicollet series

The Nicollet series consists of somewhat poorly drained, moderately permeable soils on uplands. These soils formed in calcareous loam or clay loam glacial till. Slope ranges from 1 to 3 percent.

Nicollet soils are similar to Clarion soils and are commonly adjacent to Clarion and Webster soils. Clarion soils are well drained and are on the steeper slopes. Webster soils are poorly drained and are in broad flat areas or in drainageways.

Typical pedon of Nicollet loam, 1 to 3 percent slopes, 260 feet west and 210 feet north of the southeast corner of sec. 25, T. 88 N., R. 32 W.

Ap—0 to 9 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; cloddy; friable; neutral; abrupt smooth boundary.
A12—9 to 16 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak fine and very fine subangular blocky structure; friable; neutral; gradual smooth boundary.
A3—16 to 23 inches; very dark grayish brown (10YR 3/2) clay loam, dark grayish brown (10YR 4/2) dry; very dark gray (10YR 3/1) and black (10YR 2/1) coatings on faces of peds; weak fine and very fine subangular blocky structure; friable; neutral; clear smooth boundary.
B1—23 to 29 inches; dark grayish brown (2.5Y 4/2) clay loam; few discontinuous very dark gray (10YR 3/1) and dark gray (10YR 4/1) coatings on faces of peds; few fine distinct yellowish brown (10YR 5/6) mottles; weak very fine subangular blocky structure; friable; neutral; clear smooth boundary.
B2—29 to 38 inches; grayish brown (2.5Y 5/2) clay loam; common fine distinct yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6) mottles; weak fine subangular blocky structure; friable; few fine dark and reddish accumulations of oxide; neutral; clear smooth boundary.
C1—38 to 53 inches; olive gray (5Y 5/2) clay loam; common fine prominent yellowish brown (10YR 5/8) mottles; weak fine and very fine subangular blocky structure; friable; few fine dark and reddish accumulations of oxide; few fine soft calcium carbonate accumulations; strong effervescence; moderately alkaline; gradual smooth boundary.
C2—53 to 60 inches; olive gray (5Y 5/2) clay loam; many medium prominent yellowish brown (10YR

5/8) mottles; massive; friable; few fine dark and reddish accumulations of oxide; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 20 to 48 inches. The thickness of the mollic epipedon ranges from 12 to 24 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is loam or clay loam. The B2 horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 to 4. It is loam or clay loam. It is slightly acid or neutral. The C horizon has hue of 2.5Y or 5Y, value of 5, and chroma of 2 to 4.

Okoboji series

The Okoboji series consists of very poorly drained, moderately slowly permeable soils on till plains. These soils formed in silty glacial sediments. Slope is 0 to 1 percent.

Okoboji soils are similar to Knoke and Wacousta soils and are commonly adjacent to Canisteo and Harps soils at the slightly higher elevations. Canisteo and Harps soils are calcareous. Their mollic epipedon is thinner than that of the Okoboji soils. Knoke soils are calcareous. Wacousta soils have a mollic epipedon that is less than 20 inches thick.

Typical pedon of Okoboji silty clay loam, 0 to 1 percent slopes, 950 feet south and 81 feet east of the northwest corner of sec. 24, T. 89 N., R. 34 W.

Ap—0 to 8 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak fine granular and weak very fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

A12—8 to 22 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak very fine subangular blocky structure; friable; shiny faces on peds; mildly alkaline; diffuse smooth boundary.

B2g—22 to 45 inches; black (5Y 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak very fine subangular blocky structure; friable; mildly alkaline; diffuse smooth boundary.

C1g—45 to 56 inches; black (5Y 2/1) silty clay loam, gray (10YR 5/1) dry; very few fine distinct olive gray (5Y 5/2) mottles; weak fine prismatic structure parting to weak fine subangular blocky; strong effervescence; moderately alkaline; abrupt smooth boundary.

C2g—56 to 60 inches; black (5Y 2/1) and light gray (5Y 6/1) silty clay loam; common fine prominent light olive brown (2.5Y 5/6) mottles; massive; friable; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 40 to 60 inches. The depth to carbonates ranges from 20 to 50 inches.

The A horizon is silty clay loam, silt loam, or mucky silt loam. The C horizon dominantly is silty clay loam, but it is silt loam or loam in some pedons.

Okoboji mucky silt loam, 0 to 1 percent slopes, is a taxadjunct to the Okoboji series because it is slightly acid to strongly acid in the upper 18 to 24 inches. This difference, however, does not alter the use or behavior of the soil.

Ottosen series

The Ottosen series consists of somewhat poorly drained, moderately slowly permeable soils on knolls in the uplands. These soils formed in moderately fine textured glaciofluvial deposits over glacial till. Slope ranges from 1 to 3 percent.

Ottosen soils are similar to Nicollet soils and are commonly adjacent to Bode and Kossuth soils. Bode soils are on the slightly higher parts of the landscape and are well drained. Kossuth soils are on the slightly lower parts of the landscape and are poorly drained. Nicollet soils are not so fine textured as the Ottosen soils and formed entirely in glacial till.

Typical pedon of Ottosen silty clay loam, 1 to 3 percent slopes, 100 feet south and 1,120 feet east of the northwest corner of sec. 25, T. 86 N., R. 31 W.

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

A12—8 to 14 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak fine granular and very fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

A3—14 to 20 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine prismatic structure parting to weak fine subangular blocky; friable; slightly acid; clear smooth boundary.

B1—20 to 25 inches; dark grayish brown (10YR 4/2) silty clay loam; few fine faint light yellowish brown (2.5Y 6/4) mottles; weak fine prismatic structure parting to weak fine subangular blocky; firm; common fine reddish accumulations of oxide; slightly acid; clear smooth boundary.

B21—25 to 30 inches; dark grayish brown (2.5Y 4/2) silty clay loam; olive gray (5Y 4/2) coatings on faces of peds; few fine faint olive (5Y 5/4) mottles; weak fine and medium prismatic structure parting to weak fine subangular blocky; firm; common fine reddish accumulations of oxide; slightly acid; abrupt smooth boundary.

B22—30 to 34 inches; dark grayish brown (2.5Y 4/2) clay loam; olive gray (5Y 4/2) coatings on faces of peds; few fine faint olive gray (5Y 5/2) and reddish brown (5YR 4/4) mottles; weak very fine and fine subangular blocky structure; friable; common fine reddish and dark accumulations of oxide; slightly acid; clear smooth boundary.

B3—34 to 48 inches; dark grayish brown (2.5Y 4/2) clay loam; common medium distinct olive gray (5Y 5/2) mottles; massive; friable; common fine reddish and dark accumulations of oxide; neutral; abrupt smooth boundary.
C1—48 to 60 inches; olive gray (5Y 5/2) clay loam; common medium prominent reddish brown (5YR 5/4) and yellowish red (5YR 5/6) mottles; massive; friable; many fine reddish and dark accumulations of oxide; slight effervescence; mildly alkaline.

The thickness of the solum and the depth to free carbonates range from 24 to 50 inches. The thickness of the mollic epipedon ranges from 12 to 24 inches.

The A horizon is silty clay loam or clay loam. It is black (10YR 2/1 or N 2/0) in the upper part. The A3 horizon is black or very dark grayish brown (10YR 2/1, 10YR 3/2, or 2.5Y 3/2). The upper part of the B horizon has hue of 10YR or 2.5Y. It is silty clay loam or clay loam. It is slightly acid or neutral. The lower part has value of 4 or 5 and chroma of 2 to 4. The C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 2 to 4.

Rolfe series

The Rolfe series consists of very poorly drained, slowly permeable soils in depressions in the uplands. These soils formed in glacial drift and local loamy alluvium. Slope is 0 to 1 percent.

Rolfe soils are similar to Okoboji, Wacousta, and Webster soils and are commonly adjacent to Nicollet and Webster soils. Nicollet soils are at higher elevations than the Rolfe soils and are somewhat poorly drained. Okoboji, Wacousta, and Webster soils do not have a gray A2 horizon or a distinct argillic horizon. Webster soils are at the slightly higher elevations.

Typical pedon of Rolfe silt loam, 0 to 1 percent slopes, 970 feet west and 670 feet south of the center of sec. 17, T. 86 N., R. 34 W.

A1—0 to 8 inches; black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; weak fine granular and very fine subangular blocky structure; friable; slightly acid; clear smooth boundary.
A21—8 to 18 inches; dark gray (10YR 4/1) silt loam, light gray (10YR 6/1) dry; weak thin platy and weak fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.
A22—18 to 21 inches; dark gray (10YR 4/1) silt loam, gray (10YR 5/1) dry; weak thin platy structure parting to moderate fine subangular and angular blocky; friable; slightly acid; abrupt smooth boundary.
B21tg—21 to 26 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; black (10YR 2/1) coatings on faces of peds; moderate very fine subangular blocky structure; very firm; many fine dark reddish and few fine dark accumulations of oxide; thick clay films on faces of peds; slightly acid; clear smooth boundary.
B22tg—26 to 32 inches; dark gray (5Y 4/1) silty clay, gray (10YR 5/1) dry; common fine distinct olive brown (2.5Y 4/4) mottles; moderate fine prismatic structure parting to moderate very fine subangular blocky; firm; thick clay films on faces of peds; common fine reddish and few fine dark accumulations of oxide; slightly acid; clear smooth boundary.
B23tg—32 to 44 inches; dark gray (5Y 4/1) and olive gray (5Y 5/2) clay loam, grayish brown (10YR 5/2) dry; many medium strong brown (7.5YR 5/6) mottles; moderate fine prismatic structure parting to moderate fine subangular and angular blocky; firm; few fine dark and few medium reddish accumulations of oxide; thick clay films on faces of prisms and peds; neutral; clear smooth boundary.
B3tg—44 to 60 inches; gray (5Y 5/1) and olive gray (5Y 5/2) clay loam; weak fine prismatic structure parting to weak fine subangular blocky; friable; thick black coatings in root channels and pores; few medium reddish and few fine dark accumulations of oxide; thin discontinuous clay films on faces of prisms; slight effervescence; moderately alkaline.

The depth to carbonates ranges from 42 to 60 inches. The A1 horizon has value of 2 or 3. It is silt loam, loam, or silty clay loam. The A2 horizon dominantly has value of 4 to 6, but in some pedons it has value of 3 and has lighter colored coatings. It is silt loam or loam. The B2 horizon has hue of 10YR or 5Y, value of 3 to 6, and chroma of 1 or 2. It is silty clay loam, silty clay, or clay loam. It is slightly acid or neutral. Some pedons have a C horizon of loam or clay loam.

Spillville series

The Spillville series consists of moderately well drained and somewhat poorly drained, moderately permeable soils on bottom land. These soils formed in medium textured alluvium in which the content of sand is 20 to 45 percent. Slope ranges from 0 to 5 percent.

Spillville soils are similar to Terril soils and are commonly adjacent to Coland and Terril soils. Coland soils are poorly drained and are on the lower flood plains. Terril soils are on the slightly higher parts of the landscape. They have chroma of 3 within a depth of 40 inches. Also, their A horizon is thinner than that of the Spillville soils.

Typical pedon of Spillville loam, 0 to 2 percent slopes, 1,120 feet north and 700 feet east of the southwest corner of sec. 14, T. 86 N., R. 34 W.

A11—0 to 9 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak fine granular and weak very fine subangular blocky structure; friable; neutral; gradual smooth boundary.

A12—9 to 25 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak fine granular and weak very fine subangular blocky structure; friable; neutral; gradual smooth boundary.
A13—25 to 34 inches; very dark gray (10YR 3/1) loam, gray (10YR 5/1) dry; weak fine granular and weak very fine subangular blocky structure; friable; neutral; gradual smooth boundary.
C1—34 to 60 inches; very dark gray (10YR 3/1) loam, grayish brown (10YR 5/2) dry; weak very fine subangular blocky structure; friable; neutral.

The thickness of the solum ranges from 30 to 56 inches. The depth to free carbonates typically is 4 feet or more. The thickness of the mollic epipedon ranges from 36 to more than 60 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is loam or silt loam. The C horizon has value of 3 or 4 and chroma of 1 or 2.

Storden series

The Storden series consists of well drained, moderately permeable soils. These soils formed in calcareous loam glacial till of the Late Wisconsin age. They are on glacial moraines. Slope ranges from 5 to 40 percent.

Storden soils are similar to Clarion soils and are commonly adjacent to Clarion and Terril soils. The surface layer of Clarion soils is darker than that of the Storden soils. Also, it is not calcareous. Terril soils are noncalcareous to a depth of 40 inches or more. They are on slopes below the Storden soils.

Typical pedon of Storden loam, 9 to 14 percent slopes, moderately eroded, 880 feet north and 1,790 feet west of the southeast corner of sec. 17, T. 86 N., R. 34 W.

Ap1—0 to 3 inches; mixed very dark grayish brown (10YR 3/2) and yellowish brown (10YR 5/4) loam, dark grayish brown (10YR 4/2) dry; weak fine granular and weak very fine and fine subangular blocky structure; friable; strong effervescence; moderately alkaline; abrupt smooth boundary.
Ap2—3 to 6 inches; yellowish brown (10YR 5/4 and 5/6) loam, light yellowish brown (10YR 6/4) and pale brown (10YR 6/3) dry; dark grayish brown (10YR 4/2) coatings on faces of peds; weak fine granular and weak very fine and fine subangular blocky structure; friable; strong effervescence; moderately alkaline; abrupt smooth boundary.
C1—6 to 18 inches; light olive brown (2.5Y 5/4 and 5/6) loam; weak fine granular and weak very fine and fine subangular blocky structure; friable; common fine soft calcium carbonate accumulations; few very fine dark accumulations of oxide; strong effervescence; moderately alkaline; gradual smooth boundary.
C2—18 to 38 inches; mixed light olive brown (2.5Y 5/4 and 5/6) and light yellowish brown (2.5Y 6/4) loam; massive; friable; common fine dark and few fine reddish accumulations of oxide; few fine threads of calcium carbonate; slightly stratified; strong effervescence; moderately alkaline; gradual smooth boundary.
C3—38 to 60 inches; mixed yellowish brown (10YR 5/6) and light olive brown (2.5Y 5/4 and 5/6) loam, light olive brown (2.5Y 5/4) kneaded; common medium distinct olive gray (5Y 5/2) mottles; massive; friable; many fine dark and few medium reddish accumulations of oxide; common fine soft calcium carbonate accumulations; stratified; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 6 to 10 inches. The Ap horizon has value of 3 to 5 and chroma of 2 to 6. It typically is about 6 inches thick but in some pedons is as thick as 9 inches. The C horizon ranges from dark yellowish brown (10YR 4/4) to light yellowish brown (2.5Y 6/4).

