SOIL SURVEY

Webster 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 the
Department of Soil Conservation, State of Iowa
Issued March 1975

Major fieldwork for this soil survey was done in the period 1961–1967. Soil names and descriptions were approved in 1969. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1967. This survey was made cooperatively by the Soil Conservation Service and the Iowa Agriculture and Home Economics Experiment Station, 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 Webster County Soil Conservation District.

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

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

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

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

Finding and Using Information

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

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

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

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

Game managers, sportsmen, and others can find information about soils and wildlife in the section "Use of the Soils for Wildlife and Recreation."

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

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

Newcomers in Webster County may be especially interested in the section "General Soil Map," where broad patterns of soils are described. They may also be interested in the section "General Nature of the County."

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SOIL SURVEY OF WEBSTER COUNTY, IOWA

BY MAYNARD P. KOPPEN, SOIL CONSERVATION SERVICE

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WEBSTER COUNTY is in the north-central part of Iowa (fig. 1). It has an area of about 459,520 acres. Fort Dodge, the county seat, is about 70 miles northwest of Des Moines, the State capital. The county is bounded on the north by Humboldt County, on the east by Hamilton and Wright Counties, on the west by Calhoun and Pocahontas Counties, and on the south by Boone and Greene Counties.

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

Most of the soils in Webster County formed under prairie vegetation, and they are dark and fertile. The soils near the larger rivers formed under trees, and they are lighter colored. The climate is subhumid and continental. Winters are cold, summers are warm, and the growing season is long enough for crops grown in the county to mature.

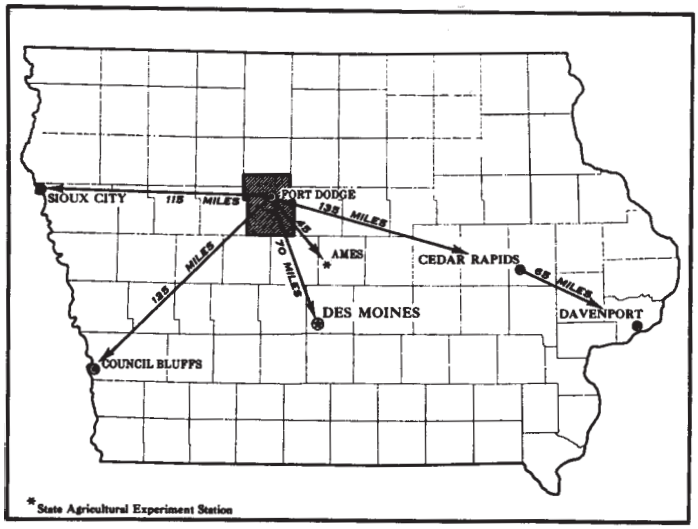

Figure 1.—Location of Webster County in Iowa.

How This Survey Was Made

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

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

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

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

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photo-

graphs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map at the back of this publication was prepared from aerial photographs.

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

Some mapping units are made up of soils of different series, or of different phases within one series. Two such kinds of mapping units are shown on the soil map of Webster County: the soil complex and the undifferentiated group.

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. An example is Storden-Hayden loams, 25 to 70 percent slopes.

An undifferentiated group is made up of two or more soils that could be delineated individually but are shown as one unit because, for the purpose of the soil survey, there is little value in separating them. The pattern and proportion of soils are not uniform. An area shown on the map may be made up of only one of the dominant soils, or two or more. The name of an undifferentiated group consists of the names of the dominant soils joined by "and." Rock land and Steep sandy land, 20 to 40 percent slopes, is an example.

In most areas surveyed there are places where the soil material is so rocky, so shallow, or so severely eroded that it cannot be classified by soil series. These places are shown on the soil map and are described in the survey, but they are called land types and are given descriptive names. Alluvial land, 2 to 5 percent slopes, is a land type in Webster County.

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

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in such a way as to be readily useful to different groups of users, among them farmers, managers of woodland, and engineers.

On the basis of yield and practice tables and other data, the soil scientists set up trial groups. They test these groups by further study and by consultation with farmers, agronomists, engineers, and others, then adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

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

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

The five soil associations in Webster County are discussed in the following pages. The terms for texture used in the descriptive heading for each association apply to the surface layer. For example, in the heading for association 1, the word "clayey" refers to the texture of the surface layer.

1. Marna-Guckeen association

Nearly level to gently sloping, poorly drained and somewhat poorly drained, loamy and clayey soils on uplands

This association is in the southern part of Webster County. It is mainly in the bottom tier of townships, but one area, southwest of the town of Callender, is in the second tier of townships north of the county line. The soils are mainly nearly level or gently sloping, but they are steeper in some places, mostly near streams (fig. 2). A few small rivers and creeks extend into this association, but the drainage pattern is not well established in most places. Some areas contain closed depressions.

This association occupies about 8 percent of the county. Marna soils make up about 56 percent of the association; Guckeen soils, about 25 percent; and minor soils, the remaining 19 percent.

The nearly level Marna soils are poorly drained. The slopes are long and in most places are slightly convex. These soils have a surface layer of black heavy silty clay loam about 14 inches thick. The subsoil is mainly olive gray. It is firm or very firm silty clay or clay in the upper part and is friable or firm clay loam or loam in the lower part.

The Guckeen soils have slopes of 1 to 3 percent and are somewhat poorly drained. These soils are on rises, generally at a slightly higher elevation than the Marna soils. They have a black surface layer, about 16 inches

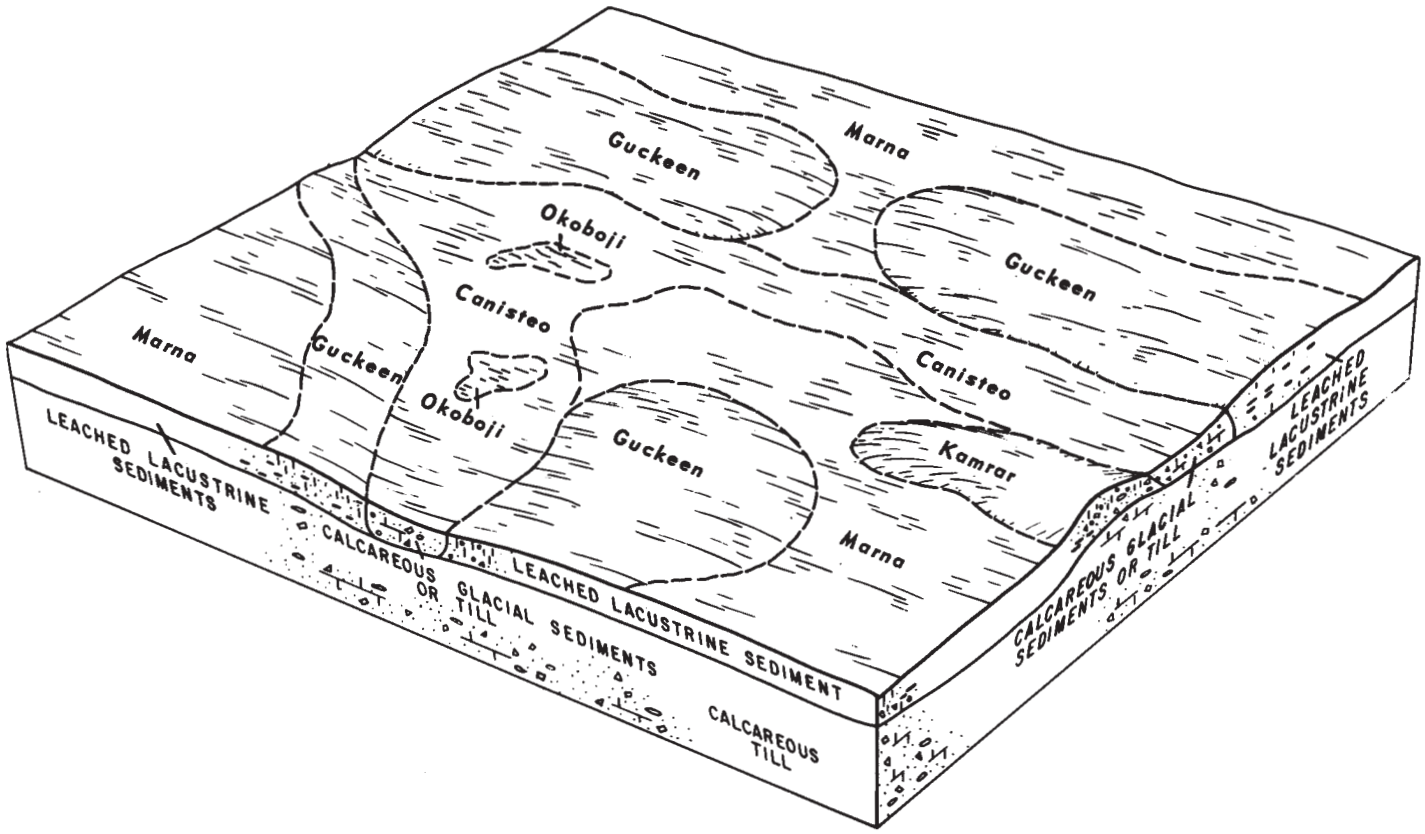

Figure 2.—**Relationship of slope and parent material to soils of the Marna-Guckeen soil association.**

thick, that is clay loam in the upper part and silty clay or clay in the lower part. The subsoil is mainly firm, dark grayish-brown light clay in the upper part and is firm, mottled, light olive-brown, olive-gray, yellowish-brown, and light-gray clay loam in the lower part.

Both the Marna and Guckeen soils formed partly in lacustrine sediment and partly in the underlying glacial till.

Minor soils in this association are mostly the Kamrar, Canisteo, Harps, Okoboji, Lanyon, and Rolfe soils, but they include a few areas of Muck. The Kamrar soils are gently sloping and are on knobs and rises upslope from the Marna and Guckeen soils. The Guckeen, Kamrar, and Marna soils formed in similar material, but the Guckeen soils are somewhat poorly drained, the Kamrar soils are moderately well drained, and the Marna soils are poorly drained. The Canisteo soils are nearly level and are in shallow swales. The Harps soils are on the narrow rims of closed depressions in most places, and they surround the soils that are in depressions. The Okoboji and Lanyon soils, both very poorly drained, and the few areas of Muck are in depressions that are commonly called potholes. The Rolfe soils generally are in small areas, typically within areas of Marna soils.

Artificial drainage is needed for many of the soils in this association. In most places tile drains are used to remove excess water, but open ditches are used in some places. Erosion is a hazard, mainly on the Kamrar soils, in a few sloping areas near streams and on a few of the longest slopes and steepest areas of Guckeen soils. In places contour tillage is used to help control erosion. Terraces are generally not built.

This association is used mostly for field crops. Corn and soybeans are the main crops, but oats, alfalfa, and alfalfa-grass mixtures are also grown to some extent (fig. 3). Much of the grain is sold for cash, but some farmers keep livestock, mainly hogs and beef cattle, and they use at least part of the grain they produce for livestock feed.

This association is served by a system of hard-surfaced and graveled roads that are mainly on section lines. Most of the farm fields have a rectangular shape. In recent years the trend has been to remove fences between fields so that fields are larger and rows are longer.

2. *Le Sueur-Luther-Hayden association*

Nearly level to moderately sloping, somewhat poorly drained and well drained, loamy soils on uplands

This association occupies a number of small areas on uplands near the valley of the Des Moines River. These areas are south of Fort Dodge. The topography of this association is undulating. This association consists of nearly level to moderately sloping soils on convex rises or on low hills and in numerous swales. The swales connect with deep gullies that extend from the sides of the valley of the Des Moines River. Some steep soils are along the drainageways and gullies that extend into areas of this association in places.

This association occupies about 3 percent of the county.

Figure 3.—Corn growing on Marna and Guckeen soils.

The Le Sueur soils make up about 33 percent of the association; Luther soils, about 33 percent; Hayden soils, about 22 percent; and minor soils, the remaining 12 percent.

The Le Sueur soils are somewhat poorly drained and mainly have slopes of 1 to 3 percent on slight rises. These soils have a surface layer of very dark gray loam about 7 inches thick. The subsurface layer is very dark grayish-brown loam about 5 inches thick. The subsoil is dark grayish-brown and grayish-brown, firm clay loam. These soils formed in glacial till under grass and trees.

The Luther soils are somewhat poorly drained and mainly have slopes of 1 to 3 percent on slight rises but are also on some slightly concave areas. These soils have a surface layer of very dark grayish-brown loam about 6 inches thick. The subsurface layer is dark grayish-brown loam about 4 inches thick. The subsoil is dark grayish-brown and brown, firm clay loam in the upper part and olive-gray, friable loam in the lower part.

The gently sloping to moderately sloping Hayden soils are well drained and are on the more abrupt rises in the association. These soils have a surface layer of very dark gray loam about 3 inches thick. The subsurface layer is dark grayish-brown to brown loam about 7 inches thick. The subsoil is mainly dark yellowish-brown and yellowish-brown firm clay loam.

Both Luther and Hayden soils formed in glacial till under trees.

Among the minor soils in this association are Cordova and Dundas soils in swales. The gently sloping to moderately sloping Lester soils are on rises and low knolls in association with the Le Sueur soils.

Erosion is a hazard on the sloping soils in this association. Contour tillage is the most common method used to control erosion. Providing drainage for the poorly drained soils in the swales is the most important concern in managing the soils in this association for crops. Tile drains are used and outlets generally are readily available.

Some areas of these soils are used for crops. Corn, soybeans, oats, and hay are the main crops. Other areas are in permanent bluegrass pasture or timbered pasture. A few areas are wooded and are used for wildlife habitat. The use of these soils generally depends, at least in part, on whether they are adjacent to steep soils on the valley sides or near intensively farmed, nearly level soils farther from the stream valley. Some areas are inaccessible because of gullies that extend into this association.

Many farms in this association consist partly of steeper

soils near the river or partly of undulating soils on uplands some distance from the stream valley. This generally influences the type of farming practiced. Some farms are of the cash-grain type, but most have livestock. Cow-calf herds are kept on some farms. Feeding beef cattle and raising hogs are also important enterprises. Poultry or sheep are raised on some farms, or dairying is practiced.

Roads have been built to serve farmsteads in this association or to lead to bridges over the Des Moines River. They are mainly surfaced with gravel. They commonly are on half- or quarter-mile lines as well as section lines and are routed to avoid steep soils. Where possible, fields are rectangular or square, but in places they are irregularly shaped. On the average, the fields in this association are not so large as those in other associations, except those in association 3.

3. *Storden-Hayden-Wadena association*

Nearly level to very steep, well-drained, loamy soils on bottom lands, benches, and valley sides

This association is mainly along the Des Moines River, but it extends along some of the larger tributaries, including Brushy Creek, Skillet Creek, and Lizard Creek, and also a short distance along a few smaller streams. This association consists mainly of very steep soils on valley sides, nearly level to gently sloping soils on benches, and nearly level soils on bottom lands. The very steep soils have many ravines and gullies that cut back into the upland. A distinct feature of the association is the contrast in relief between the valley sides and the adjacent benches and bottom lands (fig. 4).

This association occupies about 11 percent of the county. Storden and Hayden soils are closely intermingled and make up about 40 percent of the association; Wadena soils, about 10 percent; and minor soils, the remaining 50 percent.

The very steep Storden and Hayden soils occupy most of the valley sides. These soils occur together in intricate patterns on the landscape. Storden soils have a surface layer of very dark grayish-brown loam about 7 inches thick. The underlying material is yellowish-brown to light olive-brown, friable loam. These soils are calcareous throughout. Hayden soils have a surface layer of very dark gray loam about 3 inches thick. The subsurface layer is dark grayish-brown to brown loam about 7 inches thick. The subsoil is mainly dark yellowish-brown and yellowish-brown, firm clay loam. These soils formed in glacial till.

The nearly level to moderately sloping Wadena soils are well drained and are on benches along the streams. These soils have a surface layer of very dark brown loam about 12 inches thick. The subsoil is mainly dark yellowish-brown and brown loam that, in places, grades to sandy loam in the lower part. Wadena soils are underlain by sand and gravel at a depth of 24 to 40 inches.

Among the minor soils in this association are the Hanlon and Buckney soils and Sandy alluvial land on bottom lands and generally fairly close to the streams. Also on bottom lands are the Dorchester, Spillville, Colo, and Calco soils. The Biscay, Cylinder, and Estherville soils are on benches and are underlain by sand and gravel. The Ankeny, Spillville, Terril, and Turlin soils are on low benches and foot slopes. In places the Gosport and Boone

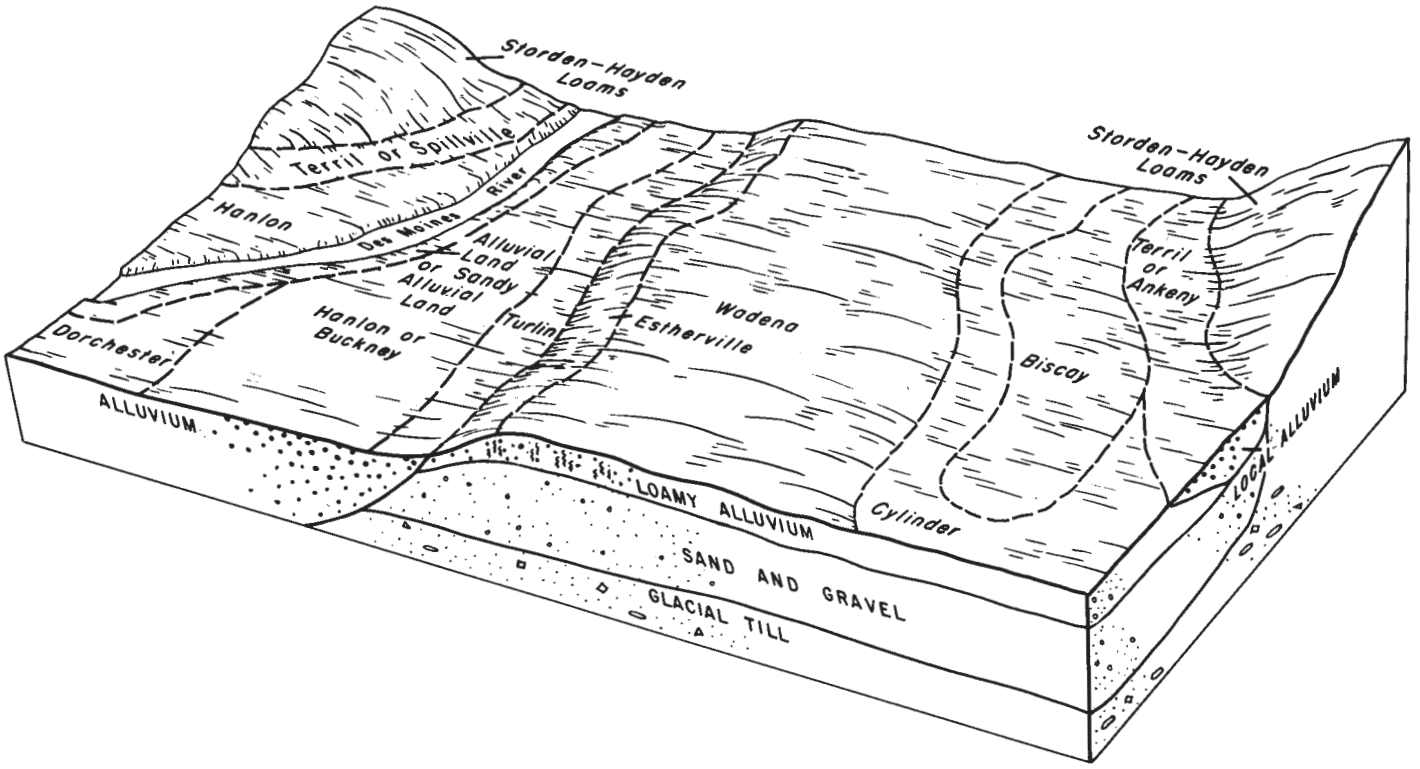

Figure 4.—**Relationship of slope and parent material to soils of the Storden-Hayden-Wadena soil association.**

soils are on the lower parts of the valley sides. The Gosport soils formed in material weathered from shale, and the Boone soils formed in material weathered from sandstone.

Erosion is a hazard on the sloping soils in this association. Contour tillage and, in places, terraces are used to control erosion. Many of the soils that are underlain by sand and gravel have limited available water capacity. Some areas of the soils are wet because of seepiness or a high water table and need artificial drainage if cultivated. Some areas of the soils on bottom lands are subject to flooding when streams overflow. Some farmers leave a strip of trees and brush between the Des Moines River and cultivated land to lessen flooding. Others attempt to stabilize the river bank by using rubble, and then grow crops to the edge of the river bank.

A large part of this association is wooded. It generally is used for pasture rather than as woodland, but a few areas are managed as woodland, and wood products are the major source of income. Other soils in this association are used for field crops or permanent bluegrass pasture. Corn, soybeans, oats, and hay, generally alfalfa or alfalfa-grass mixtures, are the main crops. A few truck gardens and apple orchards are also in this association. Some areas are a source of sand and gravel for roads and construction. A plant for the manufacture of clay products is near Lehigh.

Some farms are wholly in this association, but many consist partly of areas in this association and partly of areas on adjacent uplands. The farms differ widely. Some are general farms that generally have beef cattle or cow-calf herds to use the pasture. On others hogs, poultry, or sheep are raised or dairying is practiced. A number of people own homesites and small farms or acreages in this association. Many of these commute to jobs in nearby Fort Dodge. The output of these small farms is varied: apples are grown, and turkeys, mink, horses, and ponies are raised.

Most roads in this association provide access to bridges that cross the Des Moines River and other streams. Some are on foot slopes in the stream valley. These roads generally are crooked and seldom are on section lines. Fields and pastures in this association are irregular in shape and variable in size.

4. *Webster-Clarion-Nicollet association*

Nearly level to moderately steep, poorly drained, well-drained, and somewhat poorly drained, loamy soils on uplands

This association is mainly in the northern two-thirds of the county, but it is also in the southern and southwestern parts. The topography of much of this association is undulating. The well-drained and somewhat poorly drained soils in this association are nearly level to moderately sloping and are on convex rises, knolls, and low hills. The poorly drained or very poorly drained soils are nearly level and are on flats and in swales and depressions. In these areas the natural drainage system is not well established. In places drainage ditches have been dug to provide outlets for tile drains. In other places creeks and small streams extend into this association. Here the natural drainage pattern is better established, and in many places soils are steeper, especially in areas adjacent to the streams (fig. 5).

This association occupies about 56 percent of the county. Webster soils make up about 26 percent of the association; Clarion soils, about 24 percent; Nicollet soils, about 15 percent; and minor soils, the remaining 35 percent.

The poorly drained Webster soils are mainly in swales and draws that are generally slightly concave. Some areas are on flats. These soils have a surface layer of black, gritty silty clay loam about 18 inches thick. The subsoil is mainly olive-gray clay loam. It is firm in the upper part and friable in the lower part. These soils formed in glacial till and in sediment from glacial till.

The well-drained Clarion soils are mainly gently sloping and are on knolls and rises, but they are also moderately sloping to moderately steep in some areas. These soils have a surface layer of very dark brown loam about 11 inches thick. The subsoil is dark-brown, brown, and dark yellowish-brown, friable loam.

The somewhat poorly drained Nicollet soils mainly have slopes of 1 to 3 percent and are on convex rises. These soils have a surface layer of black heavy loam and light clay loam about 15 inches thick. The subsoil is mainly very dark grayish-brown and dark grayish-brown, friable light clay loam.

Both Clarion and Nicollet soils formed in glacial till.

Among the minor soils in this association are the Canisteo soils that are poorly drained and calcareous throughout. These soils occupy positions on the landscape similar to Webster soils and are the most extensive of the minor soils. Okoboji and Wacousta soils and Muck, shallow, are in the closed depressions. Harps soils are highly calcareous and are mainly on narrow rims around the depressions. Talcot and Biscay soils are nearly level and are in valley- or basin-like areas drained by small streams. The Storden soils are calcareous. In many places in this association, they are moderately sloping to steep.

Erosion is a hazard on the sloping soils in this association. The irregular pattern and short length of many slopes complicate the application of such conservation practices as contour farming or terracing, but these practices are used. The poorly drained and very poorly drained soils need artificial drainage. Tile lines and drainage ditches are used.

Most of the acreage in this association is used for crops. Some areas are in permanent pasture. Corn, soybeans, oats, and hay are the main crops. The hay is generally alfalfa, alfalfa-grass mixtures, or clover. Most areas of the nearly level to gently sloping soils are used for row crops.

A large amount of grain is sold for cash in this area, but most farms are diversified and have livestock. On these farms, part of the grain and most of the forage produced is fed to livestock. Raising and fattening hogs and feeding beef cattle are the most important livestock enterprises. Beef cow-calf herds, dairying, and the raising of sheep and poultry are of less importance. On a few farms turkeys are raised as a major enterprise.