Talcot series

The Talcot series consists of poorly drained, calcareous soils that are moderately permeable in the solum and rapidly permeable in the substratum. These soils are on benches. They formed in medium textured and moderately fine textured outwash or lacustrine sediments over sand and gravel. Slope ranges from 0 to 2 percent.

Talcot soils are similar to Biscay soils and are commonly adjacent to Biscay and Cylinder soils. Biscay soils have a slightly acid or neutral solum. Their positions on the landscape are similar to those of the Talcot soils. Cylinder soils are somewhat poorly drained and are on the higher parts of the landscape.

Typical pedon of Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, 800 feet south and 820 feet east of the northwest corner of sec. 9, T. 87 N., R. 34 W.

Ap—0 to 7 inches; black (N 2/0) clay loam, black (10YR 2/1) dry; weak fine subangular blocky structure; friable; common fine bits of snail shells; strong effervescence; moderately alkaline; abrupt smooth boundary.
A12—7 to 11 inches; black (N 2/0) clay loam, black (10YR 2/1) dry; weak very fine and fine subangular blocky structure; friable; common fine bits of snail shells; strong effervescence; moderately alkaline; gradual smooth boundary.
A3—11 to 15 inches; black (N 2/0) clay loam, black (10YR 2/1) dry; fine faint dark olive gray (5Y 3/2) mottles; weak very fine and fine subangular blocky structure; friable; common fine dark accumulations of oxide; slight effervescence; moderately alkaline; gradual smooth boundary.

B1g—15 to 21 inches; very dark gray (5Y 3/1) and olive (5Y 4/4) clay loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure; friable; common fine dark accumulations of oxide; strong effervescence; moderately alkaline; clear smooth boundary.
B21g—21 to 27 inches; dark gray (5Y 4/1) loam, olive (5Y 5/3) dry; common fine olive gray (5Y 5/2) mottles; weak fine prismatic structure parting to weak fine subangular blocky; friable; fine calcium carbonate filaments; common fine dark accumulations of oxide; violent effervescence; moderately alkaline; clear smooth boundary.
B22g—27 to 36 inches; olive gray (5Y 5/2) and gray (5Y 5/1) gravelly sandy loam; common fine light olive brown (2.5Y 5/4) mottles; weak fine subangular blocky structure; very friable; many fine calcium carbonate filaments; many fine dark accumulations of oxide; violent effervescence; moderately alkaline; clear smooth boundary.
B3g—36 to 39 inches; olive gray (5Y 5/2) gravelly sandy loam; many medium distinct brown (7.5YR 4/4) mottles; weak fine subangular blocky structure; very friable; many fine dark accumulations of oxide; violent effervescence; moderately alkaline; abrupt smooth boundary.
IIC1g—39 to 48 inches; olive gray (5Y 5/2) gravelly coarse sand; single grained; loose; strong effervescence; moderately alkaline; clear smooth boundary.
IIC2g—48 to 60 inches; olive gray (5Y 4/2) gravelly coarse sand; single grained; loose; strong effervescence; moderately alkaline.

The thickness of the solum, or the depth to sand and gravel, ranges from 32 to 40 inches. The thickness of the mollic epipedon ranges from 14 to 24 inches.

The A1 horizon is silty clay loam or clay loam. The B2 horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. It is silty clay loam, clay loam, loam, sandy loam, or gravelly sandy loam. The C horizon has hue of 2.5Y or 5Y, value of 4 to 6, and chroma of 2 to 6. It is gravelly sand or gravelly coarse sand. It commonly is stratified.

Terril series

The Terril series consists of moderately well drained, moderately permeable soils on upland foot slopes and convex alluvial fans. These soils formed in local loamy alluvium derived from glacial till. Slope ranges from 1 to 5 percent.

Terril soils are similar to Spillville soils and are commonly adjacent to Spillville and Storden soils. Spillville soils are slightly lower on the landscape than the Terril soils. Also, they have lower chroma in the lower part of the control section. Storden soils are well drained and are in the steeper areas upslope from the Terril soils. They are calcareous throughout.

Typical pedon of Terril loam, 1 to 5 percent slopes, 720 feet east and 65 feet south of the northwest corner of sec. 17, T. 86 N., R. 34 W.

Ap—0 to 7 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine granular and weak very fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.
A12—7 to 15 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine granular and weak very fine subangular blocky structure; friable; slightly acid; clear smooth boundary.
A3—15 to 23 inches; very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) loam, very dark grayish brown (10YR 3/2) dry; weak fine granular and weak very fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.
B21—23 to 45 inches; dark brown (10YR 3/3) loam; brown (10YR 4/3) coatings on faces of peds; weak fine subangular blocky structure; friable; neutral; clear smooth boundary.
B22—45 to 54 inches; brown (10YR 4/3) and dark yellowish brown (10YR 4/4) loam; few medium faint light yellowish brown (2.5Y 6/4) mottles; weak fine subangular blocky structure; friable; faint coatings on faces of peds; few very fine dark accumulations of oxide; neutral; clear smooth boundary.
B3—54 to 60 inches; dark yellowish brown (10YR 4/4) clay loam; weak medium subangular blocky structure; friable; common fine dark and reddish accumulations of oxide; neutral.

The thickness of the solum ranges from 36 to 60 inches or more. The A1 horizon has value of 2 or 3 and chroma of 1 or 2. It is loam, silt loam, or clay loam. The B2 horizon has chroma of 3 or 4. It is loam or clay loam. It is neutral or slightly acid.

Wacousta series

The Wacousta series consists of very poorly drained, moderately permeable soils in upland depressions. These soils formed in glacial sediments. Slope is 0 to 1 percent.

Wacousta soils are similar to Okoboji soils and are commonly adjacent to Harps and Okoboji soils. Harps soils are at the slightly higher elevations. They dominantly are loamy throughout. Okoboji soils are in depressions. Their solum is thicker than that of the Wacousta soils.

Typical pedon of Wacousta silty clay loam, 0 to 1 percent slopes, 170 feet north and 1,040 feet west of the southeast corner of sec. 6, T. 87 N., R. 33 W.

Ap—0 to 6 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; neutral; abrupt smooth boundary.
A12—6 to 11 inches; black (N 2/0) silty clay loam, dark gray (10YR 4/1) dry; weak fine granular and weak

very fine subangular blocky structure; friable; neutral; abrupt smooth boundary.
A3—11 to 16 inches; very dark gray (2.5Y 3/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine and very fine subangular blocky structure; friable; common calcium carbonate accumulations; few medium reddish and few fine dark accumulations of oxide; slight effervescence; mildly alkaline; abrupt smooth boundary.
Bg—16 to 24 inches; light olive gray (5Y 6/2) and olive gray (5Y 5/2) silty clay loam; common medium distinct olive brown (2.5Y 4/4) mottles; weak fine subangular blocky structure; friable; common calcium carbonate accumulations; few fine reddish and dark accumulations of oxide; strong effervescence; moderately alkaline; abrupt smooth boundary.
C1g—24 to 32 inches; olive gray (5Y 5/2) silty clay loam; few medium distinct light olive brown (2.5Y 5/4) mottles; weak fine subangular blocky structure; friable; few fine dark accumulations of oxide; violent effervescence; moderately alkaline; clear smooth boundary.
C2g—32 to 37 inches; olive gray (5Y 5/2) silty clay loam; massive; friable; few fine dark accumulations of oxide; violent effervescence; moderately alkaline; abrupt smooth boundary.
C3g—37 to 43 inches; olive gray (5Y 5/2) clay loam; common medium prominent olive brown (2.5Y 4/4) mottles; massive; friable; common calcium carbonate accumulations; few fine dark and reddish accumulations of oxide; violent effervescence; moderately alkaline; abrupt smooth boundary.
C4g—43 to 48 inches; olive gray (5Y 5/2) clay loam; common medium prominent light olive brown (2.5Y 5/4) mottles; massive; friable; common fine reddish and few fine dark accumulations of oxide; violent effervescence; moderately alkaline; abrupt smooth boundary.
C5g—48 to 60 inches; gray (5Y 5/1) loam; common coarse prominent light olive brown (2.5Y 5/4) mottles; massive; friable; few fine dark and reddish accumulations of oxide; violent effervescence; moderately alkaline.

The thickness of the solum ranges from 10 to 24 inches. The thickness of the mollic epipedon ranges from 8 to 18 inches.

The B horizon has value of 4 to 6 and chroma of 1 or 2. It is neutral to moderately alkaline. The C horizon is clay loam, silt loam, loam, or silty clay loam.

Wacousta Variant

The Wacousta Variant consists of very poorly drained, moderately permeable soils in upland depressions. These soils formed in glacial sediments. Slope is 0 to 1 percent.

Wacousta Variant soils are similar to Wacousta soils and are adjacent to Okoboji and Wacousta soils. Okoboji soils are in the smaller swales. Their solum is thicker than that of the Wacousta Variant soils. Wacousta soils are noncalcareous.

Typical pedon of Wacousta Variant silty clay loam, 0 to 1 percent slopes, 2,520 feet south and 1,050 feet west of the northeast corner of sec. 5, T. 88 N., R. 33 W.

Ap—0 to 8 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak fine subangular blocky structure; friable; few snail shells; strong effervescence; moderately alkaline; abrupt smooth boundary.
B2—8 to 14 inches; dark olive gray (5Y 3/2) and olive gray (5Y 4/2) silty clay loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure; friable; many snail shells; strong effervescence; moderately alkaline; abrupt smooth boundary.
C1—14 to 19 inches; grayish brown (2.5Y 5/2) and light brownish gray (2.5Y 6/2) silty clay loam; massive; friable; many calcium carbonate accumulations; strong effervescence; moderately alkaline; abrupt smooth boundary.
C2—19 to 24 inches; grayish brown (2.5Y 5/2) loam; massive; friable; few accumulations of iron oxide; strong effervescence; moderately alkaline; abrupt smooth boundary.
C3—24 to 31 inches; grayish brown (2.5Y 5/2) loam; massive; friable; strong effervescence; moderately alkaline; abrupt smooth boundary.
C4—31 to 37 inches; olive gray (5Y 4/2) silty clay loam; few fine distinct light olive brown (2.5Y 5/6) mottles; massive; friable; many small pebbles; few accumulations of iron oxide; many calcium carbonate accumulations; strong effervescence; moderately alkaline; abrupt smooth boundary.
C5—37 to 58 inches; olive gray (5Y 5/2) silty clay loam; many medium distinct light olive brown (2.5Y 5/6) mottles; massive; friable; few accumulations of iron oxide; many calcium carbonate accumulations; strong effervescence; moderately alkaline; abrupt smooth boundary.
C6—58 to 60 inches; olive gray (5Y 5/2) clay loam; massive; friable; many small pebbles; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 10 to 24 inches. The mollic colors extend to a depth of 8 to 18 inches.

The Ap or A1 horizon has hue of N, 10YR, or 2.5Y and chroma of 0 or 1. The B horizon has value of 3 to 6 and chroma of 1 or 2. The C horizon has hue of 2.5Y or 5Y, value of 4 to 6, and chroma of 1 or 2. It is silt loam, silty clay loam, clay loam, or loam.

Wadena series

The Wadena series consists of well drained soils that are moderately permeable in the upper part and very rapidly permeable in the lower part of the subsoil and in the substratum. These soils generally are on stream benches. They formed in medium textured sediments and in the underlying calcareous sand and gravel. Slope ranges from 0 to 9 percent.

Wadena soils are similar to Estherville soils and are commonly adjacent to Cylinder and Estherville soils. Cylinder soils are somewhat poorly drained and are in the lower swales. Estherville soils are somewhat excessively drained and are on the lower side slopes. Their B2 horizon is loam or sandy loam in which the content of clay is less than 18 percent.

Typical pedon of Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes, 240 feet south and 1,870 feet east of the northwest corner of sec. 21, T. 86 N., R. 34 W.

A1—0 to 8 inches; very dark brown (10YR 2/2) loam, very dark grayish brown (10YR 3/2) dry; weak fine granular and weak very fine subangular blocky structure; friable; neutral; clear smooth boundary.
A3—8 to 13 inches; very dark grayish brown (10YR 3/2) loam, brown (10YR 4/3) dry; very dark brown (10YR 2/2) coatings on faces of peds; weak fine granular and weak very fine subangular blocky structure; friable; neutral; clear smooth boundary.
B1—13 to 18 inches; dark brown (10YR 3/3) loam, brown (10YR 5/3) dry; very dark grayish brown (10YR 3/2) coatings on faces of peds; weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.
B21—18 to 26 inches; brown (10YR 4/3) loam; weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.
B22—26 to 30 inches; brown (10YR 4/3) loam; weak fine subangular blocky structure; friable; many small pebbles; neutral; clear smooth boundary.
IIB3—30 to 40 inches; dark yellowish brown (10YR 3/4) loamy coarse sand; single grained; very friable; weakly cemented at a depth of 38 to 40 inches; neutral; clear smooth boundary.
IIC2—40 to 60 inches; grayish brown (10YR 5/2) sand and gravel; single grained; loose; strong effervescence; moderately alkaline.

The thickness of the solum, or the depth to sand and gravel, ranges from 24 to 40 inches. The thickness of the mollic epipedon ranges from 12 to 20 inches.

The A1 horizon has value of 2 or 3 and chroma of 1 or 2. The B2 horizon has hue of 7.5YR or 10YR and value and chroma of 3 to 5. It is loam or clay loam. It is slightly acid or neutral. The IIB horizon is loamy coarse sand, loamy sand, coarse sandy loam, or sandy loam. The IIC horizon has value of 4 to 6 and chroma of 2 to 4. It is coarse sand or sand and gravel.

Webster series

The Webster series consists of poorly drained, moderately permeable soils on uplands. These soils formed in glacial till of mixed mineralogy and in local alluvium derived from the till. Slope ranges from 0 to 2 percent.

Webster soils are similar to Canisteo soils and are commonly adjacent to Canisteo, Clarion, Nicollet, Okoboji, and Wacousta soils. Canisteo soils are calcareous throughout. Their position on the landscape is similar to that of the Webster soils. Clarion and Nicollet soils do not have a gleyed B horizon. They are at the slightly higher elevations. Okoboji soils are in depressions. They typically contain less sand in the solum than the Webster soils. Also, their A horizon is thicker. Wacousta soils are in depressions. They typically have an abrupt boundary between the A and B horizons. Also, the A horizon is thinner than that of the Webster soils.

Typical pedon of Webster silty clay loam, 0 to 2 percent slopes, 700 feet north and 400 feet west of the southeast corner of sec. 9, T. 89 N., R. 34 W.

Ap—0 to 8 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; cloddy; friable; neutral; abrupt smooth boundary.
A12—8 to 12 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak fine granular and weak very fine subangular blocky structure; friable; neutral; clear smooth boundary.
A3—12 to 19 inches; very dark gray (5Y 3/1) clay loam, dark gray (10YR 4/1) dry; common fine distinct olive gray (5Y 4/2) mottles; weak fine granular and weak very fine subangular blocky structure; friable; mildly alkaline; clear smooth boundary.
B1g—19 to 23 inches; very dark gray (5Y 3/1) clay loam, gray (10YR 5/1) dry; common fine distinct olive gray (5Y 4/2) and few fine distinct olive gray (5Y 5/2) mottles; weak very fine and fine subangular blocky structure; friable; mildly alkaline; clear smooth boundary.
B2g—23 to 29 inches; dark gray (5Y 4/1) and olive gray (5Y 4/2) clay loam; few fine faint olive (5Y 4/3) mottles; weak fine prismatic structure parting to weak very fine and fine subangular blocky; friable; few fine dark accumulations of oxide; mildly alkaline; abrupt smooth boundary.
B3g—29 to 37 inches; olive gray (5Y 5/2) clay loam; common fine distinct light olive brown (2.5Y 5/4) mottles; weak fine prismatic structure; friable; common medium soft calcium carbonate accumulations; few fine dark and reddish accumulations of oxide; slight effervescence; mildly alkaline; clear smooth boundary.
C1g—37 to 57 inches; olive gray (5Y 5/2) and dark gray (5Y 4/1) clay loam; common medium prominent yellowish brown (10YR 5/8) mottles; massive;

friable; few medium soft calcium carbonate accumulations; common fine dark and few large reddish accumulations of oxide; strong effervescence; moderately alkaline; clear smooth boundary.

C2g—57 to 60 inches; olive gray (5Y 5/2) loam; many large prominent yellowish brown (10YR 5/8) mottles; massive; friable; few medium soft calcium carbonate accumulations; common medium reddish and dark accumulations of oxide; slight stratification; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 24 to 50 inches. The thickness of the mollic epipedon ranges from 14 to 24 inches.

The A1 horizon is silty clay loam or clay loam. The B2 and B3 horizons have hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. They are silty clay loam or clay loam. They are neutral or mildly alkaline.

factors of soil formation

Soil forms through processes that act on deposited or accumulated geologic material. The characteristics of the soil at any given point are determined by the physical and mineralogical composition of the parent material, the climate during and after the accumulation of the soil material, the plant and animal life on and in the soil, the relief, and the length of time that the forces of soil formation have acted on the soil material. Human activities also affect soil formation.

Climate and plant and animal life, chiefly plants, are active factors of soil formation. They act on the parent material that has accumulated through the weathering of rocks and slowly change it into a natural body that has genetically related horizons. The effects of climate and plants are conditioned by relief. The parent material affects the kind of soil profile that forms and, in extreme cases, determines it almost entirely. Finally, time is needed for changing the parent material into a soil. Generally, a long period is needed for the formation of distinct horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the other four.

parent material

The accumulation of parent material is the first step in the formation of a soil. Most of the soils in the county formed in material transported from other locations and deposited through the action of glacial ice, water, wind, or gravity. The principal parent materials are glacial drift, alluvium, and, to a lesser extent, lacustrine deposits.

Calhoun County was subject to three stages of glaciation—the Nebraskan, the Kansan, and the Wisconsin. Many of the soils in the county formed mainly in glacial till deposited by the most recent of these, the Wisconsin Glaciation. The county is near the center of the Des Moines lobe of this glaciation. The glacial till in this lobe was deposited by the Cary substage of this glaciation (*5,6,8*). Radiocarbon dates from the base of the till in the southern part of the lobe indicate that this deposition occurred about 13,000 to 14,000 years ago. The youth of the Cary substage also is indicated by a poorly developed surface drainage system and by numerous closed depressions.

Glacial drift is all rock material transported and deposited by glacial ice, including the material sorted by melt water. It includes glacial till, glacial sediments, and glacial outwash. Glacial till is unsorted sediment in which particles range in size from boulders to clay (*5*). It is the most extensive parent material in the county. Glacial sediments are the loamy materials that have been sorted to some extent by water (*13,14*). The fact that these sediments are in potholes or other low lying areas indicates that some of the sorting and deposition has occurred since the time of glaciation as well as during the ice age. Glacial outwash is the sandy and gravelly material sorted out by glacial melt water and deposited in valleys or other areas where water was concentrated.

Clarion, Lester, Nicollet, and Storden soils formed in glacial till. Canisteo, Harps, and Webster soils, which are in the lower lying areas on the landscape, formed in glacial till and in glacial sediments or reworked glacial till. Okoboji, Rolfe, and Wacousta soils formed in alluvial sediment derived from till that in many places washed in from nearby slopes. Estherville soils formed in loamy material that overlies glacial outwash.

Alluvium is sediment deposited by water along major and minor streams and drainageways and on benches. Calco, Coland, Millington, and Spillville soils formed in alluvium on bottom land that is subject to flooding. The texture of the alluvium varies widely because of differences in the material from which it came and the manner in which it was deposited. Some alluvium has been transported only a short distance and is called local alluvium. Such alluvium retains many characteristics of the soils in the areas from which it eroded. Terril soils formed in local alluvium. They generally are at the base of slopes, below the soils that formed in glacial till. Their texture is similar to that of the soils upslope.

Biscay, Cylinder, Talcot, and Wadena soils formed in loamy alluvium that is underlain by sand and gravel. They are mainly on benches near streams, but some are in low lying upland areas. The material in which these soils formed probably was deposited by the melt water from the receding Cary glacial ice.

The Bode, Kossuth, and Ottosen soils formed in lacustrine sediments and in the underlying glacial till. The lacustrine sediments probably were deposited by the still water of lakes near the margin of the glacial ice, rather than by rapidly moving melt water. They are mainly 24 to about 36 inches deep over the glacial till.

climate

The soils in Calhoun County formed under a variety of climatic conditions (*13*). In the post-Cary glaciation period, 13,000 to 10,500 years ago, the climate was cool and the vegetation was dominantly conifers. During the period beginning about 10,500 years ago and ending about 8,000 years ago, a warming trend changed the vegetation from conifers to mixed hardwoods. Beginning about 8,000 years ago, the climate became warmer and drier and herbaceous prairie vegetation became dominant. Probably about 3,000 years ago, a change from a dry to a more moist climate began (*4*). The soils in the county formed under the influence of this subhumid midcontinental climate.

Because it is nearly uniform throughout the county, the climate has not resulted in major differences among the soils in the survey area. The effect of the climate, however, is modified by local conditions in or near the soil. On south-facing slopes, for example, the temperature is higher and the humidity lower than is typical in nearby areas and on north- and east-facing slopes. As a result, natural stands of trees are more likely to grow well on the north- and east-facing slopes. The poorly drained or very poorly drained soils in low lying areas or depressions are wetter and cooler than the soils in most of the surrounding areas.

Changes in temperature activate the weathering of parent material by water and air. As the parent material weathers, changes caused by physical and chemical actions take place. Rainfall affects the amount of leaching in the soil and the kinds of plants on the soil.

Climate indirectly affects soil formation through the effects of temperature and other climatic factors on the plant and animal life on and in the soil.

relief

Relief is an important factor in soil formation because of its effect on drainage, runoff, depth to the water table, and erosion. Slope ranges from level to very steep in Calhoun County. A difference in topography is the main reason for the differing properties of some of the soils in the county.

Slope affects the thickness and color of the A horizon and the thickness of the solum because of its effect on erosion and the amount of water that runs off the surface and percolates through the soil. For example, it has affected the thickness and color of the A horizon in Storden, Clarion, and Nicollet soils, which formed in similar parent material. The A horizon in the moderately sloping to very steep Storden soils is thinner and lighter in color than that in the gently sloping to strongly sloping Clarion soils and the very gently sloping Nicollet soils. Likewise, Storden soils have a thinner solum and are shallower to carbonates. In soils that have a wide range of slope, such as the gently sloping to strongly sloping Clarion soils, the depth to carbonates and the thickness of the solum decrease as the percentage of slope increases.

Relief affects the color of the B horizon through its effect on drainage and soil aeration. The subsoil of a well drained soil generally is brownish because oxidized iron compounds are well distributed throughout the horizon. Clarion soils are an example. The subsoil of a poorly drained or very poorly drained, poorly aerated soil generally is grayish and mottled. The nearly level, poorly drained Webster soils and the level, very poorly drained Okoboji soils are examples. Nicollet soils are somewhat poorly drained and have a grayish brown B horizon. Their profile characteristics indicate that their drainage class is between that of a well drained soil and that of a poorly drained soil.

plant and animal life

Plant and animal life, chiefly plants, affect soil formation. Soil formation really begins when plants are established. As plants grow and die, they add organic matter to the upper layers of the soil. Native grasses have myriads of fibrous roots that penetrate the soil to a depth of 10 to 20 inches and add large amounts of organic matter to the surface layer. Trees commonly feed on plant nutrients deep in the subsoil. As a result, the surface layer generally accumulates only the organic matter from the decaying fallen leaves and dead trees. Much of this organic matter remains on the surface, where it decomposes.

All living organisms, including vegetation, animals, bacteria, and fungi, affect soil formation. The vegetation chiefly determines the color of the surface layer and the content of organic matter and nutrients in the soil. Earthworms and burrowing animals help to keep the soil open and porous. Bacteria and fungi decompose the vegetation and thereby release plant nutrients.

Most of the soils of Calhoun County formed under prairie grasses or a mixture of prairie grasses and water tolerant plants (*3*). None of the soils formed entirely under forest. Clarion and Nicollet are typical of soils that formed under prairie grasses and Webster and Canisteo of soils that formed under prairie grasses and water tolerant plants. Soils that formed under prairie grasses contain a large amount of organic matter derived from roots and have a thick dark surface layer. Soils that formed under trees have a dark surface layer that generally is less than 5 inches thick and a lighter colored subsurface layer. If these layers are mixed by plowing, the new surface layer is lighter in color than that of prairie soils.

Lester soils have properties both of the soils that formed entirely under prairie grasses and of the soils that formed entirely under forest. They probably formed under prairie grasses and then under forest. The properties generally are those of a true forest soil, but the surface layer is somewhat thicker.

time

Time enables relief, climate, and plant and animal life to change the parent material. If these factors continue to operate for a long period, very similar kinds of soil form in widely different kinds of parent material. Soil formation, however, generally is interrupted by geologic events that expose new parent material. In Calhoun County new parent material was added to the uplands at least four times (*14*). The bedrock was covered by glacial drift from two glaciers, and then loess was deposited. Another glacier subsequently deposited the present surface material.

According to radiocarbon dates from its base in the southern part of the Des Moines lobe, Cary glacial drift was deposited about 14,000 years ago (*5*). Hence, all of the soils that formed in the drift are no more than 14,000 years old. In much of Iowa, including parts of Calhoun County, geologic erosion has beveled and in places removed material from side slopes and deposited new sediments downslope (*7*). The surfaces of nearly level upland divides are older than the slopes that truncate the divides. Thus, the soils on these side slopes, including Clarion and Lester soils, are less than 14,000 years old. Further dating indicates that they are less than 3,000 years old. The sediments washed from the side slopes accumulated downslope as local alluvium. Some of the alluvium at the base of the slopes is less than 3,000 years old (*13*). Coland, Spillville, Terril, and other soils formed in this alluvium.

human activities

Important changes take place in the soil after it is drained and cultivated. Some of these changes have little effect on soil productivity, but others have drastic effects. Changes caused by erosion generally are the most significant. On some of the cultivated soils in the county, particularly the steeper ones, much of the original surface layer has been lost through sheet erosion. Many of the soils, however, have not been affected by erosion, mainly because low relief is common in the county.

Management practices have increased the productivity of some soils and reclaimed areas that otherwise are not suitable for crops. Crops can be grown, for example, in many areas where subsurface drains have sufficiently lowered the water table. Applications of commercial fertilizer have overcome the deficiencies in plant nutrients and thus have increased the productivity of many soils.

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glossary

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Area reclaim (in tables). An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

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	9 to 12
Very high	more than 12

Bench. An old alluvial plain, ordinarily flat or undulating, bordering a river. It is frequently called a second bottom, in contrast with a flood plain, and is seldom subject to overflow.

Bottom land. The normal flood plain of a stream, subject to flooding.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Coarse fragments. If round, mineral or rock particles 2 millimeters to 25 centimeters (10 inches) in diameter; if flat, mineral or rock particles (flagstone) 15.2 to 38.1 centimeters (6 to 15 inches) long.

Coarse textured soil. Sand or loamy sand.

Colluvium. Soil material, rock fragments, or both moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex, soil. A map unit of two or more kinds of soil in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils are somewhat similar in all areas.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

Conservation tillage. A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

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 stripcropping. Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Control section. The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of

the soil profile between depths of 10 inches and 40 or 80 inches.

Corrosive. High risk of corrosion to uncoated steel or deterioration of concrete.

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Deferred grazing. Postponing grazing or resting grazing land for a prescribed period.

Diversion (or diversion terrace). A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Drainage class (natural). Refers to the removal of water from the soil. Drainage classes are determined on the basis of an overall evaluation of water removal as influenced by climate, slope, and position on the landscape. Precipitation, runoff, amount of moisture infiltrating the soil, and rate of water movement through the soil affect the degree and duration of wetness. Seven classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. The soils in this class generally are free of mottles throughout. They commonly are shallow, very porous, or steep, or a combination of these.

Somewhat excessively drained.—Water is removed from the soil rapidly. The soils in this class generally are free of mottles throughout. They commonly are shallow or moderately deep, very porous, or steep, or a combination of these.

Well drained.—Water is removed from the soil so readily that the upper 40 inches generally does not have the mottles or dull colors related to wetness.

Moderately well drained.—Water is removed from the soil so slowly that the upper 20 to 40 inches has the mottles or dull colors related to wetness. The soils in this class commonly have a slowly permeable layer, have a water table, or receive runoff or seepage, or they are characterized by a combination of these.

Somewhat poorly drained.—Water is removed from the soil so slowly that the upper 10 to 20 inches has the mottles or dull colors related to wetness. The soils in this class commonly have a slowly permeable layer, have a water table, or receive runoff or seepage, or they are characterized by a combination of these.

Poorly drained.—Water is removed so slowly that either the soil is periodically saturated or the upper 10 inches has the mottles or dull colors related to wetness. The soils in this class commonly have a slowly permeable layer, have a water table, or receive runoff or seepage, or they are characterized by a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water is at or on the surface most of the time. The soils in this class commonly have a slowly permeable layer, have a water table, or receive runoff or seepage, or they are characterized by a combination of these.

Drainage, surface. Runoff, or surface flow of water, from an area.

Erosion. The wearing away of the land surface by 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 the surface.