This association is served by a network of hard-surfaced and graveled roads. Asphalt-surfaced roads connect most towns with major highways. Most roads are on section lines. Fields are mainly square or rectangular in shape. They are generally large, and the trend is to remove fences so that they can be made larger. In more rolling parts of the association there is more variation

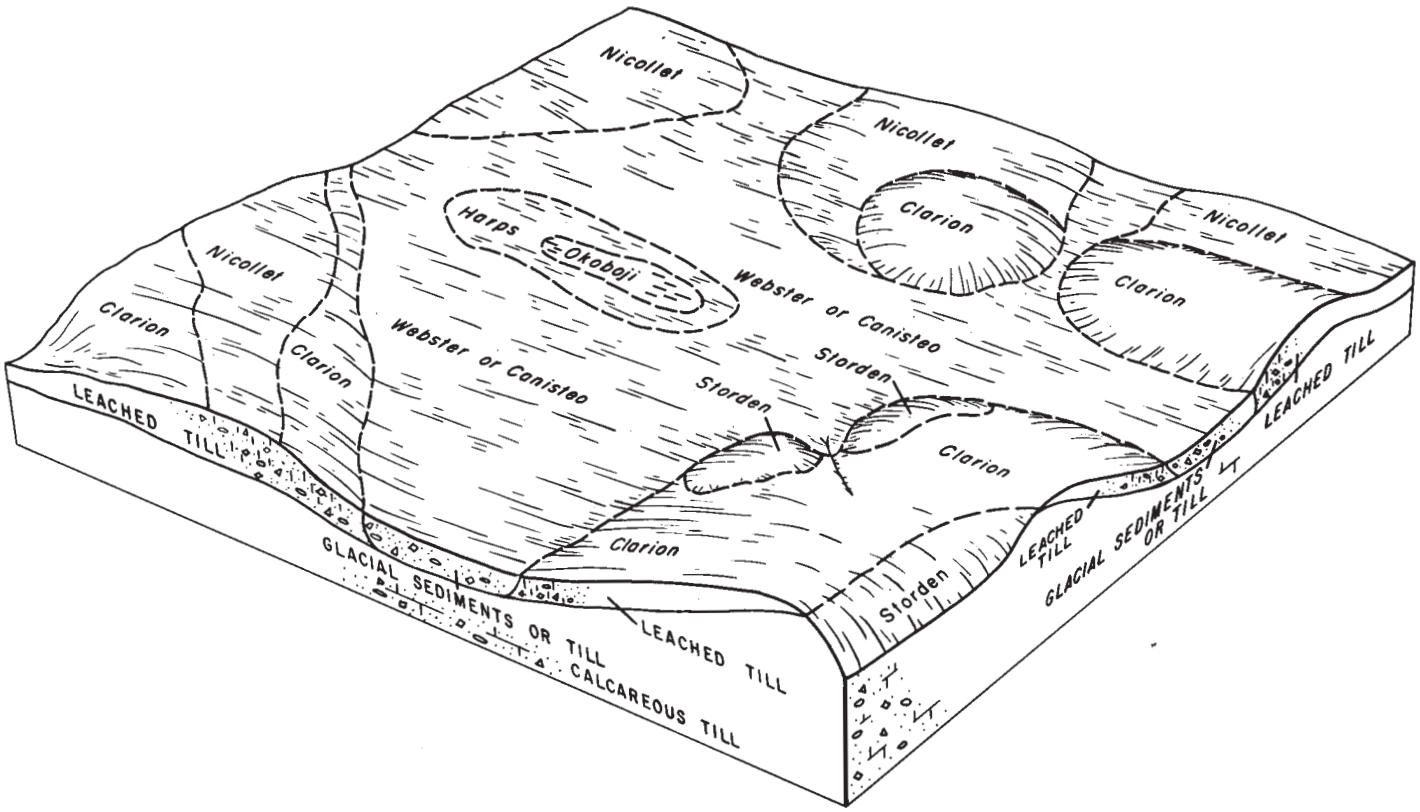

Figure 5.—**Relationship of slope and parent material to soils of the Webster-Clarion-Nicollet soil association.**

in the size and shape of fields. The few trees in this association are mainly windbreaks and ornamentals around farmsteads. A few are along fence lines or in small stream valleys.

5. *Webster-Nicollet-Canisteo association*

Nearly level, poorly drained and somewhat poorly drained, loamy soils on uplands

This association occupies a large acreage in the southern part of the county. The topography is mainly nearly level, but it is slightly undulating in many places. Most of this association consists of nearly level soils in wide, very shallow swales or on flats, but there are many slight convex rises and many large and small depressions (fig. 6). The natural drainage pattern in most of the association is indistinct and not well established. In places, however, small, sluggish streams in indistinct valleys extend into the association. In places drainage ditches have been dug in these valleys to provide outlets for tile drains (fig. 7). The ditches generally begin in a large depression and eventually empty into larger, well-defined streams.

This association occupies about 22 percent of the county. Webster soils make up about 35 percent of the association; Nicollet soils, about 30 percent; Canisteo soils, about 15 percent; and minor soils, the remaining 20 percent.

The poorly drained Webster soils have a surface layer of black gritty silty clay loam about 18 inches thick. The subsoil is mainly olive-gray clay loam. It is firm in the upper part and friable in the lower part.

The somewhat poorly drained Nicollet soils mainly have slopes of 1 to 3 percent and are on slight convex rises. These soils have a surface layer of black heavy loam and light clay loam about 15 inches thick. The subsoil is mainly very dark grayish-brown and dark grayish-brown, friable light clay loam. These soils formed in glacial till.

The poorly drained Canisteo soils are similar to the Webster soils in most profile characteristics but are calcareous at the surface and throughout the profile. Webster and Canisteo soils formed in glacial till and in sediment from glacial till, and they are in wide swales and on flats. Canisteo soils generally are at a slightly lower elevation than Webster soils.

Among the minor soils in this association are the gently sloping to moderately sloping Clarion soils on knolls or low hills and sides of stream valleys. The highly calcareous Harps soils are on narrow rims around depressions. The very poorly drained Okoboji and Wacousta soils and Muck, shallow, are in these depressions.

Much of this association needs artificial drainage. Most areas are drained by tile lines, but shallow drainage ditches are used to drain some depressions, and large drainage ditches are used in places.

Water erosion is a hazard in a few areas. These soils commonly are plowed in fall, and large areas are then left bare. If the surface is dry in spring and other weather conditions are right, soil blowing is a serious hazard in places. Soil blowing causes road ditches on the windward side of some fields to fill with soil, and clearing these ditches generally is expensive.

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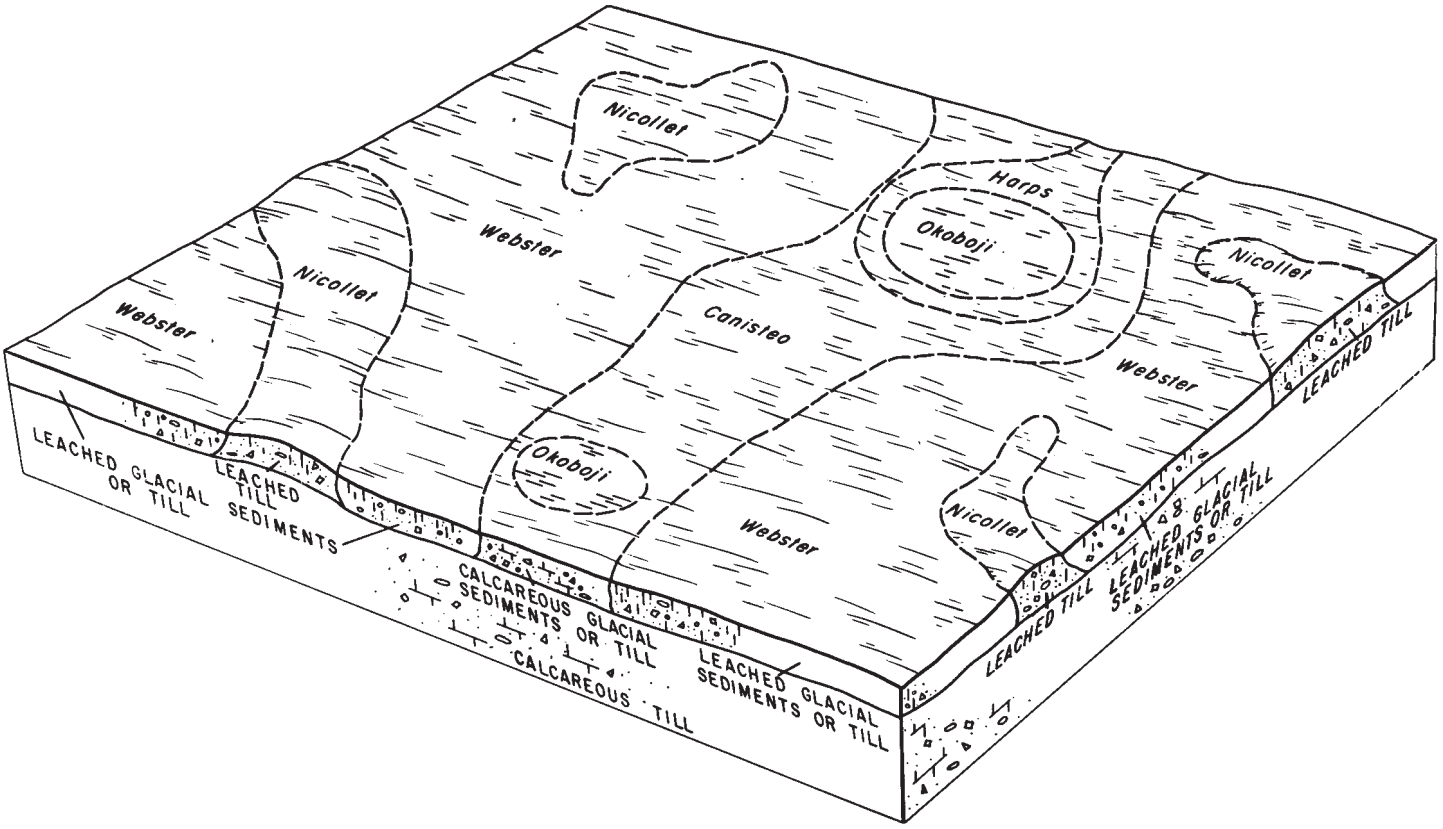

Figure 6.—**Relationship of slope and parent material to soils of the Webster-Nicollet-Canisteo soil association.**

The soils of this association are mainly used intensively for corn and soybeans. Oats and hay—generally alfalfa, alfalfa-grass mixtures, or clover—are also grown, but the acreage is minor compared to that used for row crops.

Many farmers in this association derive most of their income from the sale of corn and soybeans, but others also keep livestock and feed part of the corn and all of the forage they produce to livestock. Raising and fattening hogs and feeding beef cattle are the most important livestock enterprises. Only a few farmers keep such other types of livestock as sheep, poultry, or dairy herds.

The trees in this association are mainly in windbreaks or are ornamentals that have been planted around farmsteads. A few trees grow along drainage ditches or fence lines. Fields are large and generally are square or rectangular in shape. The trend is to remove fences so that fields can be made larger and rows of row crops longer. Graveled roads are on most section lines in this association. Hard-surfaced roads connect towns with major highways.

Figure 7.—**Drainage ditch in the Webster-Nicollet-Canisteo soil association. Canisteo soils are adjacent to the ditch.**

Descriptions of the Soils

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

An important part of the description of each soil series is the soil profile, that is, the sequence of layers from the surface downward to rock or other underlying material. Each series contains two descriptions of this profile. The first is brief and in terms familiar to the layman. The second, detailed and in technical terms, is for scientists, engineers, and others who need to make thorough and precise studies of soils. Unless it is otherwise stated, the colors given in the descriptions are those of a moist soil.

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

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

The acreage and proportionate extent of each mapping unit are shown in table 1. Many of the terms used in describing soils can be found in the Glossary at the end of this survey, and more detailed information about the terminology and methods of soil mapping can be obtained from the Soil Survey Manual (*16*).[1]

Alluvial Land

Alluvial land, 2 to 5 percent slopes (315B), consists of sandy and loamy material deposited by overflowing streams. This soil is mainly in the valleys of small tributary streams that flow into the larger streams of the county. Almost half of it is similar to Hanlon sandy loam, but more variable in texture.

Most areas are in pasture. In most places the vegetation is grass, brush, and willows. This land is well suited to pasture. It is also suited to wildlife habitat. Many areas flood whenever streams overflow. Many areas have limited available water during dry periods, but a water table generally is below the water level of the streams. Plants that are deep-rooted enough to reach this water table grow well. Capability unit Vw–1; woodland suitability group 5w2.

Ankeny Series

The Ankeny series consists of dark-colored, well-drained soils that formed in loamy alluvium. These soils are on foot slopes, low benches, and bottom lands. In places they have been affected by materials deposited by wind. They are nearly level to gently sloping. Foot slopes are concave, and rises on the benches and bottom lands are convex and elongated. These soils are mainly in the Storden-Hayden-Wadena soil association. Size of individual areas is generally 5 to 50 acres. The native vegetation was mainly grass, brush, and trees.

In a representative profile, the surface layer is fine sandy loam about 28 inches thick. It is black in the upper part and very dark grayish brown in the lower part. The subsoil is brown, very friable fine sandy loam to a depth of about 52 inches. The underlying material is brown sand.

The available water capacity is low or moderate, permeability is moderately rapid or rapid, and the content of organic matter is moderate. The surface layer is generally neutral. The subsoil is very low in available phosphorus and available potassium.

Ankeny soils are mostly cultivated. In some areas they are subject to erosion.

Representative profile of Ankeny fine sandy loam, 0 to 3 percent slopes, in a cultivated field 200 feet east and 400 feet north of the southwest corner of NE¼NW¼ sec. 31, T. 90 N., R. 28 W.

Ap—0 to 6 inches, black (10YR 2/1) fine sandy loam, very dark brown (10YR 2/2) when kneaded; very weak, fine, subangular blocky structure; very friable when moist, slightly hard when dry; neutral; gradual, smooth boundary.

A12—6 to 18 inches, black (10YR 2/1) fine sandy loam, very dark brown (10YR 2/2) when kneaded; very weak, medium, subangular blocky structure; very friable when moist, slightly hard when dry; neutral; gradual, smooth boundary.

A13—18 to 24 inches, very dark brown (10YR 2/2) fine sandy loam, very dark grayish brown (10YR 3/2) when dry; weak, fine, subangular blocky structure; very friable when moist, slightly hard when dry; neutral; gradual, smooth boundary.

A3—24 to 28 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, dark grayish brown (10YR 4/2) when dry; weak, very fine, subangular blocky structure; very friable when moist, slightly hard when dry; neutral; gradual, smooth boundary.

B1—28 to 34 inches, dark-brown (10YR 3/3) fine sandy loam, faces of peds very dark grayish brown (10YR 3/2); weak, very fine, subangular blocky structure; very friable when moist, slightly hard when dry; mildly alkaline; gradual, smooth boundary.

B2—34 to 40 inches, brown (10YR 4/3) fine sandy loam, faces of peds dark brown (10YR 3/3); very weak, fine, subangular blocky structure; very friable when moist, slightly hard when dry; mildly alkaline; gradual, smooth boundary.

B3—40 to 52 inches, brown (10YR 4/3) light sandy loam, brown (10YR 5/3) to yellowish brown (10YR 5/4) when dry; very weak, fine, subangular blocky structure; very friable when moist, slightly hard when dry; mildly alkaline; gradual, smooth boundary.

C—52 to 62 inches, brown (7.5YR 4/4) sand, yellowish brown (10YR 5/4) when dry; single grain; loose; mildly alkaline.

The A horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2) in color and from 24 to 36 inches in thickness. The B horizon ranges from dark brown (10YR 3/3) to brown (10YR 4/3 and 5/3) or dark yellowish brown (10YR 4/4). In many places it is loamy sand or sand in the lower part. The B horizon generally extends to a depth of about 4 to 5 feet. The C horizon is brown (10YR 4/3 or 5/3 to 7.5Y 4/4), dark yellowish-brown (10YR 4/4), or yellowish-brown (10YR 5/4) loamy fine sand or sand. Reaction of the A horizon is slightly acid to neutral. The B horizon is slightly acid to mildly alkaline, but this horizon is not calcareous. The C horizon is neutral to moderately alkaline. In places where it is mildly alkaline or moderately alkaline it generally is calcareous.

Ankeny soils formed in parent material similar to the Hanlon and Buckney soils. Ankeny soils are browner in the B horizon and better drained than the Hanlon soils. They are less stratified and have a thicker, darker colored A horizon than the Buckney soils, and unlike the Buckney soils, they are not calcareous.

[1] Italic numbers in parentheses refer to Literature Cited, p. 119.

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

Soil	Area	Extent	Soil	Area	Extent
	Acres	*Percent*		*Acres*	*Percent*
Alluvial land, 2 to 5 percent slopes	517	0.1	Okoboji mucky silt loam	3,719	0.8
Ankeny fine sandy loam, 0 to 3 percent slopes	254	.1	Okoboji silty clay loam	20,526	4.5
Billett fine sandy loam, 1 to 5 percent slopes	173	(1)	Rock land and Steep sandy land, 20 to 40 percent slopes	203	(1)
Billett fine sandy loam, 5 to 10 percent slopes	284	.1	Rockton loam, 2 to 5 percent slopes	166	(1)
Biscay clay loam, deep	1,530	.3	Rolfe silt loam	560	.1
Boone loamy fine sand, 25 to 45 percent slopes	1,960	.4	Sandy alluvial land	5,338	1.2
Buckney fine sandy loam, 0 to 2 percent slopes	348	.1	Spillville loam, 0 to 2 percent slopes	973	.2
Buckney fine sandy loam, 2 to 6 percent slopes	221	(1)	Spillville loam, 2 to 5 percent slopes	1,161	.3
Calamine silty clay loam, 2 to 5 percent slopes	140	(1)	Storden loam, 5 to 9 percent slopes, moderately eroded	527	.1
Calamine silty clay loam, 5 to 14 percent slopes	120	(1)	Storden loam, 9 to 14 percent slopes, moderately eroded	1,032	.2
Calco silty clay loam	221	(1)	Storden loam, 14 to 18 percent slopes, moderately eroded	361	.1
Canisteo silty clay loam	54,089	11.8	Storden loam, 18 to 25 percent slopes, moderately eroded	686	.1
Clarion loam, 0 to 2 percent slopes	247	.1	Storden loam, 25 to 45 percent slopes, moderately eroded	1,736	.4
Clarion loam, 2 to 5 percent slopes	54,121	11.8	Storden-Hayden loams, 25 to 70 percent slopes	20,052	4.4
Clarion loam, 5 to 9 percent slopes	769	.2	Talcot clay loam, deep	963	.2
Clarion loam, 5 to 9 percent slopes, moderately eroded	7,677	1.7	Talcot clay loam, moderately deep	125	(1)
Clarion loam, 9 to 14 percent slopes, moderately eroded	464	.1	Terril loam, 5 to 9 percent slopes	476	.1
Clarion loam, 14 to 18 percent slopes, moderately eroded	118	(1)	Terril loam, 9 to 14 percent slopes	193	(1)
Colo silty clay loam	4,997	1.1	Terril loam, sandy substratum, 2 to 5 percent slopes	421	.1
Colo-Spillville complex, 2 to 5 percent slopes	630	.1	Terril loam, thin surface variant, 5 to 9 percent slopes	617	.1
Cordova silty clay loam	824	.2	Terril loam, thin surface variant, 9 to 14 percent slopes	193	(1)
Cylinder loam, deep	1,119	.2	Terril loam, thin surface variant, 14 to 18 percent slopes	171	(1)
Cylinder loam, moderately deep	699	.2	Turlin loam, 2 to 5 percent slopes	729	.2
Dorchester silt loam	359	.1	Wacousta silt loam	5,214	1.2
Dorchester silt loam, frequently flooded	169	(1)	Wadena loam, deep, 0 to 2 percent slopes	350	.1
Dundas silt loam	528	.1	Wadena loam, deep, 2 to 5 percent slopes	494	.1
Estherville sandy loam, 0 to 2 percent slopes	183	(1)	Wadena loam, moderately deep, 0 to 2 percent slopes	2,287	.5
Estherville sandy loam, 2 to 5 percent slopes	1,624	.4	Wadena loam, moderately deep, 2 to 5 percent slopes	1,860	.4
Estherville sandy loam, 5 to 9 percent slopes	380	.1	Wadena loam, moderately deep, 5 to 9 percent slopes	176	(1)
Estherville sandy loam, 9 to 14 percent slopes	346	.1	Wadena loam, thin surface variant, deep, 2 to 5 percent slopes	195	(1)
Gosport silt loam, 25 to 45 percent slopes	518	.1	Wadena loam, thin surface variant, moderately deep, 2 to 5 percent slopes	188	(1)
Guckeen clay loam, 1 to 3 percent slopes	8,620	1.9	Webster silty clay loam	113,321	24.6
Hanlon fine sandy loam, 0 to 3 percent slopes	1,830	.4	Webster silty clay loam, benches, 0 to 3 percent slopes	640	.1
Harps clay loam	14,683	3.2	Gravel pits and quarries	3,047	.7
Hayden loam, 2 to 5 percent slopes	4,352	1.0	Water, borrow pits, and miscellaneous land	1,127	.3
Hayden loam, 5 to 9 percent slopes	274	.1			
Jacwin loam, 1 to 3 percent slopes	151	(1)	Total	459,520	100.0
Kamrar clay loam, 2 to 5 percent slopes	467	.1			
Lanyon silty clay	1,442	.3			
Lester loam, 2 to 5 percent slopes	2,237	.5			
Lester loam, 5 to 9 percent slopes	294	.1			
Lester loam, 9 to 14 percent slopes	223	(1)			
Lester loam, 14 to 18 percent slopes	203	(1)			
Lester loam, 18 to 35 percent slopes	390	.1			
Le Sueur loam, 1 to 3 percent slopes	4,313	.9			
Luther loam, 1 to 3 percent slopes	4,229	.9			
Marna silty clay loam	19,580	4.3			
Minnetonka silty clay loam	346	.1			
Muck, shallow	1,631	.4			
Muck, shallow, 5 to 14 percent slopes	86	(1)			
Nicollet loam, 1 to 3 percent slopes	68,362	14.9			
Nicollet loam, benches, 3 to 6 percent slopes	351	.1			

[1] Less than 0.05 percent.

Ankeny fine sandy loam, 0 to 3 percent slopes (136A).—This soil is on low benches and bottom lands, on convex elongated rises, and on foot slopes. In many places it is associated with the Hanlon soils and is commonly downslope from Hayden or Storden soils.

Included with this soil in mapping are areas of a soil that has slopes up to about 5 percent.

Most areas of this soil are in crops. Some areas are in grass, trees, and weeds. Areas that are not cultivated are generally the long, narrow strips between very steep soils and the river. These areas are small and are generally managed with the steeper soils. This soil is only moderately suited to row crops because of limited available water capacity. Some areas of the more sloping soils, especially those on foot slopes, are subject to erosion and to rilling by water that flows across them. Soil blowing is a hazard if this soil is not protected by a cover of plants. Tilth is generally good. Capability unit IIIs–1; woodland suitability group 5w2.

Billett Series

The Billett series consists of moderately dark colored, well-drained soils that formed in loamy and sandy material deposited by water and wind. These soils are mainly on high benches, but they occupy short escarpments in some places. The areas are long and narrow and are along the Des Moines River in the Storden-Hayden-Wadena soil association. Slopes are convex to concave and range from 1 to 10 percent. Size of the individual areas is generally 2 to 20 acres. The native vegetation was grasses and trees.

In a representative profile, the surface layer is very dark grayish-brown fine sandy loam about 10 inches thick. The subsurface layer, about 12 inches thick, is very dark grayish-brown and dark grayish-brown, very friable fine sandy loam in the upper part and dark grayish-brown, very friable loamy fine sand in the lower part. The upper part of the subsoil, to a depth of about 46 inches, is brown, very friable and friable fine sandy loam and fine sandy clay loam. The lower part of the subsoil, to a depth of about 52 inches, is brown, loose fine sand. Below that depth and extending to a depth of 60 inches or more, it is dark reddish-brown, slightly cemented fine sand.

The available water capacity is low or moderate, permeability is moderately rapid or rapid, and the content of organic matter is low. The surface layer and the subsurface layer are generally neutral or slightly acid. The most acid part of the subsoil is medium acid, and the rest of the subsoil is slightly acid or neutral. The subsoil is low in available phosphorus and very low in available potassium.

Billett soils are used for cultivated crops to some extent, but some areas are too droughty for cultivated crops. Other areas are managed along with steeper soils or with other soils that are not well suited to crops. Billett soils are subject to water erosion. They are also subject to soil blowing if they are cultivated and left bare. In many places available water is insufficient for good crop growth during dry periods.

Representative profile of Billett fine sandy loam, 5 to 10 percent slopes, in an idle area that has a cover of bluegrass; 400 feet west and 500 feet north of the southeast corner of NE¼SE¼ sec. 21, T. 86 N., R. 27 W.

A1—0 to 10 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; very weak, medium, subangular blocky structure that has a tendency to part into thin plates; very friable when moist; neutral; clear, smooth boundary.

A21—10 to 16 inches, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) fine sandy loam, light brownish gray (2.5Y 6/2) when dry; very weak, medium, subangular blocky structure that has a tendency to part into thin plates; very friable when moist; abundant uncoated sand grains; slightly acid; gradual, smooth boundary.