Excess fines (in tables). Excess silt and clay in the soil. The soil does not provide a source of gravel or sand for construction purposes.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

First bottom. The normal flood plain of a stream, subject to frequent or occasional flooding.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Foot slope. The inclined surface at the base of a hill.

Frost action (in tables). Freezing and thawing of soil moisture. Frost action can damage roads, buildings and other structures, and plant roots.

Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Glacial drift (geology). Pulverized and other rock material transported by glacial ice and then deposited. Also the sorted and unsorted material deposited by streams flowing from glaciers.

Glacial outwash (geology). Gravel, sand, and silt, commonly stratified, deposited by glacial melt water.

Glacial till (geology). Unsorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Glaciolacustrine deposits. Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial melt water. Many deposits are interbedded or laminated.

Gleyed soil. Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors and mottles.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.5 centimeters) in diameter. An individual piece is a pebble.

Ground water (geology). Water filling all the unblocked pores of underlying material below the water table.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an upper case letter represents the major horizons. Numbers or lower case letters that follow represent subdivisions of the major horizons. An explanation of the subdivisions is given in the *Soil Survey Manual*. The major horizons of mineral soil are as follows:

O horizon.—An organic layer of fresh and decaying plant residue at the surface of a mineral soil.

A horizon.—The mineral horizon 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.

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of transition from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) prismatic or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these. The combined A and B horizons are generally called the solum, or true soil. If a soil does not have 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 in which the solum 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.

Illuviation. The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Lacustrine deposit (geology). Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Leaching. The removal of soluble material from soil or other material by percolating water.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

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. The soil is not strong enough to support loads.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Minimum tillage. Only the tillage essential to crop production and prevention of soil damage.

Moderately coarse textured soil. Sandy loam and fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, and silty clay loam.

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).

Muck. Dark colored, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Munsell notation. A designation of color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

Neutral soil. A soil having a pH value between 6.6 and 7.3. (See Reaction, soil.)

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter. Plant and animal residue in the soil in various stages of decomposition.

Outwash, glacial. Stratified sand and gravel produced by glaciers and carried, sorted, and deposited by glacial melt water.

Outwash plain. A landform of mainly sandy or coarse textured material of glaciofluvial origin. An outwash plain is commonly smooth; where pitted, it is generally low in relief.

Parent material. The unconsolidated organic and mineral material in which soil forms.

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil adversely affecting the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated 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 inch to 2.0 inches
Moderately rapid	2.0 to 6.0 inches
Rapid	6.0 to 20 inches
Very rapid	more than 20 inches

Phase, soil. A subdivision of a soil series based on features that affect its use and management. For example, slope, stoniness, and thickness.

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Piping (in tables). Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from semisolid to plastic.

Ponding. Standing water on soils in closed depressions. The water can be removed only by percolation or evapotranspiration.

Poorly graded. Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Poor filter (in tables). Because of rapid permeability or an impermeable layer near the surface, the soil may not adequately filter effluent from a waste disposal system.

Productivity, soil. The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Reaction, soil. A measure 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
Extremely acid	below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sapric soil material (muck). The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

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.

Slope (in tables). Slope is great enough that special practices are required to insure satisfactory performance of the soil for a specific use.

Small stones (in tables). Rock fragments less than 3 inches (7.5 centimeters) in diameter. Small stones adversely affect the specified use of the soil.

Soil. A natural, three-dimensional body at the earth's surface. It 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.

Soil separates. Mineral particles less than 2 mm in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows:

	Millimeters
Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in 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 plant and animal activities are largely confined to the solum.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter.

Structure, soil. The arrangement of primary soil particles into compound particles or 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).

Substratum. The part of the soil below the solum.

Subsurface layer. Any surface soil horizon (A1, A2, or A3) below the surface.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Surface soil. The A horizon. Includes all subdivisions of this horizon (A1, A2, and A3).

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior.

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 water soaks into the soil or flows slowly to a prepared outlet.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or 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 *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Thin layer (in tables). Otherwise suitable soil material too thin for the specified use.

Till plain. An extensive flat to undulating area underlain by glacial till.

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Variant, soil. A soil having properties sufficiently different from those of other known soils to justify a new series name, but occurring in such a limited geographic area that creation of a new series is not justified.

Well graded. Refers to soil material consisting of coarse grained particles that are well distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

tables

TABLE 1.--TEMPERATURE AND PRECIPITATION

Month	Temperature*						Precipitation*				
	Average daily maximum	Average daily minimum	Average daily	2 years in 10 will have-- Maximum temperature higher than--	2 years in 10 will have-- Minimum temperature lower than--	Average number of growing degree days**	Average	2 years in 10 will have-- Less than--	2 years in 10 will have-- More than--	Average number of days with 0.10 inch or more	Average snowfall
	°F	°F	°F	°F	°F	Units	In	In	In		In
January----	26.5	7.2	16.9	52	-22	0	.71	.39	.97	3	7.0
February---	32.8	13.3	23.1	56	-17	0	1.06	.31	1.65	3	7.8
March------	42.3	23.0	32.7	76	-5	32	1.99	.94	2.83	5	10.7
April------	60.5	36.8	48.7	87	18	81	2.81	1.49	3.89	7	2.3
May--------	72.9	48.6	60.8	91	28	345	3.70	2.17	5.05	7	.0
June-------	82.2	58.6	70.4	98	42	612	5.01	2.97	6.83	7	.0
July-------	85.6	62.4	74.1	100	47	747	4.09	2.15	5.67	7	.0
August-----	83.9	60.2	72.1	98	46	685	3.79	2.03	5.23	6	.0
September--	75.3	50.9	63.1	94	32	393	3.43	1.23	5.19	6	.0
October----	65.1	40.8	53.0	88	20	179	2.14	.73	3.28	4	.2
November---	46.5	26.5	36.5	72	1	9	1.27	.31	2.02	3	3.8
December---	32.2	14.5	23.4	59	-16	0	.90	.49	1.22	3	7.1
Year-----	58.8	36.9	47.9	101	-22	3,083	30.90	23.96	37.42	61	38.9

* Recorded in the period 1951-73 at Rockwell City, Iowa.

** A growing degree day is a unit of heat available for plant growth. It can be calculated by adding the maximum and minimum daily temperatures, dividing the sum by 2, and subtracting the temperature below which growth is minimal for the principal crops in the area (50° F).

TABLE 2.--FREEZE DATES IN SPRING AND FALL

Probability	Temperature*		
	24° F or lower	28° F or lower	32° F or lower
Last freezing temperature in spring:			
1 year in 10 later than--	April 22	May 1	May 12
2 years in 10 later than--	April 18	April 27	May 8
5 years in 10 later than--	April 10	April 17	April 29
First freezing temperature in fall:			
1 year in 10 earlier than--	October 19	October 4	September 27
2 years in 10 earlier than--	October 23	October 9	October 1
5 years in 10 earlier than--	October 30	October 18	October 9

* Recorded in the period 1951-73 at Rockwell City, Iowa.

TABLE 3.--GROWING SEASON

Probability	Daily minimum temperature during growing season*		
	Higher than 24° F	Higher than 28° F	Higher than 32° F
	Days	Days	Days
9 years in 10	186	164	145
8 years in 10	191	170	151
5 years in 10	202	183	162
2 years in 10	213	195	173
1 year in 10	218	202	178

* Recorded in the period 1951-73 at Rockwell City, Iowa.

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Acres	Percent
4	Knoke silty clay loam, 0 to 1 percent slopes	705	0.2
6	Okoboji silty clay loam, 0 to 1 percent slopes	15,120	4.1
27B	Terril loam, 1 to 5 percent slopes	405	0.1
34B	Estherville sandy loam, 2 to 5 percent slopes	465	0.1
34C2	Estherville sandy loam, 5 to 9 percent slopes, moderately eroded	225	0.1
48	Knoke mucky silt loam, 0 to 1 percent slopes	3,735	1.0
52B	Bode clay loam, 2 to 5 percent slopes	670	0.2
55	Nicollet loam, 1 to 3 percent slopes	72,965	19.8
62C2	Storden loam, 5 to 9 percent slopes, moderately eroded	1,935	0.5
62D2	Storden loam, 9 to 14 percent slopes, moderately eroded	2,030	0.6
62E	Storden loam, 14 to 18 percent slopes	805	0.2
62F	Storden loam, 18 to 25 percent slopes	490	0.1
62G	Storden loam, 25 to 40 percent slopes	570	0.2
90	Okoboji mucky silt loam, 0 to 1 percent slopes	4,585	1.3
95	Harps loam, 0 to 2 percent slopes	8,400	2.3
107	Webster silty clay loam, 0 to 2 percent slopes	95,400	26.1
108	Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	3,190	0.9
108B	Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes	3,540	1.0
108C2	Wadena loam, 24 to 32 inches to sand and gravel, 5 to 9 percent slopes, moderately eroded	355	0.1
135	Coland clay loam, 0 to 2 percent slopes	10,655	2.9
135B	Coland clay loam, 2 to 4 percent slopes	960	0.3
138B	Clarion loam, 2 to 5 percent slopes	54,520	14.9
138C	Clarion loam, 5 to 9 percent slopes	1,020	0.3
138C2	Clarion loam, 5 to 9 percent slopes, moderately eroded	12,250	3.3
138D2	Clarion loam, 9 to 14 percent slopes, moderately eroded	580	0.2
202	Cylinder loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	1,920	0.5
203	Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	1,670	0.5
236B	Lester loam, 2 to 6 percent slopes	280	0.1
259	Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	800	0.2
274	Rolfe silt loam, 0 to 1 percent slopes	540	0.1
288	Ottosen silty clay loam, 1 to 3 percent slopes	1,380	0.4
308	Wadena loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	490	0.1
308B	Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes	210	0.1
388	Kossuth silty clay loam, 0 to 2 percent slopes	4,870	1.3
485	Spillville loam, 0 to 2 percent slopes	605	0.2
485B	Spillville loam, 2 to 5 percent slopes	585	0.2
506	Wacousta silty clay loam, 0 to 1 percent slopes	3,800	1.0
507	Canisteo silty clay loam, 0 to 2 percent slopes	45,710	12.5
508	Wacousta Variant silty clay loam, 0 to 1 percent slopes	200	0.1
559	Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	980	0.3
585B	Coland-Spillville complex, 2 to 5 percent slopes	470	0.1
733	Calco silty clay loam, 0 to 2 percent slopes	1,260	0.3
1048	Knoke mucky silt loam, ponded, 0 to 1 percent slopes	170	*
1458	Millington loam, channeled, 0 to 2 percent slopes	1,420	0.4
1585B	Coland-Spillville complex, channeled, 2 to 5 percent slopes	410	0.1
5010	Pits, gravel	420	0.1
5040	Orthents, loamy	795	0.2
	Water	1,520	0.4
	Total	366,080	100.0

* Less than 0.1 percent.

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE

[Yields are those that can be expected under a high level of management. Only arable soils are listed. Absence of a yield indicates that the soil is not suited to the crop or the crop generally is not grown on the soil]

Soil name and map symbol	Corn	Soybeans	Oats	Kentucky bluegrass	Grass-legume hay	Bromegrass-alfalfa	Smooth bromegrass
	Bu	Bu	Bu	AUM*	Ton	AUM*	AUM*
4 Knoke	82	31	65	3.3	3.3	5.5	4.3
6 Okoboji	84	32	67	3.3	3.4	7.3	4.3
27B Terril	112	42	98	4.2	4.7	8.0	6.6
34B Estherville	45	15	35	2.0	2.0	3.0	2.5
34C2 Estherville	---	---	25	1.5	1.2	2.5	1.8
48 Knoke	82	31	65	3.3	3.3	5.5	4.3
52B Bode	103	39	77	3.8	4.3	7.1	6.1
55 Nicollet	120	40	80	3.5	4.5	6.5	7.0
62C2, 62D2 Storden	82	31	65	3.0	3.5	5.0	5.0
62E Storden	60	---	45	2.5	3.0	4.5	4.0
62F Storden	---	---	---	2.0	2.5	3.7	3.5
62G Storden	---	---	---	1.5	---	---	---
90 Okoboji	84	32	67	3.3	3.4	7.3	4.3
95 Harps	95	36	76	3.3	4.0	6.6	5.0
107 Webster	110	42	88	4.2	4.4	7.3	6.6
108 Wadena	72	27	60	2.7	2.7	4.8	4.3
108B Wadena	70	27	60	2.7	2.8	4.7	4.3
108C2 Wadena	62	24	53	2.3	2.5	4.2	3.7
135 Coland	110	42	83	4.1	4.6	7.6	6.0
135B Coland	108	41	81	4.0	4.5	7.5	5.9
138B Clarion	110	42	88	4.2	4.6	7.6	6.7

See footnote at end of table.

Soil name and map symbol	Corn	Soybeans	Oats	Kentucky bluegrass	Grass-legume hay	Bromegrass-alfalfa	Smooth bromegrass
	Bu	Bu	Bu	AUM*	Ton	AUM*	AUM*
138C---------- Clarion	105	40	84	3.8	4.4	7.3	6.3
138C2---------- Clarion	102	39	82	3.8	4.3	7.1	6.2
138D2---------- Clarion	93	35	74	3.7	3.9	6.5	5.5
202---------- Cylinder	88	33	70	3.3	3.7	6.1	5.3
203---------- Cylinder	103	39	82	3.8	4.3	7.1	6.2
236B---------- Lester	105	35	80	3.5	4.5	6.5	6.2
259---------- Biscay	100	38	80	3.5	3.5	5.2	6.2
274---------- Rolfe	86	33	69	3.3	3.0	5.0	4.5
288---------- Ottosen	111	43	88	4.0	4.7	7.8	6.6
308---------- Wadena	92	35	74	3.7	3.7	6.2	---
308B---------- Wadena	90	34	72	3.7	3.6	6.0	---
388---------- Kossuth	104	39	85	4.0	4.2	7.3	5.9
485---------- Spillville	118	43	90	4.0	5.0	8.5	7.0
485B---------- Spillville	116	42	90	4.0	5.0	8.5	7.0
506---------- Wacousta	81	31	66	3.3	3.4	---	4.3
507---------- Canisteo	110	36	75	3.0	3.5	5.2	---
508---------- Wacousta Variant	75	29	62	2.0	4.0	---	4.0
559---------- Talcot	90	36	76	3.6	3.8	6.3	5.0
585B---------- Coland-Spillville	108	32	86	3.3	4.8	---	6.5
733---------- Calco	99	38	84	4.2	4.2	7.0	5.3
1458---------- Millington	---	---	---	2.0	---	---	---
1585B---------- Coland-Spillville	---	---	---	3.3	---	---	---

* 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 30 days.

TABLE 6.--CAPABILITY CLASSES AND SUBCLASSES

[Miscellaneous areas are excluded. Absence of an entry indicates no acreage]

Class	Total acreage	Major management concerns (Subclass)		
		Erosion (e)	Wetness (w)	Soil problem (s)
		Acres	Acres	Acres
I	74,345	---	---	---
II	236,515	61,170	168,075	7,270
III	47,320	18,170	28,685	465
IV	1,030	805	---	225
V	2,905	---	2,905	---
VI	490	490	---	---
VII	740	570	170	---
VIII	---	---	---	---

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS

[The symbol < means less than; > means more than. Absence of an entry indicates that trees generally do not grow to the given height on that soil]

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
4---------- Knoke	Redosier dogwood, silky dogwood.	Siberian dogwood, bloodtwig dogwood, Tatarian honeysuckle, Zabel honeysuckle.	Amur maple, northern white-cedar, laurel willow.	Green ash----------	Eastern cottonwood.
6---------- Okoboji	Common ninebark, redosier dogwood.	Tatarian honeysuckle, silky dogwood, autumn-olive.	Norway spruce, Amur maple, Zabel honeysuckle, northern white-cedar.	Green ash----------	Silver maple, eastern cottonwood.
27B---------- Terril	Gray dogwood, silky dogwood.	Redosier dogwood, Tatarian honeysuckle.	Amur maple, eastern redcedar.	Red pine, Norway spruce, common hackberry.	Eastern cottonwood, silver maple.
34B, 34C2--------- Estherville	Common ninebark, lilac.	Eastern redcedar, Russian-olive, Siberian crabapple, silver buffaloberry, Tatarian honeysuckle, Siberian peashrub.	Red pine, jack pine, ponderosa pine, Austrian pine, common hackberry, bur oak.	---	---
48---------- Knoke	Redosier dogwood, silky dogwood.	Siberian dogwood, bloodtwig dogwood, Tatarian honeysuckle, Zabel honeysuckle.	Amur maple, northern white-cedar, laurel willow.	Green ash----------	Eastern cottonwood.
52B---------- Bode	Redosier dogwood, gray dogwood.	Tatarian honeysuckle, Siberian dogwood.	Eastern redcedar, Amur maple.	Red pine, common hackberry, Norway spruce.	Silver maple, eastern cottonwood.
55---------- Nicollet	Gray dogwood, silky dogwood.	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, Siberian crabapple, Amur maple.	Ponderosa pine, eastern white pine, green ash, common hackberry.	Silver maple.
62C2, 62D2-------- Storden	Common ninebark, redosier dogwood.	Tall purple willow, Tatarian honeysuckle, Siberian peashrub, northern white-cedar.	Eastern redcedar, white spruce.	Green ash, Russian-olive, golden willow.	Eastern cottonwood.
62E, 62F, 62G. Storden					
90---------- Okoboji	Common ninebark, redosier dogwood.	Tatarian honeysuckle, silky dogwood, autumn-olive.	Norway spruce, Amur maple, Zabel honeysuckle, northern white-cedar.	Green ash----------	Silver maple, eastern cottonwood.
95---------- Harps	Gray dogwood, silky dogwood.	Tatarian honeysuckle, redosier dogwood, Zabel honeysuckle, common ninebark.	Laurel willow, northern white-cedar, Amur maple.	Green ash----------	Eastern cottonwood.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
107---------- Webster	Redosier dogwood, gray dogwood, silky dogwood.	Zabel honeysuckle, Tatarian honeysuckle, American plum.	Laurel willow, northern white-cedar, Amur maple.	Green ash----------	Silver maple, eastern cottonwood.
108, 108B, 108C2-- Wadena	Gray dogwood, silky dogwood.	Siberian peashrub, Siberian crabapple, lilac, Tatarian honeysuckle.	Eastern redcedar, Amur maple, northern white-cedar, white spruce.	Scotch pine, green ash, eastern white pine.	Silver maple.
135, 135B---------- Coland	Common ninebark, indiancurrant coralberry.	Redosier dogwood, Tatarian honeysuckle, silky dogwood, Zabel honeysuckle.	White spruce, northern white-cedar, Amur maple.	Green ash----------	Eastern cottonwood, silver maple.
138B, 138C, 138C2, 138D2---------- Clarion	Gray dogwood, silky dogwood.	Redosier dogwood, Tatarian honeysuckle, lilac.	Amur maple, eastern redcedar.	Red pine, Norway spruce, common hackberry.	Silver maple, eastern cottonwood.
202, 203---------- Cylinder	Gray dogwood, silky dogwood.	Redosier dogwood, Tatarian honeysuckle, American plum.	Amur maple, eastern redcedar.	Red pine, Norway spruce, common hackberry.	Eastern cottonwood, silver maple.
236B---------- Lester	Gray dogwood, silky dogwood.	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, Siberian crabapple, Amur maple, white spruce.	Eastern white pine, green ash, common hackberry, Scotch pine.	Silver maple.
259---------- Biscay	Common ninebark, indiancurrant coralberry.	Northern white-cedar, redosier dogwood, American plum, purpleosier willow, Tatarian honeysuckle.	Amur maple, white spruce.	Common hackberry, green ash, golden willow.	Eastern cottonwood, silver maple.
274---------- Rolfe	Redosier dogwood, silky dogwood.	Zabel honeysuckle, Tatarian honeysuckle, Siberian dogwood.	Laurel willow, Amur maple, northern white-cedar.	Green ash----------	Silver maple, eastern cottonwood.
288---------- Ottosen	Redosier dogwood, gray dogwood.	Siberian dogwood, Tatarian honeysuckle.	Eastern redcedar, Amur maple.	Norway spruce, common hackberry, red pine.	Silver maple, eastern cottonwood.
308, 308B---------- Wadena	Gray dogwood, silky dogwood.	Siberian peashrub, Siberian crabapple, lilac, Tatarian honeysuckle.	Eastern redcedar, Amur maple, northern white-cedar, white spruce.	Scotch pine, green ash, eastern white pine.	Silver maple.
388---------- Kossuth	Redosier dogwood, silky dogwood.	Siberian dogwood, Tatarian honeysuckle, bloodtwig dogwood.	Amur maple, eastern redcedar, northern white-cedar.	Norway spruce, green ash.	Eastern cottonwood, silver maple.
485, 485B---------- Spillville	Gray dogwood, silky dogwood.	Redosier dogwood, Tatarian honeysuckle, lilac.	Amur maple, eastern redcedar.	Common hackberry, red pine, Norway spruce.	Eastern cottonwood, silver maple.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
506---------- Wacousta	Silky dogwood-----	Zabel honeysuckle, Tatarian honeysuckle, American plum, eastern redcedar, redosier dogwood.	Laurel willow, northern white-cedar, Amur maple.	Green ash---------	Eastern cottonwood, silver maple.
507---------- Canisteo	Common ninebark---	Siberian peashrub, redosier dogwood, Tatarian honeysuckle.	Russian-olive, white spruce, ponderosa pine, Siberian crabapple, eastern redcedar.	Golden willow, green ash.	Eastern cottonwood.
508---------- Wacousta Variant	Common ninebark---	Northern white-cedar.	Common hackberry, eastern redcedar, white spruce, Norway spruce.	Laurel willow, American sycamore, green ash.	Eastern cottonwood.
559---------- Talcot	Common ninebark---	Tatarian honeysuckle, medium purple willow, redosier dogwood.	Russian-olive-----	Green ash---------	Eastern cottonwood, golden willow.
585B*: Coland----------	Common ninebark, indiancurrant coralberry.	Redosier dogwood, Tatarian honeysuckle, silky dogwood, Zabel honeysuckle.	White spruce, northern white-cedar, Amur maple.	Green ash---------	Eastern cottonwood, silver maple.
Spillville-------	Gray dogwood, silky dogwood.	Redosier dogwood, Tatarian honeysuckle, lilac.	Amur maple, eastern redcedar.	Common hackberry, red pine, Norway spruce.	Eastern cottonwood, silver maple.
733---------- Calco	Silky dogwood-----	Redosier dogwood, eastern redcedar, Tatarian honeysuckle, American plum, Zabel honeysuckle.	Laurel willow, Amur maple, northern white-cedar, white spruce.	Green ash---------	Eastern cottonwood.
1048. Knoke					
1458. Millington					
1585B*: Coland----------	Common ninebark, indiancurrant coralberry.	Redosier dogwood, Tatarian honeysuckle, silky dogwood, Zabel honeysuckle.	White spruce, northern white-cedar, Amur maple.	Green ash---------	Eastern cottonwood, silver maple.
Spillville-------	Gray dogwood, silky dogwood.	Redosier dogwood, Tatarian honeysuckle, lilac.	Amur maple, eastern redcedar.	Common hackberry, red pine, Norway spruce.	Eastern cottonwood, silver maple.
5010*. Pits					
5040*. Orthents					

* See description of the map unit for composition and behavior characteristics of the map unit.

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 indicates that the soil was not rated]

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
4 Knoke	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
6 Okoboji	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
27B Terril	Slight	Slight	Moderate: slope.	Slight	Slight.
34B Estherville	Slight	Slight	Moderate: slope, small stones.	Slight	Moderate: droughty.
34C2 Estherville	Slight	Slight	Severe: slope.	Slight	Moderate: droughty.
48 Knoke	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: ponding.
52B Bode	Slight	Slight	Moderate: slope.	Slight	Slight.
55 Nicollet	Slight	Slight	Slight	Slight	Slight.
62C2 Storden	Slight	Slight	Severe: slope.	Slight	Slight.
62D2 Storden	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
62E, 62F Storden	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
62G Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
90 Okoboji	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding.
95 Harps	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
107 Webster	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
108 Wadena	Slight	Slight	Moderate: small stones.	Slight	Slight.
108B Wadena	Slight	Slight	Moderate: slope, small stones.	Slight	Slight.
108C2 Wadena	Slight	Slight	Severe: slope.	Slight	Slight.
135, 135B Coland	Severe: floods, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, floods.
138B Clarion	Slight	Slight	Moderate: slope.	Slight	Slight.

TABLE 8.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
138C, 138C2---------- Clarion	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
138D2---------- Clarion	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: slope.
202, 203---------- Cylinder	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Slight----------	Slight.
236B---------- Lester	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
259---------- Biscay	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
274---------- Rolfe	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
288---------- Ottosen	Moderate: wetness, percs slowly.	Moderate: wetness, percs slowly.	Moderate: wetness, percs slowly.	Slight----------	Slight.
308---------- Wadena	Slight----------	Slight----------	Moderate: small stones.	Slight----------	Slight.
308B---------- Wadena	Slight----------	Slight----------	Moderate: slope, small stones.	Slight----------	Slight.
388---------- Kossuth	Severe: wetness.	Moderate: wetness, percs slowly.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
485---------- Spillville	Severe: floods.	Moderate: floods.	Severe: floods.	Moderate: floods.	Severe: floods.
485B---------- Spillville	Severe: floods.	Slight----------	Moderate: slope, floods.	Slight----------	Moderate: floods.
506---------- Wacousta	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
507---------- Canisteo	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
508---------- Wacousta Variant	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
559---------- Talcot	Severe: wetness.	Severe: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
585B*:					
Coland----------	Severe: floods, wetness.	Moderate: floods, wetness.	Severe: wetness, floods.	Moderate: wetness, floods.	Severe: floods.
Spillville----------	Severe: floods.	Moderate: floods.	Severe: floods.	Moderate: floods.	Severe: floods.
733---------- Calco	Severe: floods, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, floods.

See footnote at end of table.

TABLE 8.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
1048---------- Knoke	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: ponding.
1458---------- Millington	Severe: floods, wetness.	Severe: wetness.	Severe: wetness, floods.	Severe: wetness.	Severe: wetness, floods.
1585B*:					
Coland----------	Severe: floods, wetness.	Moderate: floods, wetness.	Severe: wetness, floods.	Moderate: wetness, floods.	Severe: floods.
Spillville----------	Severe: floods.	Moderate: floods.	Severe: floods.	Moderate: floods.	Severe: floods.
5010*. Pits					
5040*. Orthents					

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 9.--WILDLIFE HABITAT POTENTIALS

[See text for definitions of "good," "fair," "poor," and "very poor." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	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
4---------- Knoke	Fair	Fair	Fair	Poor	Very poor.	Good	Good	Fair	Poor	Good.
6---------- Okoboji	Fair	Fair	Fair	Fair	Very poor.	Good	Good	Fair	Fair	Good.
27B---------- Terril	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
34B, 34C2---------- Estherville	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
48---------- Knoke	Fair	Fair	Fair	Poor	Very poor.	Good	Good	Fair	Poor	Good.
52B---------- Bode	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
55---------- Nicollet	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
62C2, 62D2, 62E---- Storden	Fair	Good	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
62F, 62G---------- Storden	Poor	Fair	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
90---------- Okoboji	Fair	Fair	Fair	Fair	Very poor.	Good	Good	Fair	Fair	Good.
95---------- Harps	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
107---------- Webster	Good	Good	Good	Fair	Poor	Good	Good	Good	Fair	Good.
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.
135, 135B---------- Coland	Good	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.
138B---------- Clarion	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
138C, 138C2, 138D2- Clarion	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
202, 203---------- Cylinder	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
236B---------- Lester	Good	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
259---------- Biscay	Good	Good	Good	Good	Fair	Good	Good	Good	Fair	Good.
274---------- Rolfe	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.

TABLE 9.--WILDLIFE HABITAT POTENTIALS--Continued

Soil name and map symbol	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
288---------- Ottosen	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
308, 308B---------- Wadena	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
388---------- Kossuth	Good	Good	Good	Fair	Poor	Good	Good	Good	Fair	Good.
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	Good	Good	Fair	Good	Good	Good	Good	Fair	Good	Good.
507---------- Canisteo	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
508---------- Wacousta Variant	Good	Good	Fair	Fair	Poor	Good	Good	Poor	Poor	Good.
559---------- Talcot	Fair	Fair	Fair	Poor	Poor	Good	Good	Fair	Poor	Good.
585B*:										
Coland----------	Poor	Fair	Fair	Poor	Poor	Good	Good	Poor	Poor	Good.
Spillville--------	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
733---------- Calco	Good	Fair	Good	Poor	Very poor.	Good	Good	Fair	Poor	Fair.
1048---------- Knoke	Very poor.	Very poor.	Poor	Very poor.	Very poor.	Good	Good	Very poor.	Very poor.	Good.
1458---------- Millington	Poor	Poor	Fair	Fair	Very poor.	Good	Good	Poor	Good	Good.
1585B*:										
Coland----------	Poor	Fair	Fair	Poor	Poor	Good	Good	Poor	Poor	Good.
Spillville--------	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
5010*. Pits										
5040*. Orthents										

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 10.--BUILDING SITE 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 indicates that the soil was not rated]

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
4 Knoke	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, low strength, shrink-swell.	Severe: ponding.
6 Okoboji	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.
27B Terril	Slight	Slight	Slight	Slight	Severe: low strength.	Slight.
34B Estherville	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Moderate: droughty.
34C2 Estherville	Severe: cutbanks cave.	Slight	Slight	Moderate: slope.	Slight	Moderate: droughty.
48 Knoke	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, low strength, shrink-swell.	Severe: ponding.
52B Bode	Slight	Moderate: shrink-swell.	Slight	Moderate: shrink-swell.	Severe: low strength.	Slight.
55 Nicollet	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
62C2 Storden	Slight	Slight	Slight	Moderate: slope.	Moderate: frost action.	Slight.
62D2 Storden	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
62E, 62F, 62G Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
90 Okoboji	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.
95 Harps	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
107 Webster	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
108, 108B Wadena	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Slight.
108C2 Wadena	Severe: cutbanks cave.	Slight	Slight	Moderate: slope.	Slight	Slight.
135, 135B Coland	Severe: wetness.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness, shrink-swell.	Severe: floods, low strength, frost action.	Moderate: wetness, floods.
138B Clarion	Slight	Slight	Slight	Slight	Moderate: frost action.	Slight.