A22—16 to 22 inches, dark grayish-brown (10YR 4/2) loamy fine sand, light brownish gray (2.5Y 6/2) when dry; very weak, medium, subangular blocky structure; very friable when moist; abundant uncoated sand grains; slightly acid; clear, smooth boundary.

B21t—22 to 30 inches, brown (7.5YR 4/4) fine sandy loam; weak, medium, subangular blocky structure; very friable when moist; thin, discontinuous, dark reddish-brown (5YR 3/3 and 5YR 3/4) clay films; abundant uncoated sand grains; medium acid; gradual, smooth boundary.

B22t—30 to 46 inches, brown (7.5YR 4/4) fine sandy clay loam; weak, medium, subangular blocky structure; friable when moist; thin, discontinuous clay films; common uncoated sand grains; slightly acid; abrupt, smooth boundary.

IIB31—46 to 52 inches, brown (7.5YR 4/4) fine sand; single grain; loose; neutral; abrupt, smooth boundary.

IIB32t—52 to 60 inches, dark reddish-brown (5YR 3/4) medium loamy sand and sand; massive; slightly cemented; thick, discontinuous clay films; neutral.

The A1 horizon ranges from very dark gray (10YR 3/1) to very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2) in color and from 6 to 10 inches in thickness. It has granular or subangular blocky structure, but the structure tends toward platy. The A2 horizon is very dark grayish brown (10YR 3/2) or dark grayish brown (10YR 4/2), and it ranges from 4 to 12 inches in thickness. The B horizon is brown (7.5YR 4/4 to 10YR 4/3) to yellowish brown (10YR 5/4 or 10YR 5/6). It is very friable or friable fine sandy loam or fine sandy clay loam in the upper part and grades gradually or abruptly to fine sand or loamy medium sand or sand in the lower part. In places the B horizon is dark reddish brown (5YR 3/3) to strong brown (7.5YR 5/8) in the lower part. The B horizon is 20 to 40 inches thick. The C horizon, which is not included in the description of the representative profile, is loose fine or medium loamy sand or sand that is similar in color to the B horizon. Reaction of the A horizon is slightly acid to neutral. The B horizon is medium acid to slightly acid. The C horizon is neutral to moderately alkaline, and in places it is calcareous.

Billett soils in Webster County have a texture finer than loamy fine sand to a greater depth than is recognized for the Billett series. This difference does not markedly affect the loamy fine sand to a greater depth than is recognized for the use and management of these soils.

Billett soils have a grayer A1 horizon than the Wadena soils. Also, unlike the Wadena soils, they have a dark grayish-brown and grayish-brown A2 horizon, and they are not underlain by calcareous sand and gravel as are the Wadena soils. The Billett soils and soils of the Wadena series, thin surface variant, formed under similar vegetation, but the Billett soils are underlain by fine and medium sand instead of by sand and gravel. The Billett soils are finer textured in the upper part of the profile than the Boone soils, and they are not underlain by sandstone as are the Boone soils.

Billett fine sandy loam, 1 to 5 percent slopes (775B).—This soil is on benches. Included with it in mapping are areas of a soil that is underlain by coarse sand. Also included are areas in which the surface layer is light colored and thinner than is typical for Billett soils.

This Billett soil generally occurs with the more sloping soils, and it is commonly used for the same crops as the associated soils. Nearly all of the acreage is in permanent bluegrass pasture, other kinds of pasture, or hay crops. A limited available water capacity makes this soil only moderately well suited to row crops. Soil blowing is a hazard at times, and areas of the steeper soils are subject to water erosion if row crops are grown. This soil is generally in good tilth. Capability unit IIIs–1; woodland suitability group 3s1.

Billett fine sandy loam, 5 to 10 percent slopes (775C).—This soil is on benches. It has the profile described as representative for the Billett series.

Included with this soil in mapping are areas of a soil that is underlain by coarse sand, and other areas in which the surface layer is light colored and thinner than is typical for Billett soils. Also included are a few areas of a soil on foot slopes in Washington, Otho, and Pleasant Valley Townships, below areas of Boone soils. In these areas the surface layer is thicker than is typical for Billett soils.

Nearly all of the acreage is in permanent bluegrass pasture, other kinds of pasture, or hay crops. In many places inadequate available water is a severe limitation if row crops are grown on this soil. Soil blowing is also a hazard at times, and water erosion is a hazard where row crops are grown. Tilth is generally good. Capability unit IIIe–3; woodland suitability group 3s1.

Biscay Series

The Biscay series consists of dark-colored, poorly drained soils that formed in loamy alluvium. These soils are underlain by calcareous sand and gravel at a depth of about 32 to 40 inches. They are mainly on benches but also are on uplands. They are generally nearly level but in places are in slight depressions. Most of these soils are in the Webster-Clarion-Nicollet and Storden-Hayden-Wadena soil associations. A few small areas are in the Webster-Nicollet-Canisteo soil association. Individual areas are 2 to more than 100 acres in size, but most are less than 20 acres. The native vegetation was sedges and prairie grasses tolerant of wetness.

In a representative profile, the surface layer is black light clay loam about 19 inches thick. The subsoil is about 20 inches thick. It is very dark gray and dark-gray, friable light clay loam in the upper part and olive-gray, friable sandy clay loam in the lower part. The underlying material is loose olive-gray sand and gravel.

The available water capacity is moderate. Permeability is moderate to moderately slow in the upper part of the soil and rapid or very rapid in the underlying sand and gravel. The content of organic matter is high. The surface layer and the upper part of the subsoil are generally neutral. The subsoil is very low in available phosphorus and available potassium. Biscay soils are wet because of the high water table.

Representative profile of Biscay clay loam, deep, in a cultivated field 75 feet south and 600 feet west of the northeast corner of the NE¼ sec. 22, T. 89 N., R. 29 W.

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

A12—8 to 14 inches, black (10YR 2/1) light clay loam; weak, fine, granular and very fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

A3—14 to 19 inches, black (10YR 2/1) light clay loam; few, medium, dark olive-gray (5Y 3/2) mottles; weak, fine, granular and very fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

B1—19 to 23 inches, very dark gray (10YR 3/1) light clay loam; common, medium, olive-gray (5Y 4/2) mottles; weak, fine and medium, subangular blocky structure parting to weak, very fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

B21g—23 to 27 inches, dark-gray (5Y 4/1) and olive-gray (5Y 4/2) light clay loam, dark gray (5Y 4/1) when kneaded; weak, fine, prismatic structure parting to weak, very fine, subangular blocky structure; friable; mildly alkaline; clear, wavy boundary.

B22g—27 to 36 inches, olive-gray (5Y 4/2) light sandy clay loam; weak, medium, prismatic structure; worm channels filled with dark-gray (5Y 4/1) material; friable; mildly alkaline; abrupt, wavy boundary.

B3g—36 to 39 inches, olive-gray (5Y 4/2) light sandy clay loam; weak, medium, prismatic structure; worm channels filled with dark-gray (5Y 4/1) material; friable; mildly alkaline; clear, wavy boundary.

IIC1g—39 to 47 inches, olive-gray (5Y 5/2) gravelly loamy sand; structureless; loose; 20 percent gravel; mildly alkaline; slightly effervescent; clear, smooth boundary.

IIC2g—47 to 54 inches, olive-gray (5Y 5/2) sand and gravel; single grain; loose; 30 percent gravel; moderately alkaline; strongly effervescent; gradual, smooth boundary.

IIC3g—54 to 60 inches, olive-gray (5Y 4/2) sand and gravel; single grain; loose; 15 percent gravel; moderately alkaline; strongly effervescent.

The A horizon ranges from black (10YR 2/1 or N 2/0) to very dark gray (10YR 3/1) in color, from friable heavy loam to clay loam in texture, and from 16 to 22 inches in thickness. The B horizon ranges from very dark gray (10YR 3/1 to 5Y 3/1) to olive gray (5Y 4/2 or 5Y 5/2) or grayish brown (2.5Y 5/2) in color and from friable heavy loam to light clay loam or sandy clay loam in texture. In many places grayish-brown, yellowish-brown, or strong-brown mottles are common in the B2 horizon. Depth to the IIC horizon is about 32 to 40 inches. This horizon is loose, calcareous, olive-gray (5Y 4/2 or 5/2) or gray (5Y 5/1) sand and gravel. In a few places it is loamy sand or sand and contains little gravel. Reaction of the A horizon is slightly acid to mildly alkaline, but this horizon is not calcareous. The B horizon is neutral to mildly alkaline. In some places the lower part of the B horizon is calcareous. The IIC horizon is mildly alkaline or moderately alkaline, and it is calcareous.

Biscay soils differ from Talcot soils in being noncalcareous in the A and B horizons. Biscay soils are poorly drained and have a somewhat thicker A horizon and grayer colors in the B horizon than the Cylinder soils. All of these soils formed in similar parent material.

Biscay clay loam, deep (0 to 2 percent slopes) (259).—This soil occupies nearly level or slightly concave, irregularly shaped, swalelike areas on benches and uplands. It is at a slightly lower elevation than the associated Cylinder and Wadena soils.

Included with this soil in mapping are about 60 acres of soils that have sand and gravel at a depth of about 24 to 32 inches. In a few areas the sand and gravel is at depths between 40 and 50 inches. Also included are a few areas that have glacial till at a depth of about 4 feet or less.

This soil has a high water table unless drained. Most areas are drained and are cultivated. This soil is well suited to row crops if artificial drainage is provided and other management practices are good. If tilled when wet, this soil tends to dry out cloddy and hard, and tilth is poor. Some areas are large enough to manage separately, but most are managed along with the associated soils. Capability unit IIw–1; woodland suitability group 5w3.

Boone Series

The Boone series consists of light-colored, excessively drained soils that formed in material weathered from sandstone. These soils are steeply sloping and are on bench escarpments or on the lower parts of hillsides on uplands. They are in the Storden-Hayden-Wadena soil association along the valley of the Des Moines River south of Fort Dodge. Size of individual areas is 2 to more than 100 acres, but most areas are less than 40 acres. The native vegetation was mainly trees.

In a representative profile, the surface layer is very dark grayish-brown loamy fine sand about 2 inches thick. The subsurface layer is dark grayish-brown, very friable loamy fine sand about 4 inches thick. The subsoil is grayish-brown, very friable loamy sand about 10 inches

thick. The underlying material is pale-brown sand that is underlain, at a depth of about 25 inches, by weathered sandstone.

The available water capacity is very low, permeability is rapid, and the content of organic matter is very low. The surface and subsurface layers and subsoil are generally slightly acid to medium acid. The subsoil is very low in available phosphorus and potassium.

Most areas of Boone soils are in scrub timber and are used for pasture. Some areas are in Dolliver State Park. Boone soils have a shallow root zone and normally lack adequate water for good plant growth. They are subject to severe erosion if they are cleared of trees and brush.

Representative profile of Boone loamy fine sand, 25 to 45 percent slopes, in a wooded pasture 2,820 feet east and 300 feet north of the southwest corner of sec. 1, T. 87 N., R. 28 W.

A1—0 to 2½ inches, very dark grayish-brown (10YR 3/2) loamy fine sand; weak, fine, subangular blocky structure parting to weak, fine, granular structure; very friable when moist; slightly acid; abrupt, smooth boundary.

A2—2½ to 6 inches, dark grayish-brown (10YR 4/2) loamy fine sand; few, fine, faint, dark-gray (10YR 4/1) and brown (10YR 5/3) mottles on plates; moderate, thin, platy structure parting to weak, fine, subangular blocky structure; very friable when moist; slightly acid; abrupt, smooth boundary.

B2—6 to 16 inches, grayish-brown (10YR 5/2) loamy sand; weak, thick, platy structure parting to weak, medium, subangular blocky structure; very friable when moist; common sandstone fragments and mica flecks; many fine tubular pores; slightly acid; gradual, smooth boundary.

C—16 to 25 inches, brownish sand, pale brown (10YR 6/3) when dry; very weak, thick, platy structure parting to single grain; many mica flecks; common fine tubular pores; few medium iron concretions that are 3 to 4 millimeters by 1 to 2 millimeters in size; medium acid; gradual, smooth boundary.

R—25 to 31 inches, weathered sandstone, pale brown (10YR 6/3) when dry; prominent, weak, horizontal cleavage plates that are ¼ to ¾ inch thick; large brown (10YR 5/3 and 4/3) when dry mottles on plates; plates are weakly cemented; hard and noncrushable when dry; abundant mica flecks; medium acid.

The A horizon ranges from very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2) in color and from about 2 to 5 inches in thickness. It is loamy fine sand or fine sand. The A2 horizon ranges from dark grayish brown (10YR 4/2) or grayish brown (10YR 5/2) to brown (10YR 4/3 or 10YR 5/3). It is very friable loamy fine sand or fine sand, and it ranges from 2 to about 8 inches in thickness. The B horizon, which is lacking in some profiles, ranges from light gray (10YR 6/1 to 2.5Y 7/2) to grayish brown (10YR 5/2), light olive brown (2.5Y 5/4), or light yellowish brown (2.5Y 6/4) in color. It is generally loamy sand in texture but ranges to sand. It is about 4 to 16 inches thick. The C horizon ranges from light gray (10YR 7/2 or 2.5Y 7/2) to brown (10YR 5/3), pale brown or very pale brown (10YR 6/3 or 10YR 7/3) when dry. It is underlain, at a depth of 20 to 30 inches, by light-gray (10YR 7/2 or 2.5Y 7/2) to brown (10YR 5/3), light yellowish-brown (10YR 6/4), or pale-brown to pale-yellow (10YR 6/3 to 2.5Y 7/4), weakly cemented sandstone. Reaction is slightly acid to strongly acid throughout.

Boone soils are coarser textured in the upper part than Billett soils. Also, unlike the Billett soils, they are underlain by sandstone. In places these soils are associated on the landscape.

Boone loamy fine sand, 25 to 45 percent slopes (210G).—This soil is mainly on the lower part of uplands or on bench escarpments. It is commonly downslope from Storden and Hayden loams, which are mapped together as a soil complex. It is commonly upslope from Hanlon and Spillville soils.

Included with this soil in mapping are a few areas of a similar soil that has slopes of as little as 14 percent.

This soil has a shallow root zone and lacks adequate water for good plant growth. It erodes easily if vegetation is sparse. Nearly all areas of this soil are in trees and brush, and most are used for pasture. A few areas have been cleared and are used for permanent pasture. This soil is suited to very limited grazing, woodland, wildlife habitat, or recreation. Capability unit VIIe–1; woodland suitability group 5s1.

Buckney Series

The Buckney series consists of moderately dark colored or dark colored, well-drained soils that formed in loamy alluvium deposited by floodwaters. These soils are on bottom lands of the Des Moines River. They are nearly level to gently sloping. Areas are elongated and generally are at a slight angle to the depositing stream. These soils are mostly in an area that extends from just above the junction of the Des Moines and Boone Rivers to the Boone County line. Size of individual areas is 2 to 30 acres. Generally the larger areas occur as long, narrow strips.

In a representative profile, the surface layer is very dark brown and very dark grayish-brown fine sandy loam about 12 inches thick. The underlying material is mainly dark grayish-brown stratified sandy loam, but there are lenses of loamy sand, loam, and sand.

The available water capacity is moderate or low, permeability is rapid, and the content of organic matter is moderate. These soils are generally mildly alkaline. The subsoil is very low in available phosphorus and available potassium.

Most areas of Buckney soils are cultivated, but some areas have trees, brush, and weeds. Buckney soils lack adequate available water capacity for good plant growth in years when rainfall is sparse. Most areas are subject to occasional flooding.

Representative profile of Buckney fine sandy loam, 0 to 2 percent slopes, in a cultivated field 260 feet south of the edge of the Des Moines River, or 200 feet south and 60 feet east of the northwest corner of the SW¼ sec. 2, T. 86 N., R. 27 W.

Ap—0 to 8 inches, very dark brown (10YR 2/2) fine sandy loam; cloddy parting to very weak, fine, subangular blocky and moderate, fine, granular structure; very friable; mildly alkaline; slightly effervescent; abrupt, smooth boundary.

A12—8 to 12 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; very weak, fine, subangular blocky and moderate, fine, granular structure; very friable; mildly alkaline; slightly effervescent; gradual, smooth boundary.

C1—12 to 27 inches, stratified very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) fine sandy loam; very friable; thin band of grayish-brown (10YR 5/2) loamy sand at a depth of 16 inches; some horizontal cleavage; mildly alkaline; slightly effervescent; diffuse, smooth boundary.

C2—27 to 37 inches, dark grayish-brown (10YR 4/2) stratified loamy fine sand that has few thin lenses of very dark grayish-brown (10YR 3/2) loam and sandy loam; massive but has some horizontal cleavage;

very friable to loose; mildly alkaline; slightly effervescent; gradual, smooth boundary.

C3—37 to 54 inches, stratified dark grayish-brown (10YR 4/2) and grayish-brown (10YR 5/2) sandy loam that has some loam strata; few, fine, dark yellowish-brown (10YR 4/4) mottles; massive; very friable; few very dark grayish-brown (10YR 3/2) lenses; mildly alkaline; slightly effervescent.

The A horizon is very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2) in color and ranges from 10 to 18 inches in thickness. The C horizon is very dark grayish-brown (10YR 3/2) to grayish-brown (10YR 5/2), very friable, stratified sandy loam or loamy sand that has thin lenses of loam or sand.

Buckney soils in Webster County are calcareous throughout, which is not within the defined range of the Buckney series. This difference does not affect the use and management of the soils.

Buckney soils are associated with Dorchester soils, but they differ from the Dorchester soils in having more sand and less silt and clay. They are similar in texture to the Hanlon soils, but they differ from the Hanlon soils in being mildly alkaline and calcareous.

Buckney fine sandy loam, 0 to 2 percent slopes (636A).—This nearly level soil is on small to large drifts or bars that have been deposited at a slight angle to the nearby streams. It has the profile described as representative for the series. It is associated with silty Dorchester soils and with Sandy alluvial land.

Included with this soil in mapping are a few areas that have a thin, fresh deposit of sand on the surface.

Crops that have shallow or medium root depths are commonly stunted because of the lack of available moisture. In places deep-rooted crops can reach the water table of the nearby river. This soil is subject to soil blowing if vegetation is sparse, and blowing sand injures young plants in places. Tilth is good.

Cultivated areas of this soil are used for row crops, small grains, and hay and pasture. They are only moderately suited to row crops because available water capacity is inadequate during dry periods. Because they are near the river, these soils are well suited to recreational uses or wildlife habitat. Some areas are used for pasture and support grasses, brush, or weeds. Capability unit IIIs–1; woodland suitability group 3s1.

Buckney fine sandy loam, 2 to 6 percent slopes (636B).—This gently sloping soil is on small to large drifts or bars that have been deposited at a slight angle to the nearby stream. It is associated with the silty Dorchester soils and with Sandy alluvial land.

Included with this soil in mapping are a few areas that have a thin, fresh deposit of sand on the surface.

The use and management of this soil is influenced by hazards that are similar to those of the less sloping Buckney soil. There is a greater hazard of water erosion, however, and slightly less hazard of flooding. Capability unit IIIs–1; woodland suitability group 3s1.

Calamine Series

The Calamine series consists of dark-colored, poorly drained soils that formed in glacial till sediment and residuum from the underlying shale. These soils are on benches and foot slopes below Gosport soils or outcrops of shale. They are gently sloping to strongly sloping. They are in the Storden-Hayden-Wadena soil association, mainly south of Fort Dodge. Individual areas are generally from 2 to 20 acres in size. The native vegetation was water-tolerant sedges and prairie grasses.

In a representative profile, the surface layer is black silty clay loam about 20 inches thick. The upper part of the subsoil, to a depth of about 32 inches, is black to very dark gray and dark olive-gray silty clay loam. The lower part of the subsoil is firm, dark-gray heavy silty clay loam. The underlying material, at a depth of about 60 inches, is firm, laminated, very dark gray and dark-gray, weathered heavy silty clay loam.

The available water capacity is moderate to high, and permeability is very slow in the underlying material. The content of organic matter is high. These soils are neutral to mildly alkaline in the upper part, but they are moderately alkaline and calcareous in the underlying shaly material. The subsoil is very low in available phosphorus and available potassium.

These soils are wet and seepy. Some areas of these soils are cultivated, but most areas are used for pasture.

Representative profile of Calamine silty clay loam, 2 to 5 percent slopes, in a brome and alfalfa pasture 400 feet east and 410 feet south of the northwest corner of the NE¼NW¼ sec. 35, T. 88 N., R. 28 W.

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

A1—9 to 20 inches, black (N 2/0) silty clay loam; moderate, fine, granular and very fine subangular blocky structure; firm; neutral; clear, smooth boundary.

B1g—20 to 24 inches, black (10YR 2/1) silty clay loam; few, fine, olive-gray (5Y 4/2) mottles; moderate, fine, granular and very fine subangular blocky structure; firm; few, very fine, reddish oxides; neutral; clear, smooth boundary.

B21g—24 to 32 inches, very dark gray (5Y 3/1) and dark olive-gray (5Y 3/2) silty clay loam, dark olive gray (5Y 3/2) when kneaded; moderate, very fine, subangular blocky structure; firm; few, very fine, reddish oxides; few stones and pebbles; mildly alkaline; abrupt, smooth boundary.

IIB31g—32 to 42 inches, dark-gray (5Y 4/1) silty clay loam, very dark grayish brown (2.5Y 3/2) when kneaded; many, fine, olive-brown (2.5Y 4/4) mottles; moderate, fine and medium, angular blocky structure; firm; moderately alkaline; strongly effervescent; gradual, smooth boundary.

IIB32g—42 to 60 inches, dark-gray (5Y 4/1) heavy silty clay loam; weak platy structure; firm; many, medium, olive-brown (2.5Y 4/4) oxides oriented to faces of laminations; moderately alkaline; strongly effervescent; gradual, smooth boundary.

IIC1g—60 to 68 inches, very dark gray (N 3/0) and dark-gray (N 4/0) heavy silty clay loam; laminated; weak platy structure; firm; many, medium, olive-brown (2.5Y 4/4) oxides oriented to faces of laminations; moderately alkaline; strongly effervescent.

The A horizon ranges from black (N 2/0 or 10YR 2/1) to very dark gray (N 3/0 or 10YR 3/1) in color. It is friable to firm silty clay loam about 15 to 24 inches thick. The upper part of the B horizon ranges from black (N 2/0 or 10YR 2/1) olive gray (5Y 4/2) in color and is silty clay loam or clay loam in texture. Depth to the IIB horizon is commonly 24 to 36 inches. The IIB horizon, which formed in material weathered from shale, ranges from very dark gray (N 3/0) to olive gray (5Y 5/2) in color and is silty clay loam or silty clay in texture. It has angular or subangular blocky structure, or it is laminated. The IIC horizon is firm, laminated, black (10YR 2/1) to light gray (5Y 6/1) and calcareous. Reaction above the IIB horizon is generally neutral to mildly alkaline, and the IIB and IIC horizons are mildly alkaline or moderately alkaline and are calcareous.

Calamine soils have less clay increase from the A horizon

to the B horizon than is recognized in the defined range of the Calamine series. They also have dark colors to a greater depth than is recognized in the defined range of the series, and in places they have more sand in the A and B horizons. These differences do not affect the use and management of the soils.

Calamine soils are associated with Gosport soils on the landscape. They differ from Gosport soils in that the A horizon and the upper part of the B horizon formed in glacial sediment rather than shale. Calamine soils have a much thicker and darker A horizon than Gosport soils.

Calamine silty clay loam, 2 to 5 percent slopes (551B).—This soil is in long narrow areas on foot slopes. It has the profile described as representative for the series. This soil is generally downslope from Gosport soils or outcrops of shale. It is generally upslope from soils on bottom lands and benches, such as the Hanlon, Buckney, and Spillville soils.

Included with this soil in mapping are some areas that have shale at a depth of 48 to 60 inches. Also included are a few areas that have limestone rather than shaly material in the substratum.

This soil is seepy and wet. Most areas are in pasture and have a few scattered trees. This soil is suited to cultivation if it is adequately drained. Areas of this soil are also suitable for wildlife habitat. Providing drainage is generally difficult because the water that keeps these areas wet needs to be intercepted upslope before it can seep into the root zone. This soil absorbs moisture slowly. The substratum of shale is generally too shallow for the use of drain tile. Capability unit IIIw–3; woodland suitability group 5w1.

Calamine silty clay loam, 5 to 14 percent slopes (551D).—This soil is in narrow areas on foot slopes, generally below areas of Gosport soils or shale outcrops. Soils on benches or bottom lands, such as the Buckney, Hanlon, and Spillville soils, are generally downslope. This soil has a profile similar to the one described as representative for the series, except that it has a surface layer that is generally a few inches thinner.

Included with this soil in mapping are some areas that are similar but that have shale in the substratum at a depth of 48 to 60 inches. Also included are a few areas that have slopes of as much as 18 percent.

This soil is wet and seepy. It is subject to erosion if it is tilled. Most areas are in pasture and have a few scattered trees. This soil is suited to limited cultivation if it is protected from erosion and adequately drained. It is moderately suited to pasture if water-tolerant plants are grown. Providing drainage is generally difficult because the water that keeps these areas wet needs to be intercepted upslope before it can seep into the root zone. This soil absorbs moisture slowly. The underlying shaly material is generally too shallow for the use of drain tile. Capability unit IVe–2; woodland suitability group 5w1.

Calco Series

The Calco series consists of dark-colored, calcareous, poorly drained soils that formed in silty alluvium. These soils are nearly level. They are on bottom lands along streams and creeks and along some drainage ditches. They also are in a few slightly depressed areas on low benches along the Des Moines River. These areas tend to pond after rains. Individual areas are generally from 5 to 25 acres in size. The native vegetation was water-tolerant sedges and prairie grasses.

In a representative profile, the surface layer is black gritty silty clay loam about 26 inches thick. The subsoil is very dark gray and dark-gray, firm gritty silty clay loam about 11 inches thick. The underlying material, to a depth of 43 inches, is dark-gray light clay loam. Below this, to a depth of 60 inches, it is gray and olive-gray heavy loam and sandy loam.

The available water capacity is high, permeability is moderately slow, and the content of organic matter is high. These soils are mildly alkaline or moderately alkaline and calcareous throughout. The subsoil is very low in available phosphorus and available potassium.

These soils are wet because of a high water table and flooding. Most areas are cultivated, but some areas are in pasture.

Representative profile of Calco silty clay loam, in a cultivated field 355 feet east and 60 feet south of the northwest corner of the NE¼NW¼ sec. 7, T. 87 N., R. 30 W.

Ap—0 to 7 inches, black (N 2/0) gritty light silty clay loam; cloddy parting to very weak, medium and fine, subangular blocky structure; friable; mildly alkaline; abrupt, smooth boundary.

A12—7 to 13 inches, black (N 2/0) gritty light silty clay loam; weak, medium, fine and very fine, subangular blocky structure; friable; very few, coarse, sand-size, black oxides; mildly alkaline; slightly effervescent; gradual, smooth boundary.

A13—13 to 20 inches, black (N 2/0) gritty silty clay loam; weak, medium, prismatic structure parting to weak, very fine, subangular blocky structure; friable; few roots; very few, fine, black oxides; mildly alkaline; slightly effervescent; gradual, smooth boundary.

A3—20 to 26 inches, black (N 2/0) gritty silty clay loam, very dark gray (N 3/0) when kneaded; moderate, weak and medium, prismatic structure parting to very fine subangular blocky structure; firm; very few, coarse, sand-size, black oxides; mildly alkaline; gradual, smooth boundary.

B22g—26 to 31 inches, very dark gray (N 3/0) gritty medium silty clay loam; weak, medium, prismatic structure parting to weak, very fine, subangular blocky structure; firm; few, coarse, sand-size, black oxides; dark grayish-brown (2.5Y 4/2) fillings and coatings in root and worm channels; mildly alkaline; weakly calcareous; clear, wavy boundary.

B3g—31 to 37 inches, dark-gray (5Y 4/1) gritty medium silty clay loam; weak, medium, prismatic structure parting to weak, very fine, subangular blocky structure; firm; few, coarse, sand-size, black oxides; very few, fine, distinct, light olive-brown (2.5Y 5/4) oxides; very dark gray (5Y 3/1) coatings on prism faces; very dark gray (5Y 3/1) fills in crawfish holes; common, soft, white accumulations of lime; moderately alkaline; strongly effervescent; clear, wavy boundary.

C1g—37 to 43 inches, dark-gray (5Y 4/1) light clay loam; massive but has some weak vertical cleavage; friable; few, coarse, sand-size, black oxides; few, medium, distinct, light olive-brown (2.5Y 5/4) oxide stains; very dark gray (5Y 3/1) coatings on prism faces; very dark gray (5Y 3/1) fills in crawfish holes; common, soft, white accumulations of lime; few, medium, dark-colored oxides; moderately alkaline; strongly effervescent; clear, wavy boundary.

C2g—43 to 53 inches, gray and olive-gray (5Y 5/1 and 5/2) heavy loam; massive; friable; few, fine, tubular pores and worm channels; few, coarse, sand-size, black oxides; few, medium, distinct, light olive-brown (2.5Y 5/4) oxide stains; very dark gray (5Y 3/1) coatings on prism faces; very dark gray fills in crawfish holes; common, soft, white accumulations

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of lime; moderately alkaline; strongly effervescent; gradual, smooth boundary.

C3g—53 to 60 inches, gray and olive-gray (5Y 5/1 and 5/2) sandy loam; massive; very friable; few, medium, light olive-brown (2.5Y 5/4) oxide stains; few, medium, strong-brown (7.5Y 5/8) oxides; moderately alkaline; strongly effervescent.

The A horizon ranges from 24 to 36 inches in thickness. The B horizon ranges from very dark gray (N 3/0 or 10YR 3/1) to dark gray (10YR 4/1 or N 4/0) in color. It is gritty silty clay loam or clay loam about 12 to 24 inches thick. The B horizon is not recognized in all profiles. The C horizon is very dark gray (10YR 3/1 or N 3/0), dark gray (10YR 4/1 to 5Y 4/1), gray (10YR 5/1 to 5Y 5/1), or olive gray (5Y 4/2 or 5/2). It is gritty silty clay loam, clay loam, or loam. In some places sandy material is below a depth of 50 inches. Mottles and oxide stains of brown, yellowish brown, olive brown, grayish brown, and strong brown are below a depth of 30 inches in many places. Reaction is mildly alkaline to moderately alkaline. These soils are calcareous throughout.

In Webster County Calco soils contain more sand than is typical for the Calco series, and in places they contain more sand than is recognized in the defined range of the series. This difference does not affect the use and management of the soils.

Calco soils differ from Colo soils in that they are calcareous throughout. They have more clay and somewhat less sand in the surface layer and subsoil than the Spillville soils, and unlike the Spillville soils they are calcareous. These soils formed in similar parent material.

Calco silty clay loam (0 to 2 percent slopes) (733).—This nearly level soil is mainly in narrow areas on bottom lands adjacent to streams. A few areas of this soil that are slightly depressed are on low benches. This soil is adjacent to the Colo soils in places. In other places it is adjacent to the Wadena or other soils on benches. In a few places it is adjacent to soils on foot slopes, such as Terril soils, or to soils on uplands, such as Storden or Clarion soils.

This soil has a high water table, and some areas flood during periods of high rainfall. Areas of this soil on benches tend to pond after rains. The surface layer tends to dry out cloddy and hard if it is tilled when wet. Most areas are cultivated, but a few areas are used for pasture. This soil is used mainly for row crops and is well suited to this use if drainage is adequate. Some areas are cropped without drainage, but most areas are drained. Generally flooding is not severe enough to seriously hinder field operations. Capability unit IIw–2; woodland suitability group 5w3.

Canisteo Series

The Canisteo series consists of dark-colored, poorly drained soils that formed in glacial till and sediment from glacial till. These soils are nearly level. They are on uplands, occupying wide swales in the indistinct upland drainage system. They are in the Webster-Clarion-Nicollet, the Webster-Nicollet-Canisteo, and, in some places, the Marna-Guckeen soil associations. Canisteo soils occupy a large acreage, and individual areas vary widely in size. Some areas are as small as 2 acres, and some areas are as large as several hundred acres, but most are from 25 to 200 acres in size. The native vegetation was water-tolerant prairie grasses and sedges.

In a representative profile, the surface layer is about 17 inches thick. It is black gritty silty clay loam in the upper part and black clay loam in the lower part. The subsoil is very dark gray, dark-gray, and olive-gray, friable clay loam about 19 inches thick. The underlying material is mottled olive-gray and yellowish-brown loam.

The available water capacity is high, and permeability is moderate to moderately slow. The subsoil is very low in available phosphorus and potassium. Available iron is low in places.

Canisteo soils are wet because of a high water table, and they contain excess lime. Most areas of these soils are cultivated.

Representative profile of Canisteo silty clay loam, in a cultivated field 440 feet south and 350 feet east of the northwest corner of the SW¼NW¼ sec. 24, T. 87 N., R. 29 W.

Ap—0 to 7 inches, black (N 2/0) light gritty silty clay loam; cloddy parting to weak, fine, granular structure; friable; moderately alkaline; strongly effervescent; clear, smooth boundary.

A1—7 to 13 inches, black (N 2/0) gritty silty clay loam or clay loam; weak, coarse, blocky structure parting to weak, fine, granular and weak, very fine, subangular blocky structure; friable; moderately alkaline; strongly effervescent; gradual, smooth boundary.

A3—13 to 17 inches, black (N 2/0) clay loam, few fine peds of very dark gray (5Y 3/1) to dark gray (5Y 4/1); weak, coarse, blocky structure parting to weak, fine, granular and weak, very fine, subangular blocky structure; friable; moderately alkaline; strongly effervescent; gradual, smooth boundary.

B1g—17 to 24 inches, very dark gray (N 3/0) clay loam, common peds of gray (5Y 5/1) and olive gray (5Y 5/2), very dark gray (5Y 3/1) to dark gray (5Y 4/1) when kneaded; weak, coarse, blocky structure parting to weak and moderate, very fine, subangular blocky structure; friable; few, soft, calcium carbonate accumulations as much as 5 millimeters in diameter; moderately alkaline; strongly effervescent; gradual, smooth boundary.

B21g—24 to 30 inches, about 60 percent dark-gray (5Y 4/1) and about 40 percent gray (5Y 5/1) and olive-gray (5Y 5/2) clay loam; weak and moderate, very fine, subangular blocky structure that has a few, fine, subangular blocky peds; friable; few worm casts of very dark gray (N 3/0); few, soft, calcium carbonate accumulations as much as 5 millimeters in diameter; moderately alkaline; strongly effervescent; gradual, smooth boundary.

B22g—30 to 36 inches, olive-gray (5Y 5/2) light clay loam, some peds of dark gray (5Y 4/1) and gray (5Y 5/1); weak, very fine and fine, subangular blocky structure; friable; few worm holes filled with very dark gray (N 3/0) material; common, soft, dark-colored oxides; several, coarse (5 millimeters in diameter) and common, fine, soft calcium carbonate accumulations; small animal burrow filled with black (N 2/0) material vertical through the horizon; moderately alkaline; strongly effervescent; gradual, smooth boundary.

C1g—36 to 48 inches, olive-gray (5Y 5/2) heavy loam; common, fine, prominent, yellowish-brown (10YR 5/6 and 10YR 5/8) and strong-brown (7.5YR 5/8) mottles; weak, medium, subangular blocky structure to massive; friable; few, soft, dark-colored oxides; common, fine, soft, calcium carbonate accumulations; animal burrow in B22g horizon extends into this horizon; moderately alkaline; strongly effervescent; gradual, smooth boundary.

C2g—48 to 60 inches, mottled olive-gray (5Y 5/2) and yellowish-brown (10YR 5/6 and 10YR 5/8) loam; massive; friable; common, soft, dark-colored oxides; common, soft, fine, calcium carbonate concretions; moderately alkaline; strongly effervescent.

The A horizon ranges from black (10YR 2/1 or N 2/0) to very dark gray (10YR 3/1). It is light silty clay loam or clay loam about 14 to 24 inches thick. The B2 horizon is

olive gray (5Y 4/2 or 5Y 5/2), dark gray (5Y 4/1), or gray (5Y 5/1). In places the lower part of the B horizon is sandy loam. In places the B2 horizon has mottles of yellowish brown, strong brown, or olive brown. The C horizon varies in texture. It is generally loam, but in places it contains strata of silt loam, sandy loam, or loamy sand. This horizon is generally similar in color and in pattern of mottling to the lower part of the B horizon. Reaction is mildly alkaline to moderately alkaline. The soils are calcareous throughout.

Canisteo soils are associated with Webster and Harps soils on the landscape. They differ from Webster soils in that they are calcareous throughout. They have less calcium carbonate in the A and B horizons than Harps soils. Canisteo soils are similar in texture of the A and B horizons to Biscay soils, but they lack the sand and gravel that underlies these soils, and unlike Biscay soils, Canisteo soils are calcareous throughout.

Canisteo silty clay loam (0 to 2 percent slopes) (507).—This nearly level soil is in swales on uplands, similar in position to the associated Webster soils. Areas are wide and irregularly shaped. This soil commonly borders Okoboji soils that are in definite depressions, or the Harps soils that surround the Okoboji soils. In many places it is associated with and downslope from Nicollet and Clarion soils. In a few places it is associated with Guckeen and Marna soils.

Included with this soil in mapping are a few small areas that have sand and gravel in the underlying material.

This soil is wet because of a high water table, and it contains excess lime. Some areas receive runoff water from adjacent soils on higher elevations. The surface layer tends to dry out cloddy and hard if it is tilled when wet, but generally tilth is fair or good. If left without vegetative cover in the winter, it is subject to soil blowing, especially if areas are large.

Nearly all of this soil is cultivated. It is used mainly for row crops and is well suited to this use if it is adequately drained. Some areas are large enough to manage separately; others are managed along with the associated soils. Capability unit IIw–1; woodland suitability group 5w3.

Clarion Series

The Clarion series consists of dark-colored, well-drained soils that formed in glacial till. These soils are on uplands on small, low rises or knolls, on irregular convex ridgetops, and on side slopes adjacent to streams. They are nearly level to moderately steep. They are mostly in the Webster-Clarion-Nicollet soil association in the northern two thirds of the county, but they also are in other associations. Clarion soils occupy a large acreage in the county. Most areas are irregular in shape and size. Individual areas range from about 2 to more than 100 acres in size, but most areas are less than 20 acres. The native vegetation was prairie grasses.

In a representative profile, the surface layer is very dark brown loam about 11 inches thick. The subsoil is dark-brown, brown, and dark yellowish-brown, friable loam about 21 inches thick. The underlying material is yellowish-brown to light olive-brown loam that has mottles of yellowish brown and light brownish gray. There are pebbles, small stones, and a few boulders in the profile.

The available water capacity is high, permeability is moderate, and the content of organic matter is moderate or moderately low. The surface layer and subsoil are generally neutral. The subsoil is very low in available phosphorus and available potassium.

Clarion soils are subject to erosion. They are generally cultivated. Some areas, especially of the steeper soils, are used for pasture.

Representative profile of Clarion loam, 5 to 9 percent slopes, in a cultivated field 40 feet east and 40 feet north of the southwest corner of the SE¼ sec. 19, T. 90 N., R. 29 W.

Ap—0 to 9 inches, very dark brown (10YR 2/2) loam; weak, fine, subangular blocky and weak, fine, granular structure; friable; few small stones; neutral; abrupt, smooth boundary.

A12—9 to 11 inches, very dark brown (10YR 2/2) loam; weak, fine, subangular blocky and weak, fine, granular structure; friable; common small stones; neutral; clear, smooth boundary.

B1—11 to 17 inches, dark-brown (10YR 3/3) loam, some mixing of very dark grayish brown (10YR 3/2) and brown (10YR 4/3); weak and moderate, fine, subangular blocky structure; friable; very dark brown (10YR 2/2) fills in worm channels; common small stones; neutral; gradual, smooth boundary.

B21—17 to 22 inches, brown (10YR 4/3) loam; faces of peds dark brown (10YR 3/3); weak, medium, prismatic structure parting to weak, fine, subangular blocky structure; friable; very dark grayish-brown (10YR 3/2) fills in root and worm channels; few small stones; neutral; clear, smooth boundary.

B22—22 to 27 inches, dark yellowish-brown (10YR 4/4) loam; faces of peds brown (10YR 4/3); weak, medium, prismatic structure parting to weak, fine, subangular blocky structure; friable; few, very dark grayish-brown (10YR 3/2) fills in worm channels; common small stones; neutral; clear, smooth boundary.

B3—27 to 32 inches, dark yellowish-brown (10YR 4/4) and brown (10YR 4/3) loam; weak, medium, prismatic structure parting to fine, subangular blocky structure; friable; very few, fine, dark-colored oxides; common small stones; mildly alkaline; clear, smooth boundary.

C1—32 to 40 inches, yellowish-brown (10YR 5/4) to light olive-brown (2.5Y 5/4) loam; very few, fine, light brownish-gray (2.5Y 6/2) mottles; few, fine, dark-colored oxides; common small stones; moderately alkaline; strongly effervescent; gradual, smooth boundary.

C2—40 to 55 inches, yellowish-brown (10YR 5/4) to light olive-brown (2.5Y 5/4) loam; few, fine, yellowish-brown (10YR 5/8) and few, fine, light brownish-gray (2.5Y 6/2) mottles; massive; friable; common, fine, dark-colored oxides; coatings of lime in root channels; common small stones; moderately alkaline; strongly effervescent.

The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2). It is 10 to 14 inches thick unless it is eroded. The B2 horizon is brown (10YR 4/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4). It is friable loam or light clay loam. The total thickness of the B horizon ranges from 12 to about 30 inches. The C horizon is predominantly yellowish brown (10YR 5/4 or 5/6) and light olive brown (2.5Y 5/4), but there are some gray colors in places. In some places this horizon has reddish and dark oxides and accumulations of white or light-gray lime. The entire soil profile has few to common pebbles and stones and, in places, boulders. Reaction of the A horizon and the upper part of the B horizon is generally slightly acid or neutral. The lower part of the B horizon is neutral to mildly alkaline and it is calcareous in places. The C horizon is moderately alkaline, and it is calcareous.

Clarion and Wadena soils are similar in texture in the

upper part, but Clarion soils are not underlain by sand and gravel as are the Wadena soils. Clarion and Lester soils formed in similar parent material, but Clarion soils differ from the Lester soils in lacking a grayish-colored A2 horizon and in having somewhat less clay in the subsoil. They generally have a thicker, darker A1 horizon and are less acid than the Lester soils.

Clarion loam, 0 to 2 percent slopes (138A).—This soil is on all or part of low rises that range from small to large in size or on irregular convex ridges. It is associated mainly with Nicollet and Webster soils. The profile of this soil is similar to the one described as representative for the series, but the surface layer is a few inches thicker and the soil tends to be leached more deeply.

This soil has no serious hazards to its use. Soil tilth is generally good. If it is left barren in winter, there is some danger of soil blowing in spring if the surface material is dry. Nearly all areas are cultivated. It is well suited to row crops. Capability unit I–2; woodland suitability group 2o1.

Clarion loam, 2 to 5 percent slopes (138B).—This soil is mainly on low rises or knolls that range from small to large in size or on irregular convex ridgetops. It is generally upslope from and associated with the Nicollet, Webster, and Canisteo soils. In a few places it is associated with the Storden soils. Most areas are irregular in size and shape, and slopes are generally short. This soil is the most extensive Clarion soil in the county.

Included with this soil in mapping are some areas in which the underlying material is stratified silt loam or sandy loam and a few eroded areas in which the surface layer is less than 7 inches thick. Also included are a few areas in which the surface layer and subsoil are sandy. These areas are shown on the soil map by a symbol for sand.

This soil is subject to erosion. Generally tilth is good, and the soil is easy to till. If it is left barren in winter and if soil conditions are unfavorable in spring, this soil is subject to soil blowing.

Nearly all areas are cultivated. This soil is well suited to row crops most of the time if erosion is controlled. In places the use of practices to control erosion is difficult because of the undulating topography, the size and shape of areas, or the way this soil is associated with other soils. Generally this soil is managed along with the adjacent soils. Capability unit IIe–1; woodland suitability group 2o1.

Clarion loam, 5 to 9 percent slopes (138C).—This soil is on undulating knolls and on convex side slopes that border streams and upland drainageways. It is generally adjacent to and upslope from Nicollet, Webster, and other Clarion soils, or in places it is associated with Colo and Spillville soils that are mapped as a soil complex. It is also associated with Storden soils and is commonly upslope from them. This soil has the profile described as representative for the series. Most areas are irregular in shape, and slopes are generally short.

Included with this soil in mapping are a few areas in which the underlying material is silty or sandy in texture.

This soil is subject to erosion, and water runs off fairly quickly if plant cover is sparse. Tilth is generally good. This soil is mainly in pasture, but some areas are cultivated. It is moderately suited to row crops if erosion is controlled. In places the use of practices to control erosion is difficult because of the undulating topography and short slopes. Capability unit IIIe–1; woodland suitability group 2o1.

Clarion loam, 5 to 9 percent slopes, moderately eroded (138C2).—This soil is on undulating knolls and on convex side slopes that border streams or upland drainageways. It is generally adjacent to and upslope from Nicollet, Webster, or other Clarion soils, or in places it is associated with Colo and Spillville soils that are mapped as a soil complex. It is also associated with Storden soils and is commonly upslope from them. The profile of this soil is similar to the one described as representative for the series, but the surface layer is very dark grayish brown and is thinner. Plowing has exposed the subsoil in places. In places the depth to calcareous material is about 24 to 30 inches.

Included with this soil in mapping are some small areas of Storden soil. These areas are shown on the soil map by a symbol for a calcareous spot.

Most areas of this soil are cultivated, but a few areas are used for pasture. This soil is moderately suited to row crops if erosion is controlled. In places the use of practices to control erosion is difficult because of undulating topography and short slopes. This soil generally needs more nitrogen than Clarion soils that are less eroded. Capability unit IIIe–1; woodland suitability group 2o1.

Clarion loam, 9 to 14 percent slopes, moderately eroded (138D2).—This soil is mainly on convex side slopes that border stream valleys or upland drainageways, but in places it is on knolls or ridgelike areas. Slopes are generally short. Generally this soil is downslope from Clarion soils that are less sloping and is upslope from Colo soils or Colo and Spillville soils that are mapped as a soil complex. The profile of this soil is similar to the one described as representative for the series, but the surface layer is very dark grayish brown and is thinner. In most places the depth to calcareous material is 20 to 30 inches. Plowing has exposed the brownish subsoil in a few places.

Included with this soil in mapping are some small areas of Storden soils. These areas are shown on the soil map by a symbol for a calcareous spot. Also included are about 80 acres of a soil in which the surface layer is very dark brown and about 7 to 12 inches thick.

This soil is subject to erosion, and water runs off fairly rapidly if there is no plant cover. Tilth is generally fair. If it is left barren in winter and if conditions are unfavorable in spring, this soil is subject to soil blowing.

Most areas of this soil are cultivated, but some areas are in pasture. This soil is moderately suited to row crops if erosion is controlled. This soil generally needs more nitrogen than Clarion soils that are less eroded. Generally it is managed along with the associated soils. Capability unit IIIe–2; woodland suitability group 2o1.

Clarion loam, 14 to 18 percent slopes, moderately eroded (138E2).—This soil is mainly on convex side slopes adjacent to stream valleys. It is generally downslope from Clarion soils that are less sloping and upslope from soils on bottom lands and benches. The profile of this soil is similar to the one described as representative for the series, but the surface layer of this soil is very dark grayish brown or dark brown and is thinner. In a few

places plowing has mixed the subsoil in the surface layer. In most places the depth to calcareous material is between 20 and 30 inches.

Included with this soil in mapping are some areas in which the surface layer is very dark brown and about 7 to 12 inches thick. Also included are some small areas of Storden soils. These areas are shown on the soil map by a symbol for a severely eroded spot.

Erosion is a serious hazard on this soil. Most areas are in pasture, but some areas are cultivated. It is moderately suited to row crops, but is mainly left in hay or rotation pasture much of the time. Those areas associated with Clarion soils that are less sloping are more likely to be used for row crops. Capability unit IVe–1; woodland suitability group 2o1.

Colo Series

The Colo series consists of dark-colored, poorly drained soils that formed in silty alluvium. These soils are nearly level. They are on bottom lands and are also in a complex with Spillville soils in narrow drainageways. They are along some of the larger dredged ditches and along streams in all parts of the county. Individual areas generally are 5 to 50 acres in size. The native vegetation was water-tolerant prairie grasses and sedges.

In a representative profile, the surface layer is black silty clay loam about 39 inches thick. The subsoil is very dark gray, firm silty clay loam about 12 inches thick. The underlying material is dark-gray and gray gritty silty clay loam.

The available water capacity is high, permeability is moderately slow, and the content of organic matter is high. The surface layer and subsoil are generally neutral. The subsoil is low in available phosphorus and very low in available potassium.

Colo soils are wet because of a high water table and are subject to flooding. Most areas of these soils are cultivated. They are well suited to this use if they are adequately drained and if they are not flooded too frequently.

Representative profile of Colo silty clay loam, in a pasture 170 feet west and 400 feet south of the northeast corner of the NW¼NE¼ sec. 21, T. 86 N., R. 30 W.

A11—0 to 11 inches, black (N 2/0) silty clay loam; moderate, very fine and fine, granular structure; friable; neutral; clear, smooth boundary.

A12—11 to 19 inches, black (N 2/0) silty clay loam; weak, very fine, subangular blocky and moderate, fine, granular structure; friable; neutral; gradual, smooth boundary.

A13—19 to 36 inches, black (N 2/0) silty clay loam; weak, medium, prismatic structure parting to weak, very fine, subangular blocky structure; friable; neutral; diffuse, smooth boundary.

A14—36 to 39 inches, black (10YR 2/1) silty clay loam; moderate, medium, prismatic structure parting to weak, fine, subangular blocky structure; friable; common fine sand grains; neutral; diffuse, smooth boundary.