TABLE 10.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
138C, 138C2---- Clarion	Slight----	Slight----	Slight----	Moderate: slope.	Moderate: frost action.	Slight.
138D2---- Clarion	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
202, 203---- Cylinder	Severe: cutbanks cave, wetness.	Moderate: shrink-swell, wetness.	Severe: wetness.	Moderate: shrink-swell, wetness.	Severe: frost action.	Slight.
236B---- Lester	Slight----	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength.	Slight.
259---- Biscay	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
274---- Rolfe	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.
288---- Ottosen	Severe: wetness.	Moderate: wetness, shrink-swell.	Severe: wetness.	Moderate: wetness, shrink-swell.	Severe: frost action, low strength.	Slight.
308, 308B---- Wadena	Severe: cutbanks cave.	Slight----	Slight----	Slight----	Slight----	Slight.
388---- Kossuth	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: shrink-swell, frost action, low strength.	Moderate: wetness.
485---- Spillville	Moderate: floods, wetness.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: low strength, floods.	Severe: floods.
485B---- Spillville	Moderate: floods, wetness.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: low strength, floods.	Moderate: floods.
506---- Wacousta	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: low strength, ponding.	Severe: ponding,
507---- Canisteo	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
508---- Wacousta Variant	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding, frost action, low strength.	Severe: ponding.
559---- Talcot	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
585B*: Coland----	Severe: wetness.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness, shrink-swell.	Severe: floods, low strength, frost action.	Severe: floods.

See footnote at end of table.

TABLE 10.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
585B*: Spillville	Moderate: floods, wetness.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: low strength, floods.	Severe: floods.
733 Calco	Severe: wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: low strength.	Moderate: wetness.
1048 Knoke	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, low strength, shrink-swell.	Severe: ponding.
1458 Millington	Severe: wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Severe: low strength, wetness, floods.	Severe: wetness, floods.
1585B*: Coland	Severe: wetness.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness, shrink-swell.	Severe: floods, wetness, shrink-swell.	Severe: floods, low strength, frost action.	Severe: floods.
Spillville	Moderate: floods, wetness.	Severe: floods.	Severe: floods.	Severe: floods.	Severe: low strength, floods.	Severe: floods.
5010*. Pits						
5040*. Orthents						

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 11.--SANITARY FACILITIES

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," "good," "fair," and other terms. Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
4 Knoke	Severe: percs slowly, ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
6 Okoboji	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: hard to pack, ponding.
27B Terril	Slight	Moderate: seepage, slope.	Slight	Slight	Good.
34B Estherville	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
34C2 Estherville	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
48 Knoke	Severe: percs slowly, ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
52B Bode	Slight	Moderate: seepage, slope.	Slight	Slight	Good.
55 Nicollet	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
62C2 Storden	Slight	Severe: slope.	Slight	Slight	Good.
62D2 Storden	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
62E, 62F, 62G Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
90 Okoboji	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: hard to pack, ponding.
95 Harps	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: hard to pack, wetness.
107 Webster	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
108, 108B Wadena	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
108C2 Wadena	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.

TABLE 11.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
135, 135B---------- Coland	Severe: floods, wetness.	Severe: floods, wetness, seepage.	Severe: floods, wetness, seepage.	Severe: floods, wetness.	Poor: wetness, hard to pack.
138B---------- Clarion	Slight----------	Moderate: slope, seepage.	Slight----------	Slight----------	Good.
138C, 138C2--------- Clarion	Slight----------	Severe: slope.	Slight----------	Slight----------	Good.
138D2---------- Clarion	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
202, 203---------- Cylinder	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: too sandy, seepage.
236B---------- Lester	Slight----------	Moderate: seepage, slope.	Moderate: too clayey.	Slight----------	Fair: too clayey.
259---------- Biscay	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, small stones.
274---------- Rolfe	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
288---------- Ottosen	Severe: percs slowly, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
308, 308B---------- Wadena	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
388---------- Kossuth	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
485, 485B---------- Spillville	Severe: wetness, floods.	Severe: wetness, seepage, floods.	Severe: wetness, seepage, floods.	Severe: wetness, floods.	Fair: wetness.
506---------- Wacousta	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
507---------- Canisteo	Severe: wetness.	Severe: seepage, wetness.	Severe: wetness.	Severe: seepage, wetness.	Poor: wetness.
508---------- Wacousta Variant	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
559---------- Talcot	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, small stones.

TABLE 11.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
585B*:					
Coland	Severe: floods, wetness.	Severe: floods, wetness, seepage.	Severe: floods, wetness, seepage.	Severe: floods, wetness.	Poor: wetness, hard to pack.
Spillville	Severe: wetness, floods.	Severe: wetness, seepage, floods.	Severe: wetness, seepage, floods.	Severe: wetness, floods.	Fair: wetness.
733 Calco	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Severe: wetness, floods.	Poor: wetness.
1048 Knoke	Severe: percs slowly, ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
1458 Millington	Severe: floods, wetness.	Severe: wetness.	Severe: floods, wetness.	Severe: floods, wetness.	Poor: wetness.
1585B*:					
Coland	Severe: floods, wetness.	Severe: floods, wetness, seepage.	Severe: floods, wetness, seepage.	Severe: floods, wetness.	Poor: wetness, hard to pack.
Spillville	Severe: wetness, floods.	Severe: wetness, seepage, floods.	Severe: wetness, seepage, floods.	Severe: wetness, floods.	Fair: wetness.
5010*. Pits					
5040*. Orthents					

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 12.--CONSTRUCTION MATERIALS

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," "poor," "probable," and "improbable." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
4 Knoke	Poor: wetness, low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
6 Okoboji	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
27B Terril	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
34B, 34C2 Estherville	Good	Probable	Probable	Poor: small stones, area reclaim.
48 Knoke	Poor: wetness, low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
52B Bode	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
55 Nicollet	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
62C2 Storden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
62D2 Storden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones, slope.
62E, 62F Storden	Fair: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
62G Storden	Poor: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
90 Okoboji	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
95 Harps	Fair: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
107 Webster	Fair: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Good.
108, 108B, 108C2 Wadena	Good	Probable	Probable	Poor: small stones, area reclaim.
135, 135B Coland	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
138B Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Good.

TABLE 12.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
138C---------- Clarion	Good----------	Improbable: excess fines.	Improbable: excess fines.	Good.
138C2---------- Clarion	Good----------	Improbable: excess fines.	Improbable: excess fines.	Good.
138D2---------- Clarion	Good----------	Improbable: excess fines.	Improbable: excess fines.	Fair: slope.
202, 203---------- Cylinder	Fair: wetness.	Probable----------	Improbable: too sandy.	Fair: area reclaim, small stones, thin layer.
236B---------- Lester	Good----------	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
259---------- Biscay	Fair: wetness.	Probable----------	Probable----------	Poor: area reclaim.
274---------- Rolfe	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer, wetness.
288---------- Ottosen	Fair: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
308, 308B---------- Wadena	Good----------	Probable----------	Probable----------	Poor: small stones, area reclaim.
388---------- Kossuth	Fair: wetness, shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
485, 485B---------- Spillville	Good----------	Improbable: excess fines.	Improbable: excess fines.	Good.
506---------- Wacousta	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
507---------- Canisteo	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
508---------- Wacousta Variant	Poor: wetness, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
559---------- Talcot	Poor: wetness.	Probable----------	Probable----------	Poor: wetness.
585B*: Coland----------	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
Spillville----------	Good----------	Improbable: excess fines.	Improbable: excess fines.	Good.
733---------- Calco	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
1048---------- Knoke	Poor: wetness, low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.

See footnote at end of table.

TABLE 12.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
1458---------- Millington	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
1585B*:				
Coland----------	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
Spillville----------	Good----------	Improbable: excess fines.	Improbable: excess fines.	Good.
5010*. Pits				
5040*. Orthents				

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 13.--WATER MANAGEMENT

[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 indicates that the soil was not evaluated]

Soil name and map symbol	Limitations for--		Features affecting--			
	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
4---------- Knoke	Slight---------	Severe: hard to pack, ponding.	Ponding, frost action.	Ponding--------	Ponding--------	Wetness.
6---------- Okoboji	Moderate: seepage.	Severe: ponding.	Ponding, frost action.	Ponding, erodes easily.	Ponding--------	Wetness.
27B---------- Terril	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Slope----------	Favorable------	Favorable.
34B, 34C2--------- Estherville	Severe: seepage.	Severe: seepage.	Deep to water	Droughty, soil blowing, slope.	Too sandy, soil blowing.	Droughty.
48---------- Knoke	Slight---------	Severe: hard to pack, ponding.	Ponding, frost action.	Ponding--------	Ponding--------	Wetness.
52B---------- Bode	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope----------	Favorable------	Favorable.
55---------- Nicollet	Moderate: seepage.	Severe: piping.	Frost action---	Wetness--------	Wetness--------	Favorable.
62C2---------- Storden	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Slope----------	Erodes easily	Erodes easily.
62D2, 62E, 62F, 62G---------- Storden	Severe: slope.	Moderate: piping.	Deep to water	Slope----------	Slope, erodes easily.	Slope, erodes easily.
90---------- Okoboji	Moderate: seepage.	Severe: ponding.	Ponding, frost action.	Ponding--------	Ponding--------	Wetness.
95---------- Harps	Moderate: seepage.	Severe: wetness.	Frost action---	Wetness--------	Wetness--------	Wetness.
107---------- Webster	Moderate: seepage.	Severe: wetness.	Frost action---	Wetness--------	Wetness--------	Wetness.
108---------- Wadena	Severe: seepage.	Severe: seepage, piping.	Deep to water	Favorable------	Too sandy------	Favorable.
108B, 108C2------- Wadena	Severe: seepage.	Severe: seepage, piping.	Deep to water	Slope----------	Too sandy------	Favorable.
135---------- Coland	Moderate: seepage.	Severe: wetness.	Floods, frost action.	Wetness, floods.	Wetness--------	Wetness.
135B---------- Coland	Moderate: seepage, slope.	Severe: wetness.	Floods, frost action, slope.	Wetness, slope, floods.	Wetness--------	Wetness.
138B, 138C, 138C2 Clarion	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope----------	Erodes easily	Erodes easily.

TABLE 13.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for--		Features affecting--			
	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
138D2---------- Clarion	Severe: slope.	Severe: piping.	Deep to water	Slope----------	Slope, erodes easily.	Slope, erodes easily.
202, 203---------- Cylinder	Severe: seepage.	Severe: seepage, piping.	Frost action, cutbanks cave.	Wetness--------	Wetness, too sandy.	Favorable.
236B---------- Lester	Moderate: seepage, slope.	Severe: thin layer.	Deep to water	Slope----------	Erodes easily	Erodes easily.
259---------- Biscay	Severe: seepage.	Severe: seepage, wetness.	Frost action, cutbanks cave.	Wetness--------	Wetness, too sandy.	Wetness.
274---------- Rolfe	Moderate: seepage.	Severe: ponding.	Ponding, percs slowly, frost action.	Ponding, percs slowly.	Ponding--------	Wetness, percs slowly.
288---------- Ottosen	Moderate: seepage.	Moderate: piping, wetness.	Frost action---	Wetness--------	Wetness--------	Favorable.
308---------- Wadena	Severe: seepage.	Severe: seepage, piping.	Deep to water	Favorable------	Too sandy------	Favorable.
308B---------- Wadena	Severe: seepage.	Severe: seepage, piping.	Deep to water	Slope----------	Too sandy------	Favorable.
388---------- Kossuth	Moderate: seepage.	Severe: wetness.	Frost action---	Wetness--------	Wetness--------	Wetness.
485---------- Spillville	Moderate: seepage.	Moderate: piping, wetness.	Deep to water	Floods---------	Favorable------	Favorable.
485B---------- Spillville	Moderate: seepage, slope.	Moderate: piping, wetness.	Deep to water	Slope, floods.	Favorable------	Favorable.
506---------- Wacousta	Moderate: seepage.	Severe: piping, wetness, ponding.	Ponding, frost action.	Ponding--------	Ponding--------	Wetness.
507---------- Canisteo	Severe: seepage.	Severe: wetness.	Frost action---	Wetness--------	Wetness--------	Wetness.
508---------- Wacousta Variant	Moderate: seepage.	Severe: piping, wetness.	Ponding, frost action.	Ponding--------	Ponding--------	Wetness.
559---------- Talcot	Severe: seepage.	Severe: seepage, wetness.	Frost action, cutbanks cave.	Wetness--------	Wetness, too sandy.	Wetness.
585B*:						
Coland----------	Moderate: seepage.	Severe: wetness.	Floods, frost action.	Wetness, floods.	Wetness--------	Wetness.
Spillville-------	Moderate: seepage, slope.	Moderate: piping, wetness.	Deep to water	Slope, floods.	Favorable------	Favorable.

See footnote at end of table.

TABLE 13.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for--		Features affecting--			
	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
733---------- Calco	Moderate: seepage.	Severe: wetness.	Frost action, floods.	Wetness, floods.	Wetness--------	Wetness.
1048---------- Knoke	Slight---------	Severe: hard to pack, ponding.	Ponding, frost action.	Ponding--------	Ponding--------	Wetness.
1458---------- Millington	Moderate: seepage.	Severe: piping, wetness.	Floods, frost action.	Wetness, floods.	Wetness--------	Wetness.
1585B*:						
Coland----------	Moderate: seepage.	Severe: wetness.	Floods, frost action.	Wetness, floods.	Wetness--------	Wetness.
Spillville-------	Moderate: seepage, slope.	Moderate: piping, wetness.	Deep to water	Slope, floods.	Favorable------	Favorable.
5010*. Pits						
5040*. Orthents						

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 14.--ENGINEERING INDEX PROPERTIES

[The symbol < means less than; > means more than. Absence of an entry indicates that data were not estimated]

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
4	0-8	Silty clay loam	MH, OH	A-7	0	100	100	90-100	80-95	55-90	15-40
Knoke	8-18	Silty clay loam, mucky silty clay loam.	MH, OH	A-7	0	100	100	90-100	80-95	55-90	15-40
	18-60	Silty clay loam, silty clay, clay loam.	MH, CH	A-7	0	95-100	95-100	90-100	80-95	55-70	25-40
6	0-60	Silty clay loam	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
Okoboji											
27B	0-23	Loam	CL	A-6	0-5	100	95-100	70-90	60-80	30-40	10-20
Terril	23-70	Clay loam, loam	CL	A-6	0-5	100	100	85-95	65-85	25-40	10-20
34B, 34C2	0-12	Sandy loam	SM, SM-SC, SC	A-2, A-4	0-5	90-100	80-95	50-75	25-50	20-30	2-10
Estherville	12-28	Sandy loam, loam, coarse sandy loam.	SM, SM-SC, SC	A-2, A-4, A-1	0-5	85-100	70-95	40-75	15-45	20-30	2-8
	28-60	Coarse sand, gravelly coarse sand, loamy coarse sand.	SP, SP-SM, SM, GP	A-1	0-10	45-90	40-85	10-40	2-25	---	NP
48	0-8	Mucky silt loam	OH, MH	A-7	0	100	100	95-100	90-95	60-90	10-30
Knoke	8-18	Silty clay loam, mucky silty clay loam.	MH, OH	A-7	0	100	100	90-100	80-95	55-90	15-40
	18-60	Silty clay loam, silty clay, clay loam.	MH, CH	A-7	0	95-100	95-100	90-100	80-95	55-70	25-40
52B	0-11	Clay loam	CL	A-6, A-7	0	95-100	95-100	75-90	55-80	35-50	15-25
Bode	11-28	Clay loam	CL	A-6, A-7	0	95-100	90-100	75-90	55-80	35-50	15-25
	28-60	Loam	CL, CL-ML	A-4, A-6	0-5	90-100	90-95	75-90	50-75	25-40	5-15
55	0-23	Loam, clay loam	OL, ML, CL	A-6, A-7	0	95-100	95-100	85-98	55-85	35-50	10-25
Nicollet	23-38	Clay loam, loam	CL	A-6, A-7	0-5	95-100	95-100	80-95	55-80	35-50	15-25
	38-60	Loam, clay loam	CL, ML	A-6, A-4	0-5	95-100	90-100	75-90	50-75	30-40	5-15
62C2, 62D2, 62E, 62F, 62G	0-6	Loam	ML, CL	A-4, A-6	0-5	95-100	95-100	70-85	55-70	30-40	5-15
Storden	6-60	Loam	CL-ML, CL	A-4, A-6	0-5	95-100	85-97	70-85	55-70	20-40	5-15
90	0-13	Mucky silt loam	OH, MH	A-7	0	100	100	95-100	90-95	60-95	10-30
Okoboji	13-60	Silty clay loam	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
95	0-18	Loam	CL, CH	A-6, A-7	0-5	100	95-100	80-90	65-80	30-55	15-35
Harps	18-29	Loam, clay loam, sandy clay loam.	CL, CH	A-6, A-7	0-5	95-100	95-100	80-90	65-80	30-60	15-35
	29-60	Loam	CL	A-6	0-5	95-100	90-100	70-80	50-75	25-40	10-25
107	0-12	Silty clay loam	CL, CH	A-7, A-6	0-5	100	95-100	85-95	70-90	35-60	15-30
Webster	12-37	Clay loam, silty clay loam, loam.	CL	A-6, A-7	0-5	95-100	95-100	85-95	60-80	35-50	15-30
	37-60	Loam, clay loam	CL	A-6	0-5	95-100	90-100	75-85	50-75	30-40	10-20
108, 108B	0-13	Loam	ML	A-4	0	95-100	80-100	75-95	50-65	25-40	2-10
Wadena	13-30	Loam, sandy loam, sandy clay loam.	SM, ML, CL, SC	A-4, A-6	0	95-100	80-100	75-95	40-60	25-40	5-12
	30-60	Sand and gravel	SP, SP-SM, GP, GP-GM	A-1, A-3, A-2	0-5	45-100	40-95	10-80	2-10	---	NP
108C2	0-8	Loam	ML	A-4	0	95-100	80-100	75-95	50-65	25-40	2-10
Wadena	8-30	Loam, sandy loam, sandy clay loam.	SM, ML, CL, SC	A-4, A-6	0	95-100	80-100	75-95	40-60	25-40	5-12
	30-60	Sand and gravel	SP, SP-SM, GP, GP-GM	A-1, A-3, A-2	0-5	45-100	40-95	10-80	2-10	---	NP

TABLE 14.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
135, 135B-------- Coland	0-53 53-60	Clay loam-------- Clay loam, silty clay loam.	CL, CH CL, CH	A-7 A-7	0 0	100 100	100 100	95-100 95-100	65-80 65-80	45-55 45-55	20-30 20-30
138B------------- Clarion	0-14 14-41 41-60	Loam------------- Loam, clay loam Loam, sandy loam	CL, CL-ML CL, CL-ML CL, CL-ML, SC, SM-SC	A-4, A-6 A-4, A-6 A-4, A-6	0-5 0-5 0-5	95-100 90-100 90-100	95-100 85-100 85-100	75-90 75-90 75-90	50-75 50-75 45-70	25-40 25-40 25-40	5-15 5-15 5-15
138C------------- Clarion	0-14 14-41 41-60	Loam------------- Loam, clay loam Loam, sandy loam	CL, CL-ML CL, CL-ML CL, CL-ML, SC, SM-SC	A-4, A-6 A-4, A-6 A-4, A-6	0-5 0-5 0-5	95-100 90-100 90-100	95-100 85-100 85-100	75-90 75-90 75-90	50-75 50-75 45-70	25-40 25-40 25-40	5-15 5-15 5-15
138C2, 138D2----- Clarion	0-14 14-41 41-60	Loam------------- Loam, clay loam Loam, sandy loam	CL, CL-ML CL, CL-ML CL, CL-ML, SC, SM-SC	A-4, A-6 A-4, A-6 A-4, A-6	0-5 0-5 0-5	95-100 90-100 90-100	95-100 85-100 85-100	75-90 75-90 75-90	50-75 50-75 45-70	25-40 25-40 25-40	5-15 5-15 5-15
202, 203--------- Cylinder	0-23 23-33 33-60	Loam------------- Loam, clay loam Gravelly coarse sand, loamy sand.	CL CL, SC SP-SM, SM	A-6, A-7 A-6 A-1, A-2, A-3	0 0 0-10	100 95-100 75-95	90-100 80-100 75-95	80-100 80-95 20-55	50-75 45-70 5-25	30-50 30-40 ---	10-25 10-20 NP
236B------------- Lester	0-11 11-43 43-60	Loam------------- Clay loam, loam Loam, clay loam	ML, CL CL CL, CL-ML	A-6, A-4 A-7, A-6 A-6, A-4	0 0-5 0-5	95-100 95-100 95-100	90-100 90-100 90-100	80-95 80-95 75-90	50-70 55-75 50-70	30-40 35-50 20-40	5-15 15-25 5-20
259-------------- Biscay	0-19 19-34 34-60	Clay loam-------- Loam, clay loam Stratified loamy sand to gravelly coarse sand.	CL, ML CL, ML SP, SP-SM, GP, GP-GM	A-7, A-6 A-6, A-7 A-1	0 0 0-5	95-100 95-100 45-95	95-100 90-100 35-95	70-90 70-90 20-45	50-75 50-75 2-10	35-50 30-50 ---	10-25 10-20 NP
274-------------- Rolfe	0-21 21-44 44-60	Silt loam-------- Clay, silty clay, clay loam. Clay loam, loam	OL, CL, ML CH CL	A-6, A-4 A-7 A-7, A-6	0 0 0	100 100 95-100	95-100 95-100 90-100	90-100 90-100 80-90	80-95 75-95 55-75	30-40 50-65 30-45	5-15 25-35 10-20
288-------------- Ottosen	0-20 20-48 48-60	Clay loam, silty clay loam. Clay loam, silty clay loam. Loam--------------	CL, CH CL, CH CL	A-7 A-7 A-4, A-6	0 0 0-5	95-100 95-100 90-100	95-100 95-100 90-100	90-100 90-100 80-95	65-85 65-85 60-75	40-55 40-55 25-40	20-30 20-30 8-20
308, 308B-------- Wadena	0-13 13-34 34-60	Loam------------- Loam, sandy loam, sandy clay loam. Sand and gravel	ML SM, ML, CL, SC SP, SP-SM, GP, GP-GM	A-4 A-4, A-6 A-1, A-3, A-2	0 0 0-5	95-100 95-100 45-100	80-100 80-100 40-95	75-95 75-95 10-80	50-65 40-60 2-10	25-40 25-40 ---	2-10 5-12 NP
388-------------- Kossuth	0-24 24-33 33-60	Silty clay loam Silty clay loam, clay loam. Loam--------------	CL, CH CL, CH CL	A-7 A-7 A-4, A-6	0 0 0-5	95-100 95-100 95-100	95-100 95-100 90-100	80-85 80-85 70-85	75-85 75-85 50-70	40-60 45-65 25-40	20-30 25-35 8-20
485, 485B-------- Spillville	0-60	Loam--------------	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
506-------------- Wacousta	0-16 16-24 24-60	Silty clay loam Silty clay loam Loam, silty clay loam, clay loam.	CH, CL CH, CL CL, ML	A-7 A-7 A-6, A-4	0 0 0-5	100 100 95-100	100 100 95-100	95-100 90-100 85-100	95-100 90-100 80-90	40-65 40-60 30-40	20-40 20-35 5-15
507-------------- Canisteo	0-6 6-26 26-60	Silty clay loam Clay loam, loam, silty clay loam. Clay loam, loam, sandy loam.	CL CL CL, ML, SM, SC	A-7, A-6 A-6, A-7 A-6, A-4	0 0 0-5	100 98-100 90-100	100 90-100 80-95	90-100 85-95 60-90	85-100 65-85 40-80	35-50 38-50 30-40	15-25 25-35 5-15

TABLE 14.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
508---------- Wacousta Variant	0-8	Silty clay loam	CH, CL	A-7	0	100	100	95-100	95-100	40-65	20-40
	8-14	Silty clay loam	CH, CL	A-7	0	100	100	90-100	90-100	40-65	20-40
	14-60	Stratified sandy loam to silty clay loam.	CL, ML	A-6, A-4	0-5	95-100	95-100	85-100	80-90	30-40	5-15
559---------- Talcot	0-15	Clay loam--------	CL	A-7	0	100	100	80-90	60-85	40-50	15-25
	15-39	Clay loam, gravelly sandy loam, loam.	CL	A-7	0	95-100	85-100	70-90	60-85	40-50	15-25
	39-60	Stratified loamy sand to gravelly coarse sand.	SP, SP-SM, SW	A-1	0	65-90	50-85	20-50	2-10	---	NP
585B*: Coland----------	0-25	Clay loam--------	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	25-37	Clay loam, silty clay loam.	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	37-60	Loam, sandy loam, sandy clay loam.	CL, SC, CL-ML, SM-SC	A-4, A-6	0	100	90-100	60-70	40-60	20-40	5-15
Spillville------	0-49	Loam----------	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
	49-60	Sandy clay loam, loam, sandy loam.	CL, CL-ML, SM-SC, SC	A-6, A-4	0	100	95-100	80-90	35-75	20-40	5-15
733---------- Calco	0-24	Silty clay loam	CH, CL	A-7	0	100	100	95-100	85-100	40-60	15-30
	24-60	Silty clay loam, loam, clay loam.	CL	A-7, A-6	0	100	100	90-100	80-100	30-45	10-20
1048---------- Knoke	0-8	Mucky silt loam	OH, MH	A-7	0	100	100	95-100	90-95	60-90	10-30
	8-18	Silty clay loam, mucky silty clay loam.	MH, OH	A-7	0	100	100	90-100	80-95	55-90	15-40
	18-60	Silty clay loam, silty clay, clay loam.	MH, CH	A-7	0	95-100	95-100	90-100	80-95	55-70	25-40
1458---------- Millington	0-48	Loam, sandy loam	ML, CL, OL	A-6, A-7, A-4	0	90-100	90-100	80-100	70-95	30-45	8-17
	48-60	Loam, silty clay loam, sandy loam.	CL	A-7, A-6	0	95-100	90-100	80-100	70-95	28-50	10-22
1585B*: Coland----------	0-25	Clay loam--------	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	25-37	Clay loam, silty clay loam.	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	37-60	Loam, sandy loam, sandy clay loam.	CL, SC, CL-ML, SM-SC	A-4, A-6	0	100	90-100	60-70	40-60	20-40	5-15
Spillville------	0-49	Loam----------	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
	49-60	Sandy clay loam, loam, sandy loam.	CL, CL-ML, SM-SC, SC	A-6, A-4	0	100	95-100	80-90	35-75	20-40	5-15
5010*. Pits											
5040*. Orthents											

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS

[The symbol < means less than; > means more than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" and "Organic matter" apply only to the surface layer. Absence of an entry indicates that data were not available or were not estimated]