Bg—39 to 51 inches, very dark gray (N 3/0) silty clay loam; moderate, medium, prismatic structure parting to weak, fine, angular and subangular blocky structure; firm; common fine sand grains; neutral; abrupt, smooth boundary.

Cg—51 to 56 inches, dark-gray (5Y 4/1) and gray (5Y 5/1) light gritty silty clay loam; weak, medium, prismatic structure; firm; olive (5Y 5/3) oxide stains; very dark gray (5Y 3/1) crawfish fill; mildly alkaline.

The A horizon is 24 to 40 inches thick. The Bg horizon, which does not occur in some profiles, ranges from very dark gray (10YR 3/1 or N 3/0) to gray (10YR 5/1 to 5Y 5/1) in color and from 10 to 15 inches in thickness. Colors of 2 or 3 value extend to a depth of 36 inches or more. The C horizon ranges from very dark gray (N 3/0 or 10YR 3/1) to gray (5Y 5/1) and is silty clay loam or clay loam. This horizon has mottles of brown, olive, olive brown, or yellowish brown in places. Sandy strata are below a depth of 50 inches in places. Reaction of the A horizon and B horizon is slightly acid or neutral. The C horizon is neutral to mildly alkaline.

Colo soils are associated with Calco and Spillville soils on the landscape. Colo soils differ from the Calco soils in that they are not calcareous to a depth of about 3 feet or more. They are more poorly drained and are finer textured and lower in content of sand than Spillville soils.

Colo silty clay loam (0 to 2 percent slopes) (133).—This nearly level soil is on narrow and wide bottom lands in all parts of the county. It is commonly the only soil on the narrow bottom lands, and here it is adjacent to soils on foot slopes, such as Spillville or Terril soils, or to soils on uplands, such as Clarion or Storden soils. In other places it is on wider bottom lands and is associated with Spillville, Calco, and other bottom-land soils. This soil has the profile described as representative for the series.

Included with this soil in mapping are a few areas that have glacial till at a depth of about 40 inches and a few areas that have more sand throughout the profile than this soil and have sandy material at a depth of about 3 feet.

This soil is subject to flooding and wet unless it is drained. Generally tilth is good, but this soil tends to dry out cloddy and hard if tilled when wet. This soil is used mainly for row crops, and it is well suited to this use if it is adequately drained. Some areas that are inaccessible or frequently flooded are in pasture. In places areas are large enough to be managed separately, and in other places areas are managed along with the associated soils. Capability unit IIw–2; woodland suitability group 5w3.

Colo-Spillville complex, 2 to 5 percent slopes (585B).—This complex consists of soils that are in narrow drainageways, generally along small streams that eventually flow into larger creeks and into the Des Moines River. Individual areas occur as narrow strips that are bordered by moderately steep or steep soils on uplands. Colo soils make up about 60 percent of this complex and Spillville soils about 40 percent. Colo soils are nearly level and generally are closest to the waterway or intermittent stream. Spillville soils are mainly gently sloping soils on foot slopes adjacent to much steeper soils that occupy the sides of small valleys on uplands. The area of each soil in any one place is too small to map separately.

About 65 acres of this complex are badly channeled. There are a few gullies in other places. In places the meandering channels hinder cultivation. The Colo soils in the complex are wet and subject to flooding in places. The Spillville soils are subject to erosion and to rilling and gullying from runoff water from the uplands.

Areas are mostly in grass and pasture. Some areas are cultivated. The use of soils in this complex depends on the steepness of other soils on the valley sides. If the soils on the valley sides are strongly sloping, this complex is

generally cultivated along with them. If the adjacent soils are moderately steep or steep, this complex is commonly used for pasture. Cultivated areas are well suited to row crops if they are drained. Capability unit IIw–2; woodland suitability group 5w3.

Cordova Series

The Cordova series consists of dark-colored, poorly drained soils that formed in glacial till and glacial sediment that is underlain by glacial till. These soils are in nearly level to slightly concave swales on uplands. Surface water generally drains from these soils into a stabilized, deep gully that penetrates into the uplands. Cordova soils are in the Le Sueur-Luther-Hayden soil association near the valley of the Des Moines River. Individual areas are generally 2 to 10 acres in size. The native vegetation was trees and prairie grasses that are tolerant to wetness.

In a representative profile, the surface layer is black gritty silty clay loam about 15 inches thick. The subsoil is about 33 inches thick. The upper part is mainly olive-gray, firm clay loam. The lower part is loam and has few to common mottles of light olive brown. The underlying material is friable loam that is mottled light olive brown and light olive gray. Few to common pebbles and stones are throughout the profile.

The available water capacity is high, permeability is moderately slow, and the content of organic matter is high. The surface layer is generally slightly acid. The subsoil is very low or low in available phosphorus and very low in available potassium.

Cordova soils are generally cultivated, but a few areas are in trees and grasses. They are wet because of the high water table.

Representative profile of Cordova silty clay loam, in a cultivated field 250 feet north and 15 feet east of the southwest corner of the NW¼NW¼ sec. 22, T. 87 N., R. 27 W.

Ap—0 to 7 inches, black (10YR 2/1) light gritty silty clay loam; cloddy parting to weak, fine, granular and very fine, subangular blocky structure; friable; slightly acid; abrupt, smooth boundary.

A1—7 to 10 inches, black (10YR 2/1) light gritty silty clay loam; weak, medium, subangular blocky and moderate, fine, granular structure; friable; slightly acid; clear, smooth boundary.

A3g—10 to 15 inches, black (10YR 2/1) gritty silty clay loam, very dark gray (10YR 3/1) when kneaded, dark gray (5Y 4/1) when dry; weak, very fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

B21tg—15 to 22 inches, very dark gray (10YR 3/1) medium to heavy clay loam; faces of peds black (10YR 2/1) and very dark gray (10YR 3/1); weak, medium, prismatic structure parting to moderate, fine and medium, subangular blocky structure; firm; few dark-gray (5Y 4/1) peds in lower part; thick, discontinuous clay films; few small pebbles; slightly acid; clear, smooth boundary.

B22tg—22 to 30 inches, olive-gray (5Y 5/2) clay loam; faces of peds dark gray (5Y 4/1) and olive gray (5Y 5/2); very few, fine, light olive-brown (2.5Y 5/4) mottles; moderate, medium, prismatic structure parting to moderate, medium, subangular blocky structure; firm; common pebbles; thick, nearly continuous, dark-gray clay films; neutral; clear, smooth boundary.

B31tg—30 to 37 inches, olive-gray (5Y 5/2) medium clay loam; few, fine, light olive-brown (2.5Y 5/4) mottles; moderate, medium and coarse, prismatic structure parting to weak, medium, subangular blocky structure; friable; thick, discontinuous, very dark gray clay films; common pebbles; few, fine, hard carbonate concretions; mildly alkaline; gradual, smooth boundary.

B32tg—37 to 48 inches, olive-gray (5Y 5/2) loam; common, fine, light olive-brown (2.5Y 5/4) mottles; weak, coarse, prismatic structure; friable; thick, discontinuous, black to very dark gray clay films; common fine pebbles; moderately alkaline; strongly effervescent; clear, smooth boundary.

C1—48 to 58 inches, mottled light olive-gray (5Y 6/2) and light olive-brown (2.5Y 5/6) loam; massive; friable; common fine pebbles; moderately alkaline; strongly effervescent.

The A horizon ranges from friable to firm, light gritty silty clay loam to clay loam in texture and from 10 to 20 inches in thickness. It has granular or subangular blocky structure. The B horizon is very dark gray (10YR 3/1) to dark gray (10YR 4/1) or olive gray (5Y 4/2) in the upper part and olive gray (5Y 5/2) and light olive gray (5Y 6/2) in the lower part. This horizon is generally mottled olive brown or light olive brown. In places the finest part of the B horizon is light clay. The C horizon, which is at a depth of 24 to 50 inches, is olive-gray to light olive-brown loam or light clay loam. Reaction of the A horizon is slightly acid to medium acid. The B2 horizon is generally slightly acid to medium acid, but in places it ranges to neutral in the lower part. The B3 horizon is neutral to moderately alkaline, and it is calcareous.

Cordova soils generally have a thinner A horizon and have more clay in the B horizon than the Webster soils. Cordova soils do not have a distinct grayish subsurface layer as do the Dundas soils, and they have a thicker surface layer than the Dundas soils. These soils formed in similar parent material.

Cordova silty clay loam (0 to 2 percent slopes) (386).—This soil is in nearly level to slightly concave swalelike areas on uplands near the valley of the Des Moines River. It is generally adjacent to and downslope from Lester or Le Sueur soils.

Unless this soil is drained, it is wet because of a high water table. Most areas are cultivated. They are used mainly for row crops and are well suited to these crops if drained (fig. 8). Tilth is generally good, but this soil tends to dry out cloddy and hard if it is tilled when wet. Capability unit IIw–1; woodland suitability group 5w3.

Cylinder Series

The Cylinder series consists of dark-colored, somewhat poorly drained soils that formed in loamy alluvium that is underlain by sand and gravel. These soils are nearly level. They are mainly on benches along the larger rivers and streams, but a scattering of these soils is in places on uplands. Areas are generally slightly convex but range to slightly concave. Individual areas are from 2 to 30 acres in size. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black loam about 14 inches thick. The subsoil is about 15 inches thick. It is dark grayish-brown, friable heavy loam in the upper part and sandy clay loam in the lower part. The underlying material is grayish-brown and yellowish-brown, loose sand and gravel that ranges from a few feet to as much as 30 or 40 feet in thickness.

The available water capacity is low to moderate, and permeability is moderate in the upper part but rapid or very rapid in the sand and gravel. The content of organic

Figure 8.—**Corn growing in a field of Cordova and Le Sueur soils. The Cordova soils are in the foreground, and the Le Sueur soils are in the background.**

matter is moderate to high. The surface layer and upper part of the subsoil are neutral to slightly acid. The subsoil is very low in available phosphorus and available potassium.

Most areas of Cylinder soils are cultivated and a few areas are in pasture. The sand and gravel that underlies these soils is saturated during some parts of the year, but this is not for long periods during the growing season. Cylinder soils, especially the moderately deep ones, do not have adequate available water capacity for good plant growth in dry years.

Representative profile of Cylinder loam, moderately deep, in a cultivated field 1,850 feet east and 50 feet south of the northwest corner of SW¼ sec. 10, T. 89 N., R. 29 W.

Ap—0 to 7 inches, black (10YR 2/1) loam; cloddy parting to very weak, fine, granular and subangular blocky structure; friable; neutral; gradual, smooth boundary.

A12—7 to 14 inches, black (10YR 2/1) heavy loam; very weak, fine, subangular blocky and moderate, fine, granular structure; friable; neutral; clear, smooth boundary.

B1t—14 to 18 inches, very dark gray (10YR 3/1) and dark grayish-brown (2.5Y 4/2) heavy loam, very dark grayish-brown (2.5Y 3/2) when kneaded; weak, medium, subangular blocky structure; friable; thin, discontinuous clay films; neutral; gradual, smooth boundary.

B2t—18 to 24 inches, dark grayish-brown (2.5Y 4/2) heavy loam; few, fine, faint, dark yellowish-brown (10YR 4/4) mottles; weak, medium, prismatic structure parting to weak, medium, subangular blocky structure; friable; few, very dark grayish-brown (10YR 3/2) clay films; slightly acid; clear, smooth boundary.

B3t—24 to 29 inches, dark grayish-brown (10YR 4/2) sandy clay loam; common, fine, distinct, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/6) mottles; weak, medium, prismatic structure parting to weak, medium, subangular blocky structure; friable; very few, thin, discontinuous clay films; hard black iron concretions 3 and 4 millimeters in diameter; neutral; clear, smooth boundary.

IIC1—29 to 39 inches, grayish-brown (2.5Y 5/2) and yellowish-brown (10YR 5/4) gravelly loamy sand; single grain with very weak cementation in places; loose; neutral; abrupt boundary.

IIC2—39 to 52 inches, grayish-brown (2.5Y 5/2) and yellowish-brown (10YR 5/6) sand and fine gravel; single grain; loose; mildly alkaline; slightly effervescent.

The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), and very dark gray (10YR 3/1) and is 10 to 24 inches thick. The B horizon is generally dark grayish brown (2.5Y 4/2), but it ranges to very dark gray (10YR 3/1) or very dark grayish brown (2.5Y 3/2 or 10YR 3/2) in the upper part and to grayish brown (2.5Y 5/2), olive brown (2.5Y 4/4), or light olive brown (2.5Y 5/4) in the

lower part. It is mottled yellowish brown or olive brown in many places. The B horizon is loam or light clay loam, but in most places grades to sandy clay loam, loam, or sandy loam in the lower part. The IIC horizon is grayish brown (2.5Y 5/2) and yellowish brown (10YR 5/4 and 10YR 5/6), but the grayish colors range to light brownish gray (2.5Y 6/2) or olive gray (5Y 5/2) in places. The underlying sand and gravel is at a depth of about 24 to 32 inches in the moderately deep soils and at a depth of 32 to 40 inches in the deep Cylinder soils. In a few places the underlying material is loamy sand or sand without much gravel. It is generally calcareous, but in some places the upper few inches are leached. Reaction of the A horizon and the upper part of the B horizon is generally slightly acid or neutral, but it grades to neutral as depth increases. The A horizon ranges to medium acid in places. The IIC horizon is mainly mildly alkaline or moderately alkaline and calcareous, although in places it is neutral and is noncalcareous in a few inches in the upper part.

Cylinder soils differ from the Biscay and Wadena soils in being somewhat poorly drained. Cylinder soils are grayer in the B horizon than the Wadena soils, but they are not so gray as the Biscay soils. Biscay and Wadena soils formed in similar parent material. Cylinder and Nicollet soils have similar drainage, but Cylinder soils differ from the Nicollet soils in being underlain by sand and gravel.

Cylinder loam, deep (0 to 2 percent slopes) (203).—This nearly level soil is mainly on benches along streams, but it is also in a few places on uplands. Generally it is adjacent to and associated with Wadena, Biscay, or moderately deep Cylinder soils. The profile of this soil is similar to the one described as representative for the series, except that sand and gravel are at a depth of about 32 to 40 inches.

Included with this soil in mapping are a few areas of gently sloping soils and a few areas that have glacial till at a depth of about 42 to 48 inches. Most of these included areas are in the valley of Lizard Creek. Also included are some areas where the sand and gravel are at a depth of about 40 to 48 inches.

This soil is slightly wet in some years, but the growth of crops is seldom seriously affected. It has adequate available water capacity for good plant growth except in very dry years. Tilth is generally good. Most areas of this soil are cultivated. It is well suited to row crops. A few areas are large enough to be managed separately, but most areas are managed along with the associated soils. Capability unit I–1; woodland suitability group 3w1.

Cylinder loam, moderately deep (0 to 2 percent slopes) (202).—This soil is mainly on benches along streams, but it is also in a few places on uplands. Generally it is adjacent to and associated with the Wadena, Biscay, or deep Cylinder soils. This soil has the profile described as representative for the Cylinder series. The depth to sand and gravel is about 24 to 32 inches.

Included with this soil in mapping are a few areas of gently sloping soils and a few areas where glacial till is at a depth of about 42 to 48 inches. Most of these included areas are in the valley of Lizard Creek.

This somewhat poorly drained soil is slightly wet in years of above average rainfall, but crop growth is generally not seriously affected. Plant growth is hindered by lack of available water in dry years. Tilth is usually good. Most areas of this soil are cultivated. It is well suited to row crops, but in some years droughtiness is a limitation. A few areas are large enough to manage separately, but most areas are managed along with the associated soils. Capability unit IIs–1; woodland suitability group 3w1.

Dorchester Series

The Dorchester series consists of moderately dark colored, moderately well drained or somewhat poorly drained soils that formed in silty alluvium deposited by flood waters. These soils are nearly level. They are on bottom lands, mainly in elongated areas that are generally at a slight angle to the depositing stream. Most areas are in the valley of the Des Moines River south of Fort Dodge (fig. 9). Individual areas are generally 2 to 30 acres in size.

In a representative profile, the surface layer is very dark gray and very dark grayish-brown silt loam about 31 inches thick. The underlying material, to a depth of about 59 inches, is friable, dark grayish-brown silt loam. Below this, to a depth of 76 inches, it is dark grayish-brown sandy loam and loamy sand. The surface layer and underlying material tend to be stratified, and horizontal cleavage is evident.

The available water capacity is high, permeability is moderate, and the content of organic matter is moderately low or moderate. These soils are mildly or moderately alkaline and they are calcareous throughout. The subsoil is low in available phosphorus and very low in available potassium.

Dorchester soils are subject to flooding. In some places bayoulike areas need to be drained to allow surface water to run off. Most areas are cultivated, but a few are in permanent pasture or are idle.

Representative profile of Dorchester silt loam, in a cultivated field 400 feet west and 400 feet south of the northeast corner of the SW¼SE¼ sec. 25, T. 87 N., R. 27 W.

Ap—0 to 8 inches, very dark gray (10YR 3/1) silt loam; weak, medium, subangular blocky and fine, granular structure; friable; moderately alkaline; slightly effervescent; abrupt, smooth boundary.

A12—8 to 14 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, medium, subangular blocky and fine granular structure; friable; moderately alkaline; slightly effervescent; gradual, smooth boundary.

A13—14 to 22 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, fine, granular and weak, fine, subangular blocky structure; friable; horizontal cleavage attributed to sedimentation; moderately alkaline; slightly effervescent; gradual, smooth boundary.

A14—22 to 31 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, fine, granular and weak, fine, subangular blocky structure; mainly horizontal cleavage attributed to sedimentation; friable; moderately alkaline; slightly effervescent; gradual, smooth boundary.

C1—31 to 48 inches, dark grayish-brown (10YR 4/2) silt loam; very weak, fine and medium, subangular blocky structure to massive; friable; calcareous; gradual, smooth boundary.

C2—48 to 59 inches, dark grayish-brown (2.5Y 4/2) silt loam; massive; friable; moderately alkaline; slightly effervescent; abrupt, smooth boundary.

C3—59 to 65 inches, dark grayish-brown (2.5Y 4/2) very fine sandy loam; massive; friable; moderately alkaline; slightly effervescent; abrupt, smooth boundary.

C4—65 to 76 inches, dark grayish-brown (2.5Y 4/2) fine loamy sand; friable; moderately alkaline; slightly effervescent.

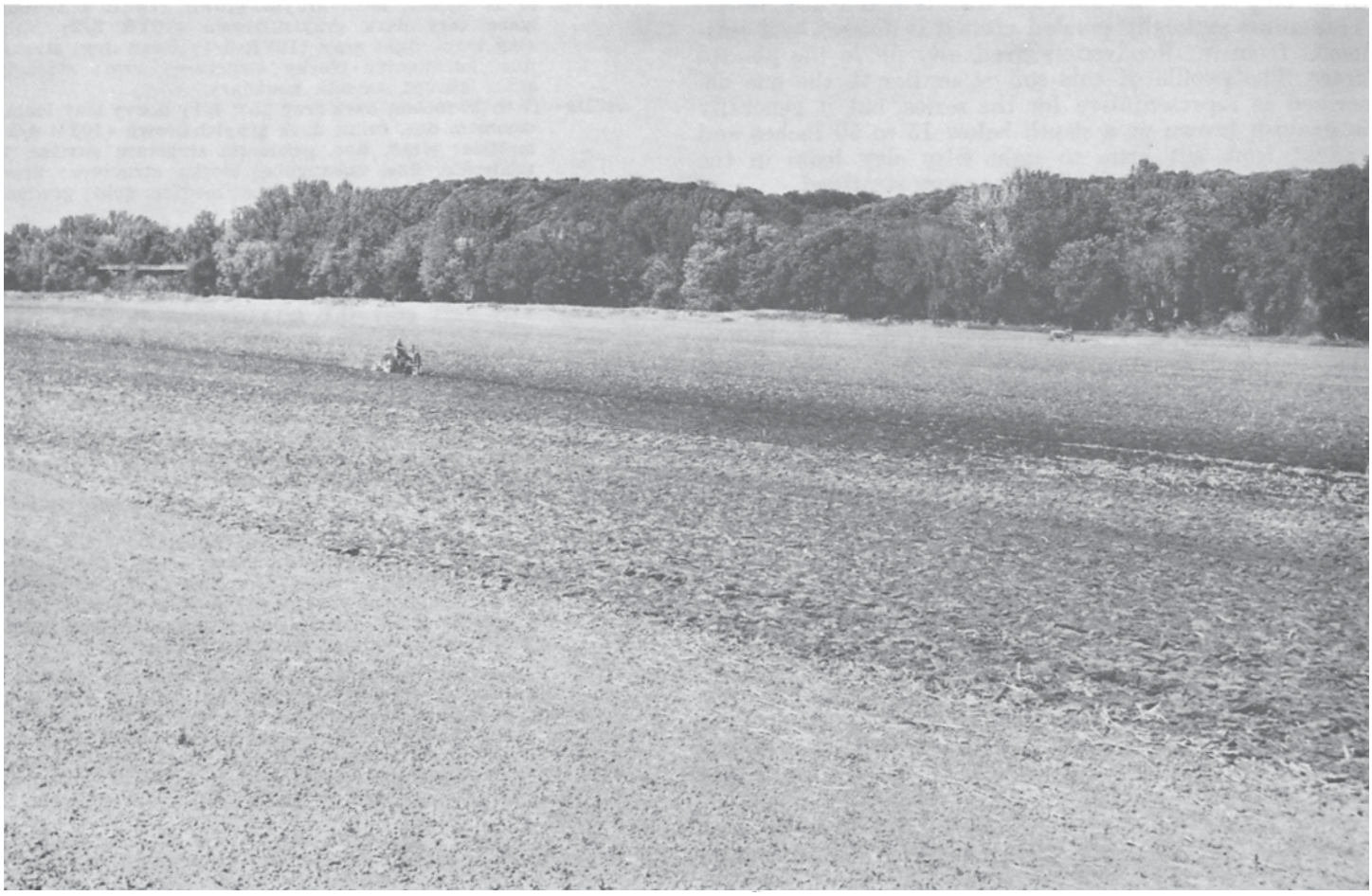

Figure 9.—**Area of Dorchester silt loam and of Dorchester silt loam, frequently flooded, in the valley of the Des Moines River about 4 miles southeast of Dayton.**

The A horizon is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). In some places the A horizon is about 10 to 20 inches thick; in other places, it is as thick as 31 inches. In places there is an AC horizon that ranges from very dark grayish brown to dark grayish brown (10YR 3/2 to 10YR 4/2). The C horizon ranges from dark grayish brown (10YR 4/2 or 2.5Y 4/2) to grayish brown (10YR 5/2 or 2.5Y 5/2). This horizon has yellowish-brown or strong-brown mottles or oxide stains in places. Generally these soils are stratified. They are mainly friable silt loam to a depth of 40 inches, but thin strata of sandier materials are in many places. A sandy layer is below a depth of 40 inches in some profiles and is below a depth of 50 inches in many places. Reaction of Dorchester soils is mildly alkaline to moderately alkaline, and these soils are calcareous throughout.

In Webster County Dorchester soils have a thicker and darker A horizon than is recognized in the defined range for the series and a higher content of sand that is coarser than very fine sand. They tend to be somewhat less stratified than Dorchester soils in other survey areas. These differences do not affect the use and management of the soils. Dorchester soils differ from the Buckney soils in being dominantly silt loam rather than sandy loam to a depth of 40 inches. They differ from the Spillville soils in being lighter colored, siltier, and calcareous between depths of 0 to 40 inches. These soils are associated on the landscape.

Dorchester silt loam (0 to 2 percent slopes) (158).—This nearly level soil is in areas that are generally at a slight angle to the nearby stream, mainly the Des Moines River. It is commonly associated with the Buckney soils, which are generally between the river and this Dorchester soil, and with the Spillville soils. This soil has the profile described as representative for the Dorchester series. Individual areas are variable in shape, but most areas are long and narrow.

Included with this soil in mapping are areas of soils that are similar, except that the soils are gently sloping.

This soil is subject to flooding. Much depends on its position on the bottom lands, but flooding generally occurs early enough in the year or is not severe enough to seriously hinder cultivation or to damage crops. Most areas are cultivated, and row crops are grown most of the time. This soil is well suited to this use if the hazard of flooding is not too severe. A few bayoulike areas are in this mapping unit. Some of these areas are wet unless an outlet is provided for surface water. A few areas are in pasture or are idle. These areas generally have trees, brush, and weeds. Tilth in cultivated areas is good. Capability unit IIw–3; woodland suitability group 5w2.

Dorchester silt loam, frequently flooded (0 to 2 percent slopes) (815).—This soil generally is in old stream cutoffs or bayoulike areas, mainly near the Des Moines River. These areas are generally concave and are flooded sooner than areas of other Dorchester soils be-

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cause they are at an elevation that is a few feet lower. This soil is generally ponded after it is flooded, and sediments from the floodwaters gradually fill in the ponded areas. The profile of this soil is similar to the one described as representative for the series, but it generally is grayish brown at a depth below 15 to 50 inches and ranges from silt loam to light silty clay loam in the surface layer. It also tends to be more stratified.

Included with this soil in mapping are some areas of a soil that ranges from dark gray to olive gray in color.