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors		Wind erodibility group	Organic matter
								K	T		
	In	Pct	G/cm³	In/hr	In/in	pH					Pct
4	0-8	27-36	1.30-1.40	0.2-0.6	0.21-0.23	7.4-8.4	High	0.37	5	7	9-12
Knoke	8-18	27-36	1.30-1.40	0.2-0.6	0.21-0.23	7.4-8.4	High	0.37			
	18-60	35-45	1.35-1.45	0.2-0.6	0.18-0.20	7.4-8.4	High	0.37			
6	0-60	35-42	1.25-1.30	0.2-0.6	0.21-0.23	6.6-7.8	High	0.37	5	4	9-12
Okoboji											
27B	0-23	18-26	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low	0.24	5	6	4-5
Terril	23-60	22-30	1.45-1.70	0.6-2.0	0.16-0.18	6.1-7.8	Low	0.32			
34B, 34C2	0-12	5-15	1.25-1.35	2.0-6.0	0.13-0.18	5.6-7.3	Low	0.20	3	3	2-4
Estherville	12-28	10-18	1.35-1.60	2.0-6.0	0.09-0.14	5.6-7.3	Low	0.20			
	28-60	0-8	1.50-1.65	6.0-20	0.02-0.04	6.6-8.4	Low	0.10			
48	0-8	20-26	1.10-1.20	0.6-2.0	0.24-0.26	7.4-8.4	Moderate	0.28	5	6	12-18
Knoke	8-18	27-36	1.30-1.40	0.2-0.6	0.21-0.23	7.4-8.4	High	0.37			
	18-60	35-45	1.35-1.45	0.2-0.6	0.18-0.20	7.4-8.4	High	0.37			
52B	0-11	32-36	1.40-1.50	0.6-2.0	0.17-0.19	6.1-7.3	Moderate	0.28	5	5	3-4
Bode	11-28	28-35	1.50-1.70	0.6-2.0	0.15-0.19	6.1-7.3	Moderate	0.28			
	28-60	22-27	1.70-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Low	0.28			
55	0-23	24-35	1.15-1.25	0.6-2.0	0.17-0.22	5.6-7.3	Moderate	0.24	5	6	5-6
Nicollet	23-38	24-35	1.25-1.35	0.6-2.0	0.15-0.19	5.6-7.8	Moderate	0.32			
	38-60	22-28	1.35-1.45	0.6-2.0	0.14-0.19	7.4-8.4	Low	0.32			
62C2, 62D2, 62E, 62F, 62G	0-6	18-27	1.35-1.45	0.6-2.0	0.20-0.22	7.4-8.4	Low	0.28	5	4L	1-2
Storden	6-60	18-27	1.35-1.65	0.6-2.0	0.17-0.19	7.4-8.4	Low	0.37			
90	0-13	20-26	1.20-1.25	0.6-2.0	0.24-0.26	5.1-6.5	High	0.37	5	4	12-18
Okoboji	13-60	35-42	1.30-1.35	0.2-0.6	0.18-0.20	6.6-7.8	High	0.37			
95	0-18	25-35	1.35-1.40	0.6-2.0	0.19-0.21	7.9-8.4	Moderate	0.24	5	4L	4-5
Harps	18-29	18-32	1.40-1.50	0.6-2.0	0.17-0.19	7.9-8.4	Moderate	0.32			
	29-60	20-26	1.50-1.70	0.6-2.0	0.17-0.19	7.9-8.4	Moderate	0.32			
107	0-12	26-36	1.35-1.40	0.6-2.0	0.19-0.21	6.6-7.3	Moderate	0.24	5	6	6-7
Webster	12-37	25-35	1.40-1.50	0.6-2.0	0.16-0.18	6.6-7.8	Moderate	0.32			
	37-60	18-29	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Moderate	0.32			
108, 108B	0-13	18-30	1.30-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Low	0.24	4	5	3-4
Wadena	13-30	18-30	1.35-1.50	0.6-2.0	0.14-0.19	5.6-7.3	Low	0.32			
	30-60	1-5	1.55-1.65	>6.0	0.02-0.04	6.6-8.4	Low	0.10			
108C2	0-8	18-30	1.30-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Low	0.24	4	5	2-3
Wadena	8-30	18-30	1.35-1.50	0.6-2.0	0.14-0.19	5.6-7.3	Low	0.32			
	30-60	1-5	1.55-1.65	>6.0	0.02-0.04	6.6-8.4	Low	0.10			
135, 135B	0-53	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High	0.28	5	7	5-7
Coland	53-60	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-8.4	High	0.28			
138B, 138C, 138C2, 138D2	0-14	18-24	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low	0.28	5	6	2-4
Clarion	14-41	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low	0.37			
	41-60	12-22	1.70-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Low	0.37			
202, 203	0-23	22-32	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Moderate	0.24	4	6	4-5
Cylinder	23-33	22-30	1.45-1.60	0.6-2.0	0.17-0.19	6.1-7.3	Moderate	0.32			
	33-60	2-12	1.60-1.70	>20	0.02-0.04	7.4-8.4	Low	0.10			
236B	0-11	15-27	1.30-1.40	0.6-2.0	0.20-0.22	5.6-6.5	Low	0.28	5	6	2-3
Lester	11-43	20-35	1.45-1.55	0.6-2.0	0.15-0.19	5.1-6.5	Moderate	0.28			
	43-60	20-30	1.55-1.75	0.6-2.0	0.14-0.19	7.3-8.4	Low	0.37			

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors		Wind erodibility group	Organic matter
								K	T		
	In	Pct	G/cm³	In/hr	In/in	pH					Pct
259----------	0-19	18-30	1.20-1.30	0.6-2.0	0.20-0.22	6.1-7.8	Moderate-----	0.28	4	6	5-7
Biscay	19-34	18-30	1.25-1.35	0.6-2.0	0.17-0.19	6.6-8.4	Moderate-----	0.28			
	34-60	1-6	1.55-1.65	6.0-20	0.02-0.04	7.4-8.4	Low----------	0.10			
274----------	0-21	22-28	1.35-1.40	0.6-2.0	0.22-0.24	5.1-7.3	Moderate-----	0.28	5	6	3-5
Rolfe	21-44	38-45	1.40-1.50	0.06-0.2	0.11-0.13	6.1-7.3	High---------	0.28			
	44-60	24-35	1.50-1.60	0.2-2.0	0.14-0.16	6.1-8.4	Moderate-----	0.28			
288----------	0-20	32-40	1.35-1.45	0.2-0.6	0.19-0.22	5.6-7.3	Moderate-----	0.28	5	7	5-6
Ottosen	20-48	30-40	1.45-1.55	0.2-0.6	0.17-0.19	6.1-8.4	Moderate-----	0.28			
	48-60	22-27	1.55-1.85	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.28			
308, 308B----------	0-13	18-30	1.30-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Low----------	0.24	4	5	3-4
Wadena	13-34	18-30	1.35-1.50	0.6-2.0	0.14-0.19	5.6-7.3	Low----------	0.32			
	34-60	1-5	1.55-1.65	>6.0	0.02-0.04	6.6-8.4	Low----------	0.10			
388----------	0-24	32-42	1.35-1.45	0.2-0.6	0.21-0.23	6.1-7.3	High---------	0.28	5	4	6-7
Kossuth	24-33	35-42	1.45-1.55	0.2-0.6	0.18-0.20	6.1-7.8	High---------	0.28			
	33-60	23-27	1.55-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Moderate-----	0.28			
485, 485B----------	0-60	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.28	5	6	4-6
Spillville											
506----------	0-16	30-36	1.20-1.25	0.6-2.0	0.21-0.23	6.1-7.3	High---------	0.28	5	7	8-10
Wacousta	16-24	32-40	1.25-1.30	0.6-2.0	0.18-0.20	7.4-7.8	High---------	0.43			
	24-60	16-24	1.30-1.40	0.6-2.0	0.20-0.22	7.4-8.4	Moderate-----	0.43			
507----------	0-6	18-35	1.20-1.30	0.6-2.0	0.20-0.22	7.4-8.4	Moderate-----	0.32	5	4L	6-7
Canisteo	6-26	20-35	1.35-1.50	0.6-2.0	0.15-0.19	7.4-8.4	Moderate-----	0.32			
	26-60	10-35	1.30-1.50	0.6-6.0	0.12-0.18	7.4-8.4	Low----------	0.32			
508----------	0-8	27-35	1.30-1.40	0.2-2.0	0.21-0.23	7.4-8.4	High---------	0.28	5	7	8-10
Wacousta Variant	8-14	27-35	1.30-1.40	0.2-2.0	0.18-0.20	7.4-8.4	High---------	0.37			
	14-60	20-30	1.35-1.45	0.6-2.0	0.20-0.22	7.4-8.4	Moderate-----	0.37			
559----------	0-15	27-35	1.20-1.30	0.6-2.0	0.18-0.22	7.4-8.4	Moderate-----	0.28	4	7	6-7
Talcot	15-39	25-35	1.25-1.35	0.6-2.0	0.17-0.20	7.4-8.4	Moderate-----	0.28			
	39-60	1-6	1.55-1.65	6.0-20	0.02-0.04	7.4-8.4	Low----------	0.15			
585B*:											
Coland----------	0-25	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28	5	7	5-7
	25-37	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28			
	37-60	12-26	1.50-1.65	2.0-6.0	0.13-0.17	6.1-8.4	Low----------	0.28			
Spillville------	0-49	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.28	5	6	4-6
	49-60	14-24	1.55-1.70	0.6-6.0	0.15-0.18	5.6-7.3	Low----------	0.28			
733----------	0-24	28-33	1.25-1.30	0.6-2.0	0.21-0.23	7.4-8.4	High---------	0.28	5	7	5-7
Calco	24-60	22-32	1.30-1.45	0.6-2.0	0.18-0.20	7.4-8.4	Moderate-----	0.28			
1048----------	0-8	20-26	1.10-1.20	0.6-2.0	0.24-0.26	7.4-8.4	Moderate-----	0.28	5	6	12-18
Knoke	8-18	27-36	1.30-1.40	0.2-0.6	0.21-0.23	7.4-8.4	High---------	0.37			
	18-60	35-45	1.35-1.45	0.2-0.6	0.18-0.20	7.4-8.4	High---------	0.37			
1458----------	0-48	20-27	1.40-1.60	0.6-2.0	0.20-0.24	7.4-8.4	Low----------	0.28	5	5	4-6
Millington	48-60	18-35	1.40-1.60	0.6-2.0	0.17-0.20	7.4-8.4	Moderate-----	0.28			
1585B*:											
Coland----------	0-25	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28	5	7	5-7
	25-37	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28			
	37-60	12-26	1.50-1.65	2.0-6.0	0.13-0.17	6.1-7.3	Low----------	0.28			
Spillville------	0-49	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.28	5	6	4-6
	49-60	14-24	1.55-1.70	0.6-6.0	0.15-0.18	5.6-7.3	Low----------	0.28			
5010*. Pits											
5040*. Orthents											

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 16.--SOIL AND WATER FEATURES

[The definitions of "flooding" and "water table" in the text explain terms such as "brief," "apparent," and "perched." The symbol < means less than; > means more than. Absence of an entry indicates that the feature is not a concern]

Soil name and map symbol	Hydrologic group	Flooding			High water table			Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months		Uncoated steel	Concrete
					Ft					
4---------- Knoke	B/D	None--------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Low.
6---------- Okoboji	B/D	None--------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Low.
27B---------- Terril	B	None--------	---	---	>6.0	---	---	Moderate	Moderate	Low.
34B, 34C2---------- Estherville	B	None--------	---	---	>6.0	---	---	Low------	Low------	Low.
48---------- Knoke	B/D	None--------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Low.
52B---------- Bode	B	None--------	---	---	>6.0	---	---	Moderate	Moderate	Low.
55---------- Nicollet	B	None--------	---	---	2.5-5.0	Apparent	Nov-Jul	High-----	High-----	Low.
62C2, 62D2, 62E, 62F, 62G---------- Storden	B	None--------	---	---	>6.0	---	---	Moderate	Low------	Low.
90---------- Okoboji	B/D	None--------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Low.
95---------- Harps	B/D	None--------	---	---	1.0-3.0	Apparent	Nov-Jun	High-----	High-----	Low.
107---------- Webster	B/D	None--------	---	---	1.0-2.0	Apparent	Nov-Jul	High-----	High-----	Low.
108, 108B, 108C2-- Wadena	B	None--------	---	---	>6.0	---	---	Low------	Low------	Low.
135, 135B---------- Coland	B/D	Occasional	Brief-----	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
138B, 138C, 138C2, 138D2---------- Clarion	B	None--------	---	---	>6.0	---	---	Moderate	Low------	Low.
202, 203---------- Cylinder	B	None--------	---	---	2.0-4.0	Apparent	Nov-Jul	High-----	Moderate	Low.
236B---------- Lester	B	None--------	---	---	>6.0	---	---	Moderate	Low------	Moderate.
259---------- Biscay	B/D	None--------	---	---	1.0-3.0	Apparent	Nov-Jun	High-----	Moderate	Low.
274---------- Rolfe	C	None--------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Moderate.
288---------- Ottosen	B	None--------	---	---	2.0-4.0	Apparent	Nov-Jul	High-----	High-----	Low.
308, 308B---------- Wadena	B	None--------	---	---	>6.0	---	---	Low------	Low------	Low.
388---------- Kossuth	B/D	None--------	---	---	1.0-2.0	Apparent	Nov-Jul	High-----	High-----	Low.

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydrologic group	Flooding			High water table			Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months		Uncoated steel	Concrete
					Ft					
485---------- Spillville	B	Frequent----	Very brief	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	Moderate	High-----	Moderate.
485B---------- Spillville	B	Occasional	Very brief	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	Moderate	High-----	Moderate.
506---------- Wacousta	B/D	None--------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Low.
507---------- Canisteo	C/D	None--------	---	---	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
508---------- Wacousta Variant	B/D	None--------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Low.
559---------- Talcot	B/D	None--------	---	---	1.0-2.0	Apparent	Nov-Jul	High-----	High-----	Low.
585B*:										
Coland----------	B/D	Frequent----	Brief-----	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
Spillville-------	B	Frequent----	Very brief	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	Moderate	High-----	Moderate.
733---------- Calco	B/D	Occasional	Brief-----	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
1048---------- Knoke	B/D	None--------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Low.
1458---------- Millington	B/D	Frequent----	Brief-----	Feb-Nov	0-2.0	Apparent	Nov-Jul	High-----	High-----	Low.
1585B*:										
Coland----------	B/D	Frequent----	Brief-----	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
Spillville-------	B	Frequent----	Very brief	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	Moderate	High-----	Moderate.
5010*. Pits										
5040*. Orthents										

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 17.--CLASSIFICATION OF THE SOILS

Soil name	Family or higher taxonomic class
Biscay	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Haplaquolls
Bode	Fine-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
Cylinder	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Aquic Hapludolls
Estherville	Coarse-loamy over sandy or sandy-skeletal, mixed, mesic Typic Hapludolls
Harps	Fine-loamy, mesic Typic Calciaquolls
Knoke	Fine, montmorillonitic (calcareous), mesic Cumulic Haplaquolls
Kossuth	Fine-loamy, mixed, mesic Typic Haplaquolls
Lester	Fine-loamy, mixed, mesic Mollic Hapludalfs
Millington	Fine-loamy, mixed (calcareous), mesic Cumulic Haplaquolls
Nicollet	Fine-loamy, mixed, mesic Aquic Hapludolls
Okoboji	Fine, montmorillonitic, mesic Cumulic Haplaquolls
Orthents	Loamy, mixed, mesic Typic Udorthents
Ottosen	Fine-loamy, mixed, mesic Aquic Hapludolls
Rolfe	Fine, montmorillonitic, mesic Typic Argialbolls
Spillville	Fine-loamy, mixed, mesic Cumulic Hapludolls
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
Wacousta Variant	Fine-silty, mixed (calcareous), mesic Typic Haplaquolls
Wadena	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Hapludolls
Webster	Fine-loamy, mixed, mesic Typic Haplaquolls

☆ U.S. GOVERNMENT PRINTING OFFICE: 1981-349-049/1066

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