Many areas of this soil are cultivated along with other Dorchester soils. Floodwaters that generally recede from other Dorchester soils remain ponded in many places on this soil. Sometimes this water soaks away before killing the crop, but the crop is generally stunted. Tilth is fair or good. This soil generally is moderately suited to row crops if ponded areas are drained. Some areas have a growth of trees, brush, and weeds and are in pasture or are idle. Capability unit IIIw–2; woodland suitability group 5w2.

Dundas Series

The Dundas series consists of moderately dark colored, poorly drained soils that formed in glacial till and sediment from glacial till. These soils are in nearly level areas or in slight depressions on uplands. They are in the Le Sueur-Luther-Hayden soil association near the valley of the Des Moines River extending from Fort Dodge to the south county line. Areas are generally 2 to 15 acres in size. The native vegetation was trees and grass.

In a representative profile, the surface layer is very dark gray silt loam about 9 inches thick. The subsurface layer is very dark grayish-brown and dark grayish-brown, friable silt loam about 3 inches thick. The subsoil is about 28 inches thick. It is dark-gray and olive-gray, firm heavy clay loam that has black to dark-gray coatings on the individual soil aggregates. The underlying material is yellowish-brown and olive-gray light clay loam that contains a few pebbles or stones.

The available water capacity is high, and permeability is moderately slow or slow. The content of organic matter is moderate. Most of the surface and subsurface layer and the subsoil is slightly acid or medium acid. The subsoil is low in available phosphorus and very low in available potassium.

Dundas soils are wet, and water tends to pond on the surface in some areas. Some areas are cultivated and used for row crops, small grains, or forage crops. Other areas are in wooded pasture.

Representative profile of Dundas silt loam, in a cultivated field 400 feet east and 10 feet south of the northeast corner of the SW¼NW¼ sec. 22, T. 87 N., R. 27 W.

A1—0 to 9 inches, very dark gray (10YR 3/1) silt loam, gray (5Y 5/1) when dry; weak, fine and very fine, subangular blocky structure; friable; slightly acid; abrupt, smooth boundary.

A2—9 to 12 inches, very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) heavy silt loam, light gray (10YR 6/1) when dry; weak, thin, platy structure parting to moderate, very fine, subangular blocky structure; friable; medium acid; abrupt, smooth boundary.

B1—12 to 17 inches, dark grayish-brown (10YR 4/2) and some very dark grayish-brown (10YR 3/2) light clay loam, light gray (10YR 6/1) when dry; strong, fine, subangular blocky structure; firm; strongly acid; abrupt, smooth boundary.

B21tg—17 to 25 inches, dark-gray (5Y 4/1) heavy clay loam; common, fine, faint, dark grayish-brown (10YR 4/2) mottles; weak, fine, prismatic structure parting to moderate, fine, subangular blocky structure; firm; thin discontinuous clay films; medium acid; gradual, smooth boundary.

B22tg—25 to 34 inches, olive-gray (5Y 4/2) heavy clay loam; common, fine, distinct, olive-brown (2.5Y 4/4) mottles; weak, fine, prismatic structure parting to moderate, medium, subangular blocky structure; firm; very dark gray (5Y 4/1) coatings on peds; black (5Y 2/1) coatings on prism faces; common, fine concretions of a yellowish-brown and black oxide; thick, discontinuous clay films; slightly acid; gradual, smooth boundary.

B3—34 to 40 inches, yellowish-brown (10YR 5/6) and olive-gray (5Y 5/2) medium clay loam; moderate, medium, prismatic structure; firm; very dark gray (5Y 3/1) and black (5Y 2/1) clay films and clay fillings in pores; mildly alkaline; clear, smooth boundary.

C—40 to 58 inches, yellowish-brown (10YR 5/6) and olive-gray (5Y 5/2) light clay loam; weak, coarse, prismatic structure; friable; few, fine, dark-colored, soft oxides; abundant accumulations of white, soft lime; black (5Y 2/1) coatings on cleavage faces and pores; moderately alkaline; slightly effervescent.

The A1 horizon ranges from 5 to 10 inches in thickness and from loam or silt loam to light clay loam or light silty clay loam in texture. It has weak, very fine or fine, granular or subangular blocky structure. The A2 horizon ranges from 2 to 6 inches in thickness, from very dark grayish brown (10YR 3/2) to dark gray (10YR 4/1) or dark grayish brown (10YR 4/2) in color, and is friable silt loam or loam in texture.

The B horizon commonly extends to a depth of 36 to 48 inches. It is dark gray (10YR 4/1) or dark grayish brown (10YR 4/2) in the upper part and gray (5Y 5/1) or olive gray (5Y 4/2 or 5/2) to grayish brown (2.5Y 5/2) in the lower part. Generally black to grayish coatings are on ped or prism faces, and brownish or olive mottles are in many places in this horizon. The texture is firm heavy clay loam or light clay in the finest textured part of the B horizon. In places the upper part of the B horizon is gritty silty clay loam. In places yellowish-brown colors are in the B3 horizon, and in places the texture is loam.

The C horizon is mottled yellowish-brown and olive-gray, calcareous, friable loam or light clay loam. It has other closely related colors in places. Small stones and pebbles are throughout the profile in many places, and in some places there are larger stones or boulders. Reaction of the solum is slightly acid to strongly acid in the upper part, but it is neutral or mildly alkaline, but noncalcareous, in the lower part.

Dundas soils in Webster County tend to have an A2 horizon that is less prominent and that has a higher content of organic matter than is recognized in the defined range of the Dundas series. These soils also tend to be somewhat finer textured in the finest part of the B horizon. These differences do not affect the use and management of the soils.

Dundas soils typically have a somewhat lighter colored A1 horizon and a somewhat more prominent A2 horizon than Rolfe soils. They are not so dark colored in the upper part of the B horizon. These soils formed in similar parent material.

Dundas silt loam (0 to 2 percent slopes) (307).—This soil is in nearly level to slightly depressed areas on uplands. It is associated with Luther, Le Sueur, and Cordova soils.

Included with this soil in mapping are a few areas where the underlying material is stratified silt loam and

sandy loam. Also included are about 80 acres of a soil that has a lighter colored, thinner surface layer and a somewhat less gray subsoil.

This soil is wet, and water ponds on the surface in places. This soil is used for timber, pasture, and cultivated crops. It is moderately suited to row crops if adequately drained. Tilth is generally fair or good in cultivated areas. Capability unit IIIw–1; woodland suitability group 5w3.

Estherville Series

The Estherville series consists of dark-colored, somewhat excessively drained soils that formed in loamy alluvium that is underlain by sand and gravel, generally at a depth of 15 to 30 inches. These soils are nearly level to strongly sloping and are on benches and bench escarpments mainly along the Des Moines River and its larger tributaries in the Storden-Hayden-Wadena soil association. A few scattered areas are in other soil associations. Individual areas generally are 2 to 30 acres in size. The native vegetation was prairie grasses.

In a representative profile, the surface layer is very dark brown sandy loam about 14 inches thick. The subsoil, to a depth of 24 inches, is dark-brown and brown, very friable sandy loam. Below this, to a depth of 35 inches, the subsoil is very friable, brown, coarse sandy loam that has some gravel. The underlying material is grayish-brown and dark yellowish-brown, loose sand and gravel.

The available water capacity is low or very low. Permeability is moderately rapid in the upper part, but it is rapid or very rapid in the sand and gravel. The content of organic matter is moderately low. The subsoil is very low in available phosphorus and available potassium. The surface layer and subsoil are slightly acid to neutral.

Estherville soils lack adequate available water for good plant growth during dry periods. Sloping areas are subject to water erosion, and soil blowing is a hazard in places. Some areas are cultivated, but most areas of moderately sloping or strongly sloping soils are in pasture. A few areas have been cultivated but are now idle.

Representative profile of Estherville sandy loam, 0 to 2 percent slopes, in a cultivated field 45 feet south and 780 feet east of the northwest corner of the SW¼ sec. 10, T. 89 N., R. 29 W.

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

A12—7 to 10 inches, very dark brown (10YR 2/2) sandy loam; very weak, medium, subangular blocky and moderate, fine, granular structure; friable; slightly acid; gradual, smooth boundary.

A3—10 to 14 inches, very dark brown (10YR 2/2) to very dark grayish-brown (10YR 3/2) sandy loam; very weak, medium, subangular blocky structure; friable; neutral; clear, smooth boundary.

B1—14 to 18 inches, dark-brown (7.5YR 3/2) and very dark brown (10YR 2/2) sandy loam; weak, medium, subangular blocky structure; very friable; neutral; gradual, smooth boundary.

B2—18 to 24 inches, brown (10YR 4/3 to 7.5YR 4/4) sandy loam; medium, subangular, blocky structure; very friable; thin discontinuous clay films; neutral; gradual, smooth boundary.

B3—24 to 35 inches, brown (7.5YR 4/4) coarse sandy loam that has some gravel; weak, medium, subangular blocky structure; very friable; some clay-iron bridging; neutral; clear, smooth boundary.

IIC—35 to 52 inches, mixed grayish-brown (10YR 5/2) and dark yellowish-brown (10YR 4/4) fine sand and gravel; single grain; loose; mildly alkaline; slightly effervescent at a depth of 48 inches.

The A horizon is 8 to 16 inches thick. The A1 horizon ranges from black (10YR 2/1) to very dark brown (10YR 2/2). The A3 horizon is very dark brown (10YR 2/2), very dark gray (10YR 3/1), very dark grayish brown (10YR 3/2), or dark brown (10YR 3/3) in color. The B horizon is dark brown (7.5Y 3/2 or 10YR 3/3) to brown (10YR 4/3 or 7.5Y 4/4), strong brown (7.5Y 5/6), or yellowish brown (10YR 5/6) and is very friable or friable sandy loam that ranges to loamy sand in the B3 horizon. The content of sand-size material and gravel generally increases with depth. A considerable amount of gravel is in the profile, beginning at a depth of 15 to 30 inches. The IIC horizon is mildly alkaline to moderately alkaline, loose, dark yellowish-brown or yellowish-brown (10YR 4/4 or 5/4) or grayish-brown (10YR 5/2 or 2.5Y 5/2) sand and gravel. In many places this horizon is calcareous throughout. In others it is not calcareous in the upper part.

Estherville soils in Webster County are more deeply leached of free carbonates and have less difference in texture between the material in the B horizon and in the IIC horizon than is recognized in the defined range of the Estherville series. These differences do not affect the use and management of the soils.

Estherville soils are associated with Wadena soils on the landscape. They differ from Wadena soils in being sandy loam rather than loam in texture in the A and B horizons.

Estherville sandy loam, 0 to 2 percent slopes (34A).—This nearly level soil is on benches. It generally is associated with Wadena and Cylinder soils. It has the profile described as representative for the series.

Included with this soil in mapping are a few areas of soils that have a surface layer and a subsoil that are loam in texture to a depth of about 18 inches.

This soil has low available water capacity and in most years this limits crop growth. Soil blowing is a hazard at times, and blowing sand injures young plants in some places. Many areas of this soil are cultivated. Some are in pasture. This soil generally is managed along with surrounding soils. It is moderately suited to row crops, but plant populations need to be limited to the number that can be supported by available water. Tilth is good. Capability unit IIIs–1; woodland suitability group 4s1.

Estherville sandy loam, 2 to 5 percent slopes (34B).—This gently sloping soil is mainly on low knolls on benches and generally is associated with Wadena, Cylinder, or other Estherville soils. The profile of this soil is similar to the one described as representative for the series, but the surface layer generally is thinner and the depth to sand and gravel generally is about 24 inches.

Included with this soil in mapping are a few areas of soils that are similar to this soil and that have glacial till at a depth of 42 to 48 inches. A few areas that have bedrock at a depth of 30 to 50 inches are shown on this soil map by a special symbol for rock. Also included are a few areas that have fine and medium sand as the underlying material. About 55 acres are gravelly and calcareous throughout. These areas are similar to Salida soils mapped in other places in Iowa. A few areas are loam in texture to a depth of about 18 inches. Most of the included soils are in the valley of Lizard Creek.

This soil is subject to soil blowing, and at times blowing sand injures young plants. The hazard of water erosion

is slight, but it occurs in places if vegetation is sparse. Some areas of this soil are cultivated; others are in pasture. The soil is moderately suited to row crops, but plant populations need to be limited to the amount that can be supported by available water. Lack of adequate available water limits crop growth in most years. Tilth is good. Capability unit IIIe–3; woodland suitability group 4s1.

Estherville sandy loam, 5 to 9 percent slopes (34C).—This soil is mainly on knolls or on escarpments between bench levels. It is generally in association with Wadena, Cylinder, or other Estherville soils. The profile of this soil is similar to the one described as representative for the series, but the surface layer generally is about 10 inches thick. It is very dark brown or very dark grayish brown. The depth to sand and gravel is generally about 20 to 24 inches.

Included with this soil in mapping are a few areas where the underlying material is fine to medium sand. Also included are about 90 acres of a soil that is gravelly and calcareous throughout. It is similar to Salida soils mapped in other counties in Iowa. Most of these included soils are in the valley of Lizard Creek.

This soil is subject to soil blowing and water erosion. The low available water capacity is a severe limitation during dry periods. A few areas are cultivated, but most areas are in pasture that has scattered brush and trees. A few areas have been cultivated but are now idle and used as wildlife habitat. This soil is moderately suited to row crops, but inadequate available water limits crop growth in most years. This soil is also suited to pasture or to use as wildlife habitat. If row crops are grown, plant populations need to be limited to the number that can be supported by available moisture. Capability unit IIIe–3; woodland suitability group 4s1.

Estherville sandy loam, 9 to 14 percent slopes (34D).—This soil is mainly on short escarpments between benches. Wadena, Cylinder, or other Estherville soils generally are upslope on the benches. Cylinder, Biscay, or bottomland soils, such as Spillville or Colo soils, generally are downslope. The profile of this soil is similar to the one described as representative for the series, but the surface layer generally is 8 to 12 inches thick. It is very dark brown or very dark grayish brown in color. The depth to sand and gravel is generally about 15 to 24 inches. Areas are generally long and narrow in shape, but relatively small in size.

Included with this soil mapping are a few areas that have slopes of as much as 18 percent, a few areas where the underlying material is fine to medium sand, and a few areas that are gravelly and calcareous throughout. Most of these included soils are in the valley of Lizard Creek.

This soil is subject to erosion if vegetation is sparse. The low available water capacity severely limits plant growth in most years. A few areas are cultivated, but most areas are in pasture that has scattered brush and trees. A few areas have been cultivated but are now idle and used as wildlife habitat. Cultivated areas are better suited to forage crops than to row crops, but row crops are grown in a few areas in some years. Capability unit IVe–1; woodland suitability group 4s1.

Gosport Series

The Gosport series consists of moderately dark colored, steep, moderately well drained soils that formed in material weathered from shale. These soils are on the lower parts of side slopes on uplands. They are below soils that formed in glacial till. In a few places they are steep and are on escarpments of benches. These soils are in the valley of the Des Moines River and extend a short distance up the valley of Lizard Creek. They are mostly between Deception Hollow State Park and about one-half mile north of Lehigh, and from the mouth of Holiday Creek to a short distance north of Fort Dodge. Areas range from 2 to 50 acres in size and generally are long and narrow in shape. The native vegetation was trees and forest plants.

In a representative profile, the surface layer is very dark gray silt loam about 5 inches thick. The subsurface layer is friable, light brownish-gray silt loam about 2 inches thick. The subsoil is firm, olive-gray silty clay about 11 inches thick. The underlying material is dark grayish-brown and light olive-brown silty clay.

The available water capacity is low or moderate, and permeability is very slow. The content of organic matter is low. The surface and subsurface layers are generally medium acid to strongly acid, and the subsoil and substratum are strongly acid or very strongly acid. The subsoil is very low in available phosphorus and available potassium.

Gosport soils are subject to erosion if vegetation is sparse. They absorb water very slowly. Runoff is rapid. Most areas of these soils are in second-growth timber and are used as wooded pasture. A few areas are not in pasture and are used as woodland.

Representative profile of Gosport silt loam, 24 to 45 percent slopes, in a timber pasture 700 feet east and 1,000 feet north of the southwest corner of the NE¼ sec. 12, T. 87 N., R. 28 W.

A1—0 to 3 inches, very dark gray (10YR 3/1) silt loam, gray (5Y 5/1) when dry; weak, thin, platy structure parting to weak, fine, granular and very fine subangular blocky structure; friable; common light-gray silica particles; abundant roots; neutral; abrupt, smooth boundary.

A12—3 to 5 inches, very dark gray (10YR 3/1) and grayish-brown (2.5Y 5/2) silt loam, gray (10YR 5/1) and light gray (10YR 6/1) when dry; weak, thin and medium, platy structure parting to moderate, very fine and fine, subangular blocky structure; friable; abundant roots; medium acid; abrupt, smooth boundary.

A2—5 to 7 inches, light brownish-gray (2.5Y 6/2) silt loam, light gray (10YR 7/1) when dry; moderate, thin and medium, platy structure parting to weak, fine, subangular blocky structure; friable; many, hard, unweathered oxides; few hard ferromagnesium plates; many roots; strongly acid; abrupt, smooth boundary.

B21—7 to 9 inches, olive-gray (5Y 5/2) silty clay, light gray (5Y 7/1) when dry; strong, very fine, angular and subangular blocky structure; firm; hard oxides, 2 inches in diameter, at a depth of 7 to 9 inches; common roots; common, moderately hard, cemented oxides; very strongly acid; clear, smooth boundary.

B22—9 to 14 inches, olive-gray (5Y 5/2) silty clay; strong, very fine and fine, subangular blocky structure; firm; abundant light-gray silica particles; common, cemented, moderately hard oxides; many hard shale fragments; very strongly acid; clear, smooth boundary.

B3—14 to 18 inches, olive (5Y 5/3), olive-gray (5Y 5/2), and light olive-brown (2.5Y 5/4) silty clay; weak, fine, prismatic structure parting to moderate, very fine and fine, angular and subangular blocky structure; firm; few roots; common, light olive-brown, cemented oxides; few, cemented, soft shale fragments; very strongly acid; abrupt, smooth boundary.

C—18 to 28 inches, dark grayish-brown (5Y 4/2) and light olive-brown (2.5Y 5/4) silty clay; weak, medium, prismatic structure parting to very weak, very fine and fine, angular and subangular blocky structure; firm; few roots; common, light olive-brown, cemented oxides; few soft shale fragments; hard, cemented, concentric oxides 3 inches in diameter at a depth of 18 inches; very strongly acid.

R—28 to 60 inches, olive-gray (5Y 6/2) shale; massive; very hard.

The A1 horizon is 3 to 9 inches thick. This horizon is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2) and is silt loam or silty clay loam. In places this horizon is dark grayish brown (10YR 4/2). The A2 horizon is 2 to 7 inches thick. This horizon ranges from dark gray (10YR 4/1) to light brownish gray (2.5Y 6/2) and is silt loam or silty clay loam. The B horizon is 8 to 10 inches thick. It is olive gray (5Y 5/2) to pale olive (5Y 6/3), grayish brown (2.5Y 5/2), or olive brown (2.5Y 5/4) and is firm silty clay or clay. This horizon has strong angular or subangular blocky structure. The C horizon is firm silty clay or clay in texture and has colors similar to those in the B horizon. In places yellowish-brown, strong-brown, and brown mottles are in the B and C horizons. Reaction of the B and C horizons is strongly acid to extremely acid.

Gosport soils in Webster County tend to have a thinner solum than recognized in the defined range for the Gosport series, and the chroma in the upper part of the B horizon tends to be lower. These differences do not affect the use and management of the soils.

Gosport soils differ from Calamine soils in that they formed entirely in shale rather than in glacial sediment over shale. They have less sand and more clay than Calamine soils.

Gosport silt loam, 25 to 45 percent slopes (313G).—This steep soil is in the valleys of the Des Moines River and Lizard Creek. It is generally below Storden-Hayden loams and upslope from bottom-land soils. Individual areas are long and narrow.

Included with this soil in mapping are small acreages where as much as 40 inches of glacial till covers the shale. Also included are a few areas that have slopes of 9 to 25 percent.

Nearly all areas of this soil are in woodland. Most are used as wooded pasture, but the production of forage is low. Grazing livestock, in some places, establishes trails that erode and cause gullies. It is not practical to clear most areas of this soil to establish more productive pasture plants, because the soil is steep and topography is rough. Many areas would be more productive if managed as woodland or used for wildlife habitat or recreation. Capability unit VIIe–1; woodland suitability group 5w1.

Guckeen Series

The Guckeen series consists of dark-colored, somewhat poorly drained soils that formed in clayey lacustrine sediment and underlying glacial till. These soils are nearly level to gently sloping. They are on uplands. They are mainly in the Marna-Guckeen soil association that is mostly in the southern tier of townships in the county. Individual areas range from 2 to about 50 acres, but most are larger than 20 acres in size. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black and is about 16 inches thick. It is clay loam in the upper part and silty clay and clay in the lower part. The subsoil is about 44 inches thick. The upper part is very dark gray, very dark grayish-brown, and dark grayish-brown, firm heavy clay loam and light clay. The lower part is mottled light olive-brown, olive-gray, yellowish-brown, and light-gray, firm light clay loam. The underlying material is mottled yellowish-brown and light-gray, friable light clay loam glacial till that contains a few pockets and seams of coarse sandy loam.

The available water capacity is high, and permeability is slow in the most clayey layers. The content of organic matter is moderate or high. The surface layer and the upper part of the subsoil are typically medium acid or slightly acid. The subsoil is very low in available phosphorus and very low or low in available potassium.

Representative profile of Guckeen clay loam, 1 to 3 percent slopes, in a cultivated field 857 feet south and 1,120 feet east of the northwest corner of sec. 26, T. 86 N., R. 28 W.

Ap1—0 to 5 inches, black (10YR 2/1) clay loam, black (10YR 2/1) when crushed, very dark gray (10YR 3/1) when dry; cloddy parting to weak, fine, granular structure; friable; medium acid; abrupt, smooth boundary.

Ap2—5 to 9 inches, black (10YR 2/1) clay loam, black (10YR 2/1) when crushed, very dark gray (10YR 3/1) when dry; moderate, fine and medium, angular blocky and fine subangular blocky structure; friable; slightly acid; clear, smooth boundary.

A12—9 to 16 inches, black (10YR 2/1) light silty clay and clay, dark gray (10YR 4/1) when dry; moderate, fine, subangular blocky and very fine granular structure; friable; few very dark grayish-brown (2.5Y 3/2) peds in lower part; few 1/8-inch pebbles; slightly acid; gradual, smooth boundary.

B1—16 to 21 inches, very dark gray (10YR 3/1) and about 25 percent very dark grayish brown (2.5Y 3/2) heavy clay loam, faces of peds black (10YR 2/1) and about 20 percent very dark gray (10YR 3/1); moderate, fine and very fine, subangular blocky structure; friable; few pebbles; slightly acid; clear, smooth boundary.

B21—21 to 28 inches, dark grayish-brown (2.5Y 4/2) light clay, faces of peds very dark grayish brown (2.5Y 3/2) and very dark gray (10YR 3/1), some peds very dark gray (10YR 3/1) throughout; weak, medium, prismatic and moderate, fine and medium, subangular blocky structure; firm; thin, distinct clay films; few, very fine, soft, dark yellowish-brown oxides; some root hole fillings are black (10YR 2/1); few small shale and quartz pebbles; few pebbles as much as about 1 inch in diameter; medium acid; clear, smooth boundary.

B22—28 to 36 inches, dark grayish-brown (2.5Y, 4/2) light clay, faces of peds dark gray (10YR 4/1) and dark grayish brown (2.5Y 4/2); few, fine, yellowish-brown (10YR 5/6) mottles; moderate, fine, prismatic structure parting to strong, medium, subangular blocky structure; firm; thin discontinuous clay films on smaller peds; common fine tubular pores; few black (10YR 2/1) fillings in root channels and pores; few stones and shale fragments; common concretions of dark-brown oxide; slightly acid; clear, smooth boundary.

I&IIB31—36 to 40 inches, light olive-brown (2.5Y 5/4) and and about 20 percent olive-gray (5Y 5/2) clay loam; weak, fine, prismatic structure parting to weak, medium, subangular blocky structure; firm; some peds are dark gray (10YR 4/1) on the vertical faces; dis-

tinct clay flows and pure fillings of very dark gray (10YR 3/1) to dark gray (10YR 4/1); many, fine, inped tubular pores; common, very fine, yellowish-brown (10YR 5/8), soft oxides; mildly alkaline; clear, wavy boundary.

IIB32—40 to 48 inches, mottled light olive-brown (2.5Y 5/4) and light-gray (5Y 6/1) light clay loam; weak, medium, subangular blocky structure that has some vertical cleavage; friable; some dark-gray (10YR 4/1) lime coatings on vertical faces and some lime segregated in pores; common lime rock pebbles and other pebbles ½ to 1 inch in diameter; few, fine, red and strong-brown oxides; few shale fragments; moderately alkaline; slightly effervescent; gradual, smooth boundary.

IIB33—48 to 60 inches, mottled yellowish-brown (10YR 5/4) and light-gray (5Y 6/1) light clay loam; very weak subangular blocky structure that has some vertical faces; friable; many fine pores; segregated lime in pores; many, fine, strong-brown and red oxides; common pebbles and stones; moderately alkaline; strongly effervescent; diffuse, smooth boundary.

IIC—60 to 72 inches, mottled yellowish-brown (10YR 5/4) and light-gray (5Y 6/1) light clay loam; very weak subangular blocky structure that has some vertical faces; friable; many fine pores; few pockets and seams of coarse sandy loam; many, fine, strong-brown and red oxides; many pebbles and stones; accumulations of lime; moderately alkaline; strongly effervescent.

The A horizon ranges from 10 to 20 inches in thickness and from black (10YR 2/1) to very dark brown (10YR 2/2) and very dark gray (10YR 3/1) in color. The texture is commonly silty clay loam or clay loam, but it ranges to clay in the lower part. This horizon generally has granular or subangular blocky structure, but in places it has angular blocky structure in the plow layer. The B horizon is mainly dark grayish brown (2.5Y 4/2), but colors in the upper part range to very dark gray (10YR 3/1), and the lower part is mottled with olive brown (2.5Y 5/4), grayish brown (2.5Y 5/2), olive gray (5Y 5/2), light gray (5Y 6/1), and yellowish brown (10YR 5/4). In places mottles of these colors are in the upper part of the B horizon. The texture in the upper part is heavy clay loam or silty clay loam to light clay. The depth to glacial till is typically 24 to 36 inches. In places a thin I&IIB3 horizon is below this depth. Reaction of the A horizon and the upper part of the B horizon is neutral to medium acid. The B2 horizon is neutral or slightly acid in the lower part.

Guckeen soils are not so poorly drained as Marna soils and are not so gray in the B horizon. Guckeen soils are not so well drained as Kamrar soils and lack brown and yellowish-brown colors in the upper part of the B horizon. They are more clayey in the B horizon than Nicollet soils. Marna and Kamrar soils are associated on the landscape. Nicollet soils have similar drainage.

Guckeen clay loam, 1 to 3 percent slopes (385A).—This soil is on slight rises on uplands. It is mainly at slightly higher elevations than the associated Marna soils and slightly lower than the similar but better drained Kamrar soils. In some places it is associated with Canisteo, Webster, Harps, Okoboji, and Lanyon soils.

Included with this soil in mapping are a very few areas of soils that have slopes of as much as about 5 percent.

Nearly all areas of this soil are cultivated. This soil is used mainly for row crops, and it is well suited to this use. It slopes enough for surface water to run off, but erosion is not a serious hazard. In wet springs or when rainfall is above average, some areas are somewhat wet, but most areas are not tile drained. Tilth generally is satisfactory, but the surface layer tends to dry out cloddy and hard if tilled when wet. Capability unit I–1; woodland suitability group 3w1.

Hanlon Series

The Hanlon series consists of dark-colored, somewhat poorly drained soils that formed in loamy alluvium. These soils are nearly level to gently sloping and are mainly near the Des Moines River and its larger tributaries. They are high enough that they do not flood every time the river overflows, but they are covered with water during the more severe floods. Individual areas vary widely in size but are generally from 5 to 30 acres. The native vegetation was grass, brush, and trees.

In a representative profile, the surface layer is very dark brown fine sandy loam about 27 inches thick. The subsoil is very dark grayish-brown to dark grayish-brown, very friable fine sandy loam about 19 inches thick. The underlying material is grayish-brown medium and coarse sand.

The available water capacity is low or moderate, and permeability is moderately rapid. The content of organic matter is moderate. The surface layer and the upper part of the subsoil are neutral. The subsoil is very low in available phosphorus and available potassium.

Most areas of Hanlon soils are cultivated, but some are in pasture. They lack adequate available water for good plant growth during dry periods. They are subject to flooding and are subject to soil blowing if left bare of vegetation.

Representative profile of Hanlon fine sandy loam, 0 to 3 percent slopes, in a cultivated field 15 feet west and 125 feet north of the southeast corner of sec. 7, T. 89 N., R. 29 W.

Ap—0 to 9 inches, very dark brown (10YR 2/2) fine sandy loam, very dark grayish brown (10YR 3/2) when dry; very weak, medium, subangular blocky structure; very friable; weak platiness caused by compaction; neutral; abrupt, smooth boundary.

A12—9 to 20 inches, very dark brown (10YR 2/2) fine sandy loam, very dark grayish brown (10YR 3/2) when dry; very weak, fine and medium, subangular blocky structure; very friable; neutral; gradual, smooth boundary.

A13—20 to 27 inches, very dark brown (10YR 2/2) to very dark gray (10YR 3/1) fine sandy loam, very dark grayish brown (10YR 3/2) when dry; very weak, fine and medium, subangular blocky structure; very friable; neutral; gradual, smooth boundary.

B1—27 to 35 inches, very dark grayish-brown (10YR 3/2) fine sandy loam, dark grayish brown (10YR 4/2) when dry; very weak, medium, subangular blocky structure; very friable; neutral; gradual, smooth boundary.

B2—35 to 46 inches, very dark grayish-brown (10YR 3/2) to dark grayish-brown (10YR 4/2) fine sandy loam, grayish brown (10YR 5/2) when dry; very weak, medium, subangular blocky structure; very friable; mildly alkaline; slightly effervescent; clear, smooth boundary.

IIC—46 to 60 inches, grayish-brown (10YR 5/2) medium and coarse sand; single grain; loose; moderately alkaline; slightly effervescent.

The A horizon is 24 to 30 inches thick. This horizon is black (10YR 2/1), very dark gray (10YR 3/1), or very dark brown (10YR 2/2) in color and is friable or very friable in consistence. It has very weak or weak, very fine or fine, granular or subangular blocky structure. The B horizon is very dark grayish brown (10YR 3/2) or dark grayish brown (10YR 4/2) in color, is friable or very friable in consistence, and has very weak or weak subangular blocky structure. This horizon generally extends to a depth of about 40 to 50 inches. The C horizon is dark grayish brown

(10YR 4/2) or grayish brown (10YR 5/2), friable to loose sandy loam, loamy sand, or sand. Reaction generally is neutral in the A horizon and neutral or mildly alkaline in the B horizon. In some places the lower part of the B horizon is calcareous. The C horizon is neutral to moderately alkaline, and it is calcareous.

Hanlon soils in Webster County are shallower to free calcium carbonates than is recognized in the defined range for the series, and the thickness of the dark-colored surface layer is minimal for the series. These differences do not affect the use and management of the soils.

Hanlon and Turlin soils are associated on the landscape. Hanlon soils are sandy loam in texture, but Turlin soils are loam. Hanlon and Ankeny soils formed in similar parent material. Hanlon soils are not so well drained as Ankeny soils and have dark grayish brown rather than brown colors in the B horizon.

Hanlon fine sandy loam, 0 to 3 percent slopes (536A).—This nearly level to gently sloping soil is on bottom lands (fig. 10). It is generally associated with Turlin or Spillville soils, Sandy alluvial land, or Alluvial land.

Included with this soil in mapping are about 75 acres of a similar soil that is slightly sandier. It is mostly in section 1 of Douglas Township and section 7 of Cooper Township. Also included are about 15 acres, mostly in section 12 of Deer Creek Township, of a soil that has a thinner surface layer and browner colors in the subsoil. Also included, mostly in sections 12 and 13 of Deer Creek Township, are about 30 acres of similar soils that have fragmented limestone bedrock at a depth of 30 to 50 inches. These areas, underlain by bedrock, are indicated on the soil map by a special symbol.

Inadequate available water is a limitation during dry periods. This soil is subject to flooding, and, if left bare of vegetation, is subject to soil blowing. Most areas of this soil are cultivated. Some of the very steep soils on uplands and escarpments above them are inaccessible to machinery. These areas are managed as pasture. This soil is well suited to row crops, but inadequate available water limits crop growth. The amount of available water in the soil depends on timeliness of rains and whether the plant roots can grow deep enough to reach a water table. This soil absorbs rainfall at a moderately rapid rate, so there is little runoff. Some areas are subject to soil blowing, and young plants are damaged by blowing sand in places. Factors affecting the use of this soil are the hazard of flooding and the occurence of a possible perched water table. Tilth generally is good. Capability unit IIs–1; woodland suitability group 5w2.

Harps Series

The Harps series consists of dark-colored, highly calcareous, poorly drained soils that formed in glacial till and glacial sediment. These soils occur almost entirely as narrow convex rims around depressions or potholes on uplands. Individual areas are narrow in shape and generally are small in size. The native vegetation was swamp grasses, sedges, and prairie grasses tolerant of wetness.

In a representative profile, the surface layer is light clay loam about 16 inches thick. It is black in the upper part and very dark gray in the lower part. The subsoil is light olive-gray, olive-gray and gray, calcareous, friable loam about 26 inches thick. The underlying material is mottled, dark-gray, gray, and dark yellowish-brown loam.

The available water capacity is high, and permeability is moderate. The content of organic matter is high. These soils are moderately alkaline and calcareous throughout. The subsoil is very low in available phosphorus and available potassium.

Harps soils are wet because of a high water table. If the surface layer is laid bare by plowing, soil blowing is a hazard. Fertility is low enough that special treatment is used in many places. Minor elements are deficient for some crops. Most areas of these soils are cultivated.

Representative profile of Harps clay loam, in a cultivated field 225 feet west and 125 feet south of the northeast corner of the SE¼ sec. 23, T. 89 N., R. 27 W.

Apca—0 to 8 inches, black (10YR 2/1) light clay loam, dark gray (5Y 4/1) when dry; moderate, fine, granular structure; friable; some pebbles; violently effervescent; moderately alkaline; abrupt, smooth boundary.

Alca—8 to 12 inches, black (10YR 2/1) light clay loam, very dark gray (10YR 3/1) when kneaded, dark gray (10YR 4/1) when dry; moderately fine granular structure; friable; moderately alkaline; violently effervescent; clear, smooth boundary.

A3ca—12 to 16 inches, very dark gray (N 3/0) and 20 percent dark-gray (5Y 4/1) light clay loam, very dark gray (10YR 3/1 to 5Y 3/1) when kneaded, gray (10YR 5/1) when dry; weak, fine and very fine, subangular blocky structure; friable; some pebbles; moderately alkaline; violently effervescent; clear, wavy boundary.

B1gca—16 to 26 inches, light olive-gray (5Y 6/2) and gray (5Y 5/1) loam; common, fine, dark yellowish-brown (10YR 4/4) mottles; weak, fine, subangular blocky structure; very friable; few very dark gray (10YR 3/1) krotovinas; some pebbles; moderately alkaline; violently effervescent; clear, smooth boundary.

B2g—26 to 34 inches, olive-gray (5Y 5/2) and gray (5Y 5/1) loam; many, fine, light olive-brown (2.5Y 5/6) mottles; weak, medium, prismatic structure parting to very weak, medium, subangular blocky structure; friable; very dark gray (10YR 3/1) krotovina 1 inch in diameter; some pebbles; moderately alkaline; strongly effervescent; gradual, smooth boundary.

B3g—34 to 42 inches, olive-gray (5Y 5/2) and gray (5Y 5/1) loam; many, fine, dark yellowish-brown (10YR 4/4) mottles; few dark-gray (5Y 4/1) and very dark gray (N 3/0) prism faces; weak, medium, prismatic structure parting to very weak, medium, subangular blocky structure; friable; very dark gray (N 3/0) krotovina 1 inch in diameter; some pebbles; moderately alkaline; strongly effervescent; diffuse, smooth boundary.

Cg—42 to 60 inches, mottled gray (5Y 5/1), dark-gray (5Y 4/1), and dark yellowish-brown (10YR 4/4) loam; massive, some vertical cleavage at a depth of 42 to 48 inches; friable; some pebbles, moderately alkaline; strongly effervescent.

The A horizon ranges from 10 to 18 inches in thickness, from black (10YR 2/1) to very dark gray (10YR 3/1) or (N 3/0) in color, and is light clay loam or heavy loam in texture. Snail shell fragments are in this horizon in many places. This horizon is generally granular in structure, but it is subangular blocky in the lower part. The B horizon ranges from gray (5Y 5/1) to light olive gray (5Y 6/2) or light grayish brown (2.5Y 6/2) in color, and from light clay loam to heavy loam in texture. In places in the lower part the texture is sandy clay loam, and in places thin strata of sandy loam occur. This horizon has granular or subangular blocky structure and in places has prismatic structure in the lower part. This horizon generally has yellowish-brown, olive-brown, or olive mottles in the lower part. It generally extends to a depth of about 30 to 48 inches. The C horizon generally is dark gray (5Y 4/1), gray (5Y 5/1), or olive gray (5Y 5/2) in color and is mottled with colors similar to those in the B horizon. Reaction is moderately alkaline, and these soils are calcareous throughout. The sur-

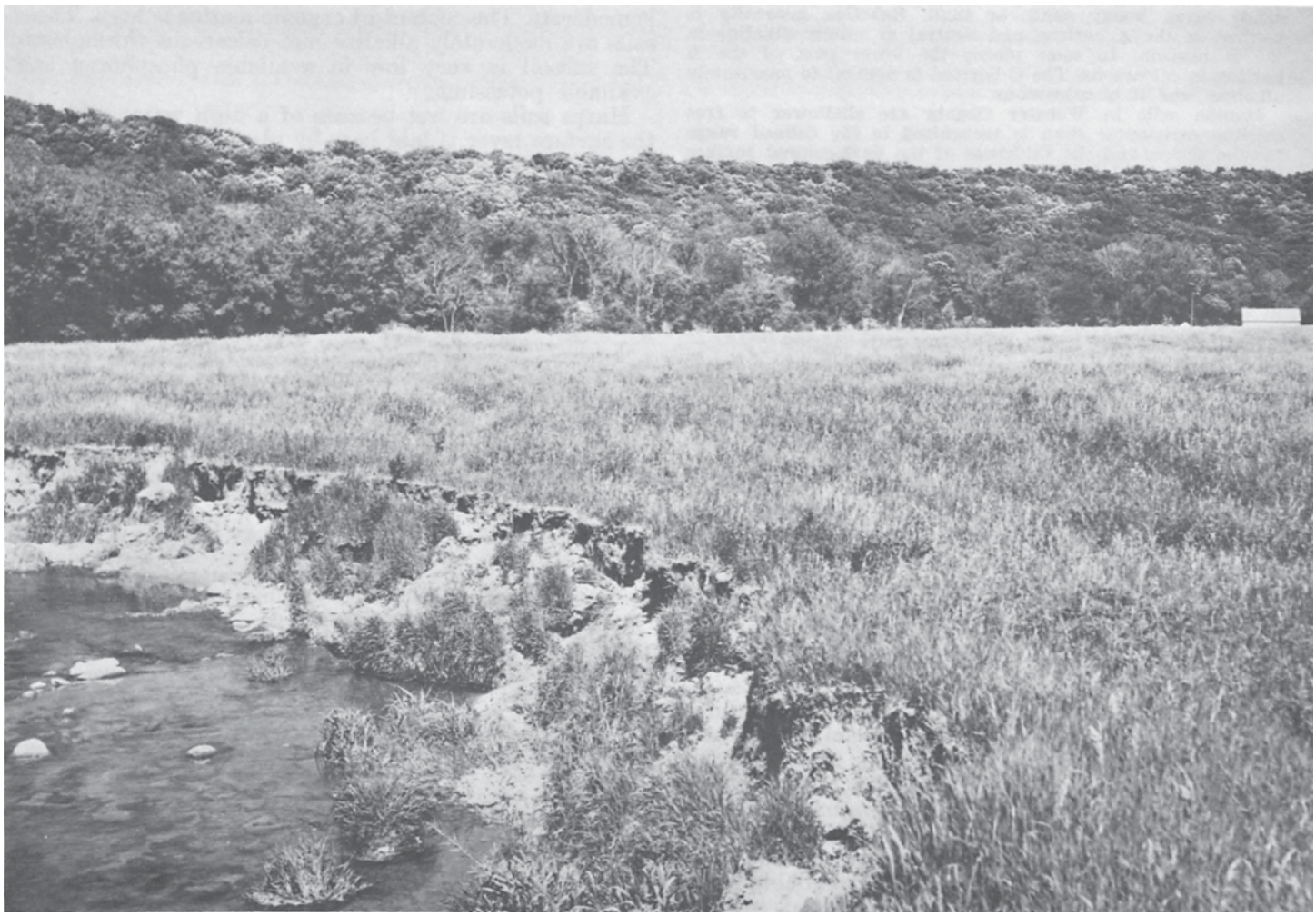

Figure 10.—**Area of bottom land consisting mainly of Hanlon fine sandy loam, 0 to 3 percent slopes. Storden-Hayden loams, 25 to 70 percent slopes, are on the side slopes of hills in the background.**

face layer and the upper part of the subsoil are especially high in calcium carbonate.

Harps soils are associated with Canisteo soils on the landscape. These soils contain a greater amount of lime and generally have somewhat less clay in the A horizon and the upper part of the B horizon than Canisteo soils. Harps and Talcot soils are calcareous throughout, but Harps soils have more lime than Talcot soils and are not underlain by sand and gravel.

Harps clay loam (0 to 2 percent slopes) (95).—This nearly level soil is generally on narrow rims surrounding depressions or potholes occupied by Okoboji, Wacousta, Lanyon, or Muck soils (fig. 11). Webster or Canisteo soils generally are in large areas surrounding this soil.

Included with this soil in mapping are a few areas of soils around larger depressions that are similar to this soil but that are sandier throughout. Small areas of this included soil are indicated on the soil map by a symbol for a calcareous spot.

This soil is wet unless tile drained. Special treatment is needed in many places to maintain fertility and obtain satisfactory crop growth. Available phosphorus, potassium, or minor elements limit plant growth in many places.

Nearly all areas of this soil are cultivated and are managed along with the associated soils. They are used mainly for row crops. The soil is well suited to this use if drainage is provided and fertility is maintained. Tilth generally is fair or good. Capability unit IIw–1; woodland suitability group 5w3.

Hayden Series

The Hayden series consists of light-colored, well-drained soils that formed in glacial till. The gently sloping or moderately sloping soils are on ridges and side slopes on uplands, and the steep or very steep soils are on sides of the valley of the Des Moines River in a complex with Storden soils. Individual areas of Hayden soils are generally 2 to 30 acres in size, but the areas that are in complex with Storden soils are much larger. The native vegetation was trees.

In a representative profile, the surface layer is very

Figure 11.—**Area of Harps, Okoboji, and Muck soils. The Harps soil is in the light-colored, higher areas, and the Okoboji and Muck soils occupy the lower areas.**

dark gray loam about 3 inches thick. The subsurface layer is dark grayish-brown to brown, friable loam about 7 inches thick (fig. 12). The subsoil is mainly dark yellowish-brown, firm clay loam about 42 inches thick. Strong-brown and grayish mottles are in the lower part of the subsoil. The underlying material is yellowish-brown and light olive-brown loam that is mottled with strong brown and grayish brown.

The available water capacity is high, and permeability is moderate. The content of organic matter is low. The surface and subsurface layers and the upper part of the subsoil generally are slightly acid or medium acid. The subsoil is medium in available phosphorus and very low in available potassium.

Hayden soils are subject to erosion if cultivated. Some areas of the gently sloping and moderately sloping Hayden soils are in cultivation and some are in trees or wooded pasture. The steep and very steep soils are almost entirely wooded, and most areas are in pasture.

Representative profile of Hayden loam, 2 to 5 percent slopes, in a wooded pasture 300 feet west and 650 feet south of the northeast corner of the NW¼NE¼ sec. 15, T. 88 N., R. 28 W.

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

A2—3 to 10 inches, dark grayish-brown (10YR 4/2) to brown (10YR 4/3) loam, pale brown (10YR 6/3) when dry; weak, thin, platy structure parting to weak, very fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

B1—10 to 15 inches, brown (10YR 4/3) loam, pale brown (10YR 6/3) when dry; moderate, fine, subangular blocky structure; friable; many silt coatings when dry; light gray (10YR 7/1) when dry; few fine pebbles; medium acid; clear, smooth boundary.

B21t—15 to 21 inches, dark yellowish-brown (10YR 4/4) clay loam, faces of peds dark brown (10YR 3/3) and brown (10YR 4/3); strong, medium, prismatic structure parting to moderate, fine, subangular blocky structure; firm; thin, discontinuous, dark-brown clay films; common silt coatings, light gray (10YR 6/1) when dry; few fine pebbles; slightly acid; gradual, smooth boundary.

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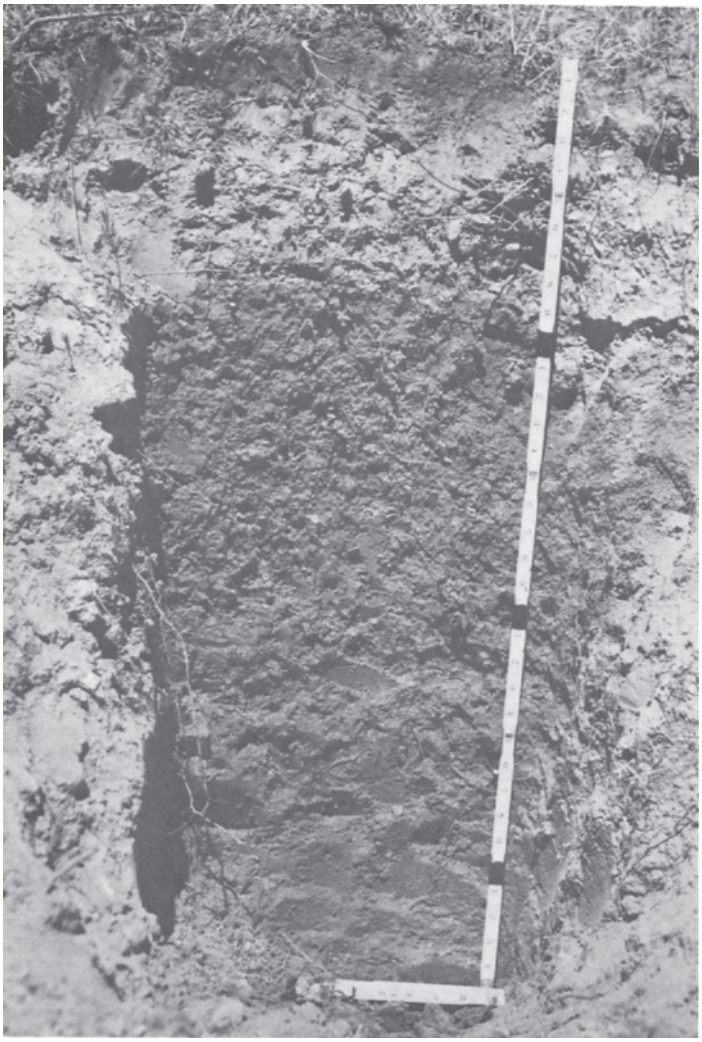

Figure 12.—**Profile of a Hayden loam. The grayish subsurface layer is distinctly visible when this soil is dry.**

B22t—21 to 28 inches, dark yellowish-brown (10YR 4/4) and yellowish-brown (10YR 5/6) clay loam, faces of peds dark yellowish brown (10YR 4/4); weak, medium, prismatic structure parting to strong, fine to medium, angular and subangular blocky structure; firm; thick, nearly continuous, dark-brown (10YR 3/3) clay films; few silt coatings, light gray (10YR 6/1) when dry; few fine pebbles; slightly acid; gradual, smooth boundary.

B23t—28 to 35 inches, yellowish-brown (10YR 5/4) clay loam, faces of peds dark yellowish brown (10YR 4/4); few, very fine, strong-brown (7.5YR 5/8) mottles; moderate, medium, prismatic structure parting to moderate, medium, angular and subangular blocky structure; firm; few silt coatings, pale brown (10YR 6/3) when dry; few, thick, discontinuous clay films on prisms, on peds, and in pores; few, fine, dark-colored iron and manganese concretions; few fine pebbles; slightly acid; gradual, smooth boundary.

B31t—35 to 42 inches, yellowish-brown (10YR 5/4 and 5/6) and light olive-brown (2.5Y 5/4) clay loam; common, very fine, strong-brown (7.5YR 5/8) mottles; moderate, coarse to medium, angular and subangular blocky structure; firm; few fine pebbles; thick, dis-

continuous, dark-brown (7.5YR 3/2 and 10YR 3/3) clay films on prisms and peds and in pores and root channels; common, medium, dark-colored iron and manganese concretions; neutral; clear, smooth boundary.

B32t—42 to 52 inches, yellowish-brown (10YR 5/4 and 5/6) and light olive-brown (2.5Y 5/4) loam; common, fine, strong-brown (7.5YR 5/8) and few, fine, grayish-brown (2.5Y 5/2) mottles; medium, coarse, prismatic structure; friable; very few, thick, discontinuous, dark-brown (7.5YR 3/2 and 10YR 3/3) clay films on prisms; common fine pebbles; few, medium concretions of a hard, dark-colored oxide; accumulations of white lime in root channels; moderately alkaline; strongly effervescent; gradual, smooth boundary.

C—52 to 60 inches, yellowish-brown (10YR 5/6) and light olive-brown (2.5Y 5/4) loam; common, fine, strong-brown (7.5YR 5/8) and few, fine, grayish-brown (2.5Y 5/2) mottles; weak, coarse, prismatic structure; friable; medium, hard concretions of a dark-colored oxide; intermittent white accumulations of lime in pores; common small pebbles; moderately alkaline; strongly effervescent.

An A1 horizon, 2 to 4 inches thick, is in noncultivated or uneroded areas. It ranges from very dark gray (10YR 3/1) to dark gray (10YR 4/1) in color. The A2 horizon ranges from 4 to 9 inches in thickness and from dark grayish brown (10YR 4/2) or grayish brown (10YR 5/2) to brown (10YR 4/3 or 5/3) in color. In cultivated areas the Ap horizon generally is dark grayish brown (10YR 4/2). The B horizon ranges from 24 to 44 inches in thickness and from brown (10YR 4/3) to yellowish brown (10YR 5/4) or light olive brown (2.5Y 5/4) in color. It is friable or firm in consistence. This horizon commonly has strong-brown, grayish-brown, or olive-brown mottles in the lower part. The C horizon is brown (10YR 4/3) to yellowish brown (10YR 5/4 or 5/6) or light olive brown (2.5Y 5/4) in color and is clay loam or loam in texture. Mottles, especially those that have a lower chroma, are more abundant in this horizon than in the B horizon. The A1 and A2 horizons and the upper part of the B horizon are slightly acid to strongly acid. The B3 horizon ranges from slightly acid to moderately alkaline.

Hayden and Lester soils formed in similar parent material. Hayden soils have a thinner and generally lighter colored A1 horizon and generally have a lighter colored, somewhat more prominent A2 horizon than Lester soils. They generally have a somewhat finer textured, stronger structured B horizon than these soils.

Hayden loam, 2 to 5 percent slopes (168B).—This gently sloping soil is on low rises or convex ridges. It is associated with the Dundas, Luther, and other Hayden soils. It has the profile described as representative for the series. In cultivated areas the plow layer generally is dark grayish brown.

Some areas of this soil are cultivated. The rest is mainly in wooded pasture. Areas are small enough that their use generally depends on the associated soils. This soil is well suited to row crops if erosion is controlled. Tilth in cultivated areas generally is fair to good. Capability unit IIe–1; woodland suitability group 2o1.

Hayden loam, 5 to 9 percent slopes (168C).—This soil is on side slopes and irregular convex ridges. It is associated with Dundas, Luther, and other Hayden soils. In cultivated areas the plow layer generally is dark grayish brown.

This soil is subject to erosion. A few areas of this soil are cultivated. Most cultivated areas are associated with less sloping soils. Most other areas are in wooded pasture. This soil is moderately suited to row crops if erosion is controlled. Tilth in cultivated areas generally is fair to good. Capability unit IIIe–1; woodland suitability group 2o1.

Jacwin Series

The Jacwin series consists of dark-colored, somewhat poorly drained soils that formed in loamy alluvium about 3 feet thick and in material weathered from underlying shale. These soils are nearly level to gently sloping and are on benches along the Des Moines River north of Fort Dodge and near the Humbolt County line. Individual areas range from 2 to 50 acres in size. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black loam about 12 inches thick. The subsoil is about 36 inches thick. The upper part, to a depth of about 24 inches, is mainly dark grayish-brown, brown, and olive-brown, friable light clay loam. Below this, to a depth of 36 inches, the subsoil is yellowish-brown, very friable cobbly loam. The lower part of the subsoil, to a depth of 48 inches, is yellowish-brown and greenish-gray, laminated silty clay shale and heavy loam. The underlying material is yellowish-brown and greenish-gray laminated shale that has many fragments of limestone and standstone.

The available water capacity is moderate or high. Permeability is moderate in the loamy soil material and very slow in the underlying shale. The content of organic matter is high. The surface layer and the upper part of the subsoil generally are neutral or slightly acid. The subsoil is very low or low in available phosphorus and available potassium.

Most areas of Jacwin soils are cultivated, but a few areas are in pasture. In some seasons a perched water table is above the shale, but crop growth generally is not seriously affected.

Representative profile of Jacwin loam, 1 to 3 percent slopes, in a cultivated field 500 feet east and 30 feet south of the northwest corner of the NE¼NW¼ sec. 13, T. 90 N., R. 29 W.

Ap—0 to 7 inches, black (10YR 2/1) heavy loam, dark gray (10YR 4/1) when dry; cloddy; friable; slightly acid; abrupt, smooth boundary.

A3—7 to 12 inches, black (10YR 2/1) to very dark gray (10YR 3/1) heavy loam; common, fine, faint, very dark grayish-brown (10YR 3/2) mottles; weak, fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

B1—12 to 17 inches, very dark grayish-brown (10YR 3/2) and very dark gray (10YR 3/1) light clay loam, dark gray (10YR 4/1) and dark grayish brown (10YR 4/2) when dry; few, fine, faint, brown (10YR 4/3) mottles; weak, very fine and fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

B21—17 to 20 inches, dark grayish-brown (2.5Y 4/2) and brown (10YR 4/3) light clay loam, grayish brown (2.5Y 5/2) and light olive brown (2.5Y 5/4) when dry, dark grayish brown to olive brown (2.5Y 4/3) when kneaded; moderate, very fine and fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

B22—20 to 24 inches, olive-brown (2.5Y 4/4) light clay loam to loam, dark yellowish brown (10YR 4/4) when kneaded; common, fine, distinct, yellowish-brown (10YR 5/6) mottles; moderate, fine, subangular blocky structure; friable; mildly alkaline; abrupt, wavy boundary.

B23—24 to 36 inches, yellowish-brown (10YR 5/4 and 5/6) cobbly loam; moderate, fine, subangular blocky structure; very friable; common dark-colored concretions; mildly alkaline; gradual, smooth boundary.

IIB3—36 to 48 inches, yellowish-brown (10YR 5/4) and greenish-gray (5GY 6/1) laminated silty clay shale

and heavy loam; firm; moderately alkaline; slightly effervescent; abrupt, wavy boundary.

IIC—48 to 54 inches, yellowish-brown (10YR 5/4) and greenish-gray (5GY 6/1) shale that has many fragments of limestone and sandstone; very firm; moderately alkaline; strongly effervescent.

The A horizon ranges from 10 to 20 inches in thickness. The A3 horizon ranges from black (10YR 2/1) to very dark grayish brown (10YR or 2.5Y 3/2). The B2 horizon ranges from dark grayish brown (10YR 4/2 or 2.5Y 4/2) to yellowish brown (10YR 5/6) in color and is loam or light clay loam in texture. In places, strata of sandy clay loam or sandy loam are above the IIB horizon. The depth to the IIB3 horizon is 30 to 40 inches in most places. The A horizon and B1 and B2 horizons are neutral or slightly acid. The IIB3 horizon is neutral to moderately alkaline and is calcareous.

Jacwin soils are associated with Rockton soils. They differ from these soils in having grayish-brown colors in the upper part of the B horizon and in being underlain by shale rather than limestone. Jacwin soils are similar to Cylinder soils, but they are underlain by shale rather than sand and gravel.

Jacwin loam, 1 to 3 percent slopes (444A).—Nearly all areas of this soil are nearly level to gently sloping and are on benches. This soil is associated with Rockton soils.

Included with this soil in mapping are a few areas of soils that are shallower to shale. Also included are areas of soils that have slopes of as much as about 5 percent.

This soil is somewhat poorly drained, but it is seldom wet enough to seriously hinder crop growth. In very dry years lack of adequate moisture is a limitation, but in most years available water is adequate.

This soil is cultivated or is in permanent pasture. Large boulders are common in some areas. This soil is well suited to row crops if the large boulders are removed. Tilth in cultivated areas generally is good. Capability unit I–1; woodland suitability group 5w1.

Kamrar Series

The Kamrar series consists of dark-colored, moderately well drained soils that formed in lacustrine sediment, about 24 to 48 inches thick, and underlying glacial till. These gently sloping soils are on rises or knolls on uplands. They are mainly in the southeastern part of the county in the Marna-Guckeen soil association. Individual areas generally are only 2 to 10 acres in size. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black clay loam about 12 inches thick. The subsoil is about 19 inches thick. It is mainly brown and dark yellowish-brown, firm heavy clay loam, but it is friable light clay loam in the lower part. The underlying material is friable, yellowish-brown and light olive-brown loam to light clay loam that has dark yellowish-brown and olive-gray mottles. A few small pebbles are in the lacustrine sediment; pebbles are common at the area of contact between sediment and till; and a few pebbles, stones, and boulders are in the glacial till.

The available water capacity is high, and permeability is moderately slow. The content of organic matter is moderate. The surface layer and the upper part of the subsoil are medium acid to slightly acid. The subsoil is low in available phosphorus and very low or low in available potassium.

Kamrar soils are subject to erosion, but the hazard generally is not serious. Most areas are cultivated.

Representative profile of Kamrar clay loam, 2 to 5 percent slopes, in a cultivated field 90 feet west of fence and 450 feet south of northeast corner of SE¼SW¼ sec. 12, T. 86 N., R. 27 W.

Ap—0 to 7 inches, black (10YR 2/1) medium clay loam; weak, fine, subangular blocky structure; friable; few small pebbles; medium acid; abrupt, smooth boundary.

A3—7 to 12 inches, black (10YR 2/1) heavy clay loam, very dark brown (10YR 2/2) when kneaded; weak, very fine, subangular blocky structure; friable; few small pebbles; slightly acid; clear, smooth boundary.

B1—12 to 16 inches, very dark grayish-brown (10YR 3/2) heavy clay loam, faces of peds very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2); moderate, very fine, subangular blocky structure; firm; few brown (10YR 4/3) peds; few, thin, discontinuous clay films; few small pebbles; slightly acid; clear, smooth boundary.

B21t—16 to 20 inches, brown (10YR 4/3) and dark yellowish-brown (10YR 4/4) heavy clay loam, faces of peds mostly very dark grayish brown (10YR 3/2); moderate, very fine, subangular blocky structure; firm; thin, nearly continuous clay films; few small pebbles; slightly acid; clear, smooth boundary.

B22t—20 to 26 inches, brown (10YR 4/3) and dark yellowish-brown (10YR 4/4) clay loam, faces of peds very dark grayish brown (10YR 3/2) and brown (10YR 4/3); weak, fine, prismatic structure parting to moderate, fine, subangular blocky structure; firm; thin, nearly continuous clay films; few small pebbles; neutral; gradual, smooth boundary.

IIB3t—26 to 31 inches, yellowish-brown (10YR 5/4) to light olive-brown (2.5Y 5/4) light clay loam; weak, fine, prismatic structure parting to weak, fine, subangular blocky structure; friable; thin, discontinuous, very dark grayish-brown clay films; few small pebbles, distinct pebble band; mildly alkaline; slightly effervescent; clear, smooth boundary.

IIC1—31 to 48 inches, yellowish-brown (10YR 5/4) to light olive-brown (2.5Y 5/4) loam to light clay loam; common, fine, olive-gray (5Y 5/2) and few, medium, dark yellowish-brown (10YR 4/4) mottles; weak, medium, prismatic structure parting to very weak, fine, subangular blocky structure; friable; few yellowish-brown oxide stains; abundant accumulation of lime; common small pebbles; common soft and hard oxides; moderately alkaline; slightly effervescent; gradual, smooth boundary.

IIC2—48 to 56 inches, light olive-brown (2.5Y 5/4) loam; many, fine, olive-gray (5Y 5/2) and common, fine, dark yellowish-brown (10YR 4/4) mottles; weak, fine and medium, prismatic structure parting to weak, fine, subangular blocky structure; friable; common small pebbles; moderately alkaline; strongly effervescent.

The A horizon ranges from 8 to 15 inches in thickness. In places it is very dark gray (10YR 3/1) in the lower part and is light clay in texture. It has granular or subangular blocky structure. The B horizon ranges from 15 to 48 inches in thickness and generally is brown (10YR 4/3) or dark yellowish brown (10YR 4/4) in color. It ranges to very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2) in the upper part and to mottled yellowish brown (10YR 5/4) and light olive brown (2.5Y 5/4) in the lower part. The B2 horizon is friable or firm clay loam or light clay in texture. The B horizon contains more clay and less sand than the IIC horizon, which is glacial till. The IIC horizon is friable, calcareous glacial till that is mottled with colors of brown to yellowish brown (10YR 4/3 to 5/6), dark grayish brown to light olive brown (2.5Y 4/2 to 5/4), and olive gray to light olive gray and gray (5Y 4/2 to 6/2 and 5/1). The lacustrine material is 24 to 48 inches thick. The A horizon and most of the B horizon are slightly acid to neutral. The lower part of the B horizon ranges from neutral and noncalcareous to moderately alkaline and calcareous.

Kamrar soils are associated with Guckeen soils on the landscape. These soils are better drained, have browner

colors in the B horizon, and generally have a thinner surface layer than Guckeen soils.

Kamrar clay loam, 2 to 5 percent slopes (387B).—This gently sloping soil is on rises and knolls. Slopes are generally short and irregular. It generally is upslope from poorly drained Marna and somewhat poorly drained Guckeen soils.

Included with this soil in mapping are a few moderately eroded areas where the surface layer is thinner and is very dark brown or very dark grayish brown in color.

Nearly all areas of this soil are cultivated and managed along with the associated soils. This soil is used mainly for row crops and is well suited to this use if erosion is controlled. Tilth is generally good, but the plow layer dries out cloddy and hard in places if tilled when wet. Capability unit IIe–1; woodland suitability group 2o1.

Lanyon Series

The Lanyon series consists of dark-colored, very poorly drained soils that formed in clayey lacustrine sediment. These soils are in depressions on uplands. They are mainly in the Marna-Guckeen soil association in the southern part of the county. Individual areas range from 5 to 50 acres in size. The native vegetation was swamp grasses and sedges.

In a representative profile, the surface layer is black light silty clay about 13 inches thick. The subsoil is very dark gray, dark grayish-brown, dark-gray, and olive-gray, firm light silty clay about 7 inches thick. It is calcareous. The underlying material is mostly dark-gray silty clay and silty clay loam that has mottles of olive, light olive brown, and yellowish brown.

The available water capacity is high, and permeability is moderately slow or slow. The content of organic matter is high. The surface layer is neutral to mildly alkaline, and the soil is moderately alkaline and calcareous below. The subsoil is very low in available phosphorus and available potassium.

Lanyon soils are very wet. They have a high water table, and runoff from surrounding soils ponds in places. The surface layer puddles easily if worked when wet. Most areas of these soils are artificially drained and are cultivated.

Representative profile of Lanyon silty clay, in a large depression, in a cultivated field 15 feet west and 200 feet north of the center of east side of NE¼ sec. 31, T. 86 N., R. 28 W.

Ap—0 to 7 inches, black (N 2/0) light silty clay; weak to moderate, fine, granular and very fine subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A1—7 to 13 inches, black (5Y 2/1) light silty clay; few, fine, very dark grayish-brown (2.5Y 3/2) and dark-gray (N 4/0) mottles; moderate, very fine, subangular blocky structure; firm; mildly alkaline; abrupt, smooth boundary.

B1g—13 to 16 inches, very dark gray (5Y 3/1) and dark grayish-brown (2.5Y 4/2) light silty clay, dark olive gray (5Y 3/2) when kneaded; common, medium, olive (5Y 4/3) mottles; weak, medium, prismatic structure parting to weak, fine, subangular blocky structure; firm; abundant very fine bits of snail shells; moderately alkaline; strongly effervescent; clear, smooth boundary.

B2g—16 to 20 inches, very dark gray (5Y 3/1), dark-gray (5Y 4/1), and olive-gray (5Y 4/2) light silty clay, olive gray (5Y 4/2) when kneaded; weak, medium, prismatic structure parting to weak, fine, subangular blocky structure; firm; common snail shells; few, large, light olive-brown (2.5Y 5/4) oxides; moderately alkaline; strongly effervescent; gradual, smooth boundary.

C1g—20 to 25 inches, dark-gray (5Y 4/1) and olive-gray (5Y 4/2) light silty clay; weak, fine and medium, prismatic structure parting to weak, fine, subangular blocky structure; firm; few, medium, brown (7.5YR 4/4) oxides; few, hard concretions of a dark-colored oxide; moderately alkaline; strongly effervescent; gradual, smooth boundary.

C2g—25 to 37 inches, dark-gray (5Y 4/1) silty clay; common, fine, olive (5Y 4/3) mottles; weak, fine and medium, prismatic structure parting to weak, fine, angular blocky structure; firm; common snail shells; few, hard concretions of a dark-colored oxide; large, soft, white accumulations of lime; moderately alkaline; strongly effervescent; gradual, smooth boundary.

C3g—37 to 46 inches, gray (5Y 5/1) silty clay; common, large, yellowish-brown (10YR 5/6) mottles; weak, fine and medium, prismatic structure parting to weak, fine, subangular blocky structure; friable; very few, hard concretions of a dark-colored oxide; few, medium, hard, light-gray concretions of lime; moderately alkaline; strongly effervescent; gradual, smooth boundary.

C4g—46 to 52 inches, dark-gray (5Y 4/1) silty clay loam; common, medium, light olive-brown (2.5Y 5/4) mottles; weak, fine, subangular blocky structure; friable; few, hard, dark-colored oxides; few, medium, hard, light-gray concretions of lime; moderately alkaline; strongly effervescent; abrupt, smooth boundary.

C5g—52 to 70 inches, dark-gray (5Y 4/1) light clay loam; many, medium, light olive-brown (2.5Y 5/4) mottles; weak, fine and medium, subangular blocky structure to massive; friable; numerous small stones; common concretions of a dark-colored oxide, moderately alkaline; strongly effervescent.

The Ap or A1 horizon ranges from 8 to 16 inches in thickness. This horizon is black (10YR 2/1 or N 2/0) or very dark gray (N 3/0 to 5Y 3/1) in color and is heavy silty clay loam or silty clay in texture. An intermediate layer, 2 to 8 inches thick, is in most places and is designated as an ABg, Bg, or ACg horizon. This horizon ranges from dark grayish brown (2.5Y 4/2) to colors that have a hue of 5Y, a value of 3 to 6, and a chroma of 1 or 2. Faint to prominent mottles of 10YR and 5Y hue are common. The texture of this horizon is similar to that of the horizon above. The Cg horizon is dark gray (5Y 4/1) to light olive gray (5Y 6/2) in color and has mottles of high chroma and 10YR and 2.5Y hue. Above a depth of 40 inches the texture of this horizon generally is light silty clay but ranges to heavy silty clay loam and silty clay. In places, below a depth of 40 inches, this horizon is loam or clay loam in texture. Sandy loam strata are in a few places. The Ap and A1 horizons are neutral or mildly alkaline. Beginning at a depth of 12 to 20 inches this soil is moderately alkaline and calcareous.

Lanyon and Marna soils formed in similar parent material. Lanyon soils have a thicker A1 horizon and are not so deep to carbonates as Marna soils. Lanyon and Wacousta soils are in similar landscape positions. Lanyon soils have a higher clay content to a depth of 40 inches or more than Wacousta soils.

Lanyon silty clay (0 to 1 percent slopes) (606).—This soil is in shallow depressions that generally are surrounded by Marna soils. It is also associated with Guckeen and Kamrar soils and, in a few places, with Webster or Canisteo soils.

Included with this soil in mapping are a few areas of similar soils that have a few inches of muck or mucky silt loam on the surface.

This soil is wet. It has a high water table, and water

tends to pond after heavy rains. In some years crops are severely damaged or drowned out. Almost all of this soil is drained or partly drained and is cultivated. This soil is mainly used for row crops. It is well suited to this use if drainage is adequate. Even if this soil is drained, tillage commonly is delayed in spring and after heavy rains. The surface layer tends to dry out cloddy and hard if worked when wet, therefore tilth is poor at times. A few areas are large enough to be managed as a separate field, but most are managed along with the surrounding soils. Capability unit IIIw–2; woodland suitability group 5w3.

Lester Series

The Lester series consists of moderately dark colored, well-drained soils that formed in glacial till on uplands. These are gently sloping soils on knolls and ridges and moderately sloping to steep soils on side slopes. They are mainly in the Le Sueur-Luther-Hayden soil association near the Des Moines River. Individual areas range from 2 to 30 acres in size. The native vegetation was grasses and trees.

In a representative profile, the surface layer is black and very dark grayish-brown loam about 5 inches thick. The subsurface layer is friable, very dark gray loam about 4 inches thick. The subsoil is mainly brown and dark yellowish-brown, firm clay loam about 39 inches thick. It has a few olive-gray and yellowish-brown mottles in the lower part. The underlying material is calcareous, olive-brown loam. The soils contain small pebbles and a few stones and boulders throughout.

The available water capacity is high, and permeability is moderate. The content of organic matter is moderately low. Most of the surface layer and subsoil are generally slightly acid or medium acid. The subsoil is medium in available phosphorus and very low in available potassium.

Lester soils are subject to erosion. Sidehill drainageways are common on the more sloping Lester soils, and these soils are subject to gullying unless erosion is controlled. Steep Lester soils are in timbered pasture or woods. Some areas of less sloping soils are cleared and cultivated, and some are in pasture or woods.

Representative profile of Lester loam, 2 to 5 percent slopes, in a pasture 385 feet south and 45 feet east of the northwest corner of the NE¼NE¼ sec. 20, T. 87 N., R. 27 W.

A1—0 to 5 inches, black (10YR 2/1) and very dark grayish-brown (10YR 3/2) loam, very dark gray (10YR 3/1) when kneaded, dark gray (10YR 4/1) when dry; very weak, thin, platy structure parting to weak, fine, granular and very fine subangular blocky structure; friable; neutral; clear, smooth boundary.

A2—5 to 9 inches, very dark gray (10YR 3/1) loam, very dark gray (10YR 3/1) when kneaded, gray (10YR 5/1) and grayish brown (10YR 5/2) when dry, few dark grayish-brown (10YR 4/2) peds, abundant silty coatings on peds; very weak, thin, platy structure parting to weak, fine, granular and very fine subangular blocky structure; friable; slightly acid; clear, smooth boundary.

B11—9 to 12 inches, 70 percent dark grayish-brown (10YR 4/2), 15 percent brown (10YR 4/3), and 15 percent very dark gray (10YR 3/1) loam, dark grayish brown (10YR 4/2) when kneaded, gray (10YR 5/1) and grayish brown (10YR 5/2) when dry; abundant silt coatings on peds; moderate, very fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

B12—12 to 17 inches, brown (10YR 4/3) loam, pale brown (10YR 6/3) when dry; few very dark grayish-brown (10YR 3/2) peds, abundant silt coatings on peds; moderate, very fine and fine, subangular blocky structure; friable; medium acid; gradual, smooth boundary.

B21t—17 to 22 inches, dark yellowish-brown (10YR 4/4) light clay loam, brown (10YR 4/3) when kneaded, pale brown (10YR 6/3) and yellowish brown (10YR 5/4) when dry; many silty coatings on peds; moderate, fine, subangular blocky structure; firm; thin, discontinuous clay films on peds; medium acid; gradual, smooth boundary.

B22t—22 to 28 inches, dark yellowish-brown (10YR 4/4) medium clay loam; moderate, fine, subangular blocky structure; firm; common silty coatings on peds; thin, nearly continuous, dark yellowish-brown (10YR 3/4) clay films on peds; medium acid; gradual, smooth boundary.

B23t—28 to 34 inches, dark yellowish-brown (10YR 4/4) light clay loam; weak, fine, prismatic structure parting to moderate, fine and medium, subangular blocky structure; firm; common silty coatings on peds and prisms; dark-colored coatings in pore channels; medium acid; gradual boundary.

B31t—34 to 41 inches, dark yellowish-brown (10YR 4/4) light clay loam; few, very fine, distinct, olive-gray (5Y 5/2) and yellowish-brown (10YR 5/8) mottles; weak, fine, prismatic structure; friable; thick dark yellowish-brown (10YR 3/4) clay films on prism faces; dark-colored coatings in pore channels; slightly acid; gradual, smooth boundary.

B32t—41 to 48 inches, olive-brown (2.5Y 4/4) light clay loam; weak, medium, prismatic structure; friable; thick clay films on prisms and vertical cleavage faces; neutral; clear, smooth boundary.

C—48 to 72 inches, olive-brown (2.5Y 4/4) loam; massive but has tendency to horizontal cleavage; friable; thin oxide coatings on cleavage faces; pores coated in upper few inches; common light-gray accumulations of lime; common dark-colored oxides; moderately alkaline; strongly effervescent; diffuse boundary.

The A1 horizon ranges from 4 to 8 inches in thickness and from black (10YR 2/1) to very dark grayish brown (10YR 3/2) in color. This horizon generally has granular to subangular blocky structure, but it has very weak platy structure in places. The A2 horizon ranges from 2 to 8 inches in thickness and from very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2) in color. This horizon generally has weak platy structure parting to granular and subangular blocky structure. In eroded or cultivated areas much of this horizon is mixed with the A1 horizon. The B horizon is friable or firm, loam to medium clay loam in texture, and is mostly brown (10YR 4/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4) in color. Strong-brown, olive-brown, grayish-brown, or olive-gray mottles are in the lower part of this horizon. It extends to a depth of 30 to 48 inches in most places. The C horizon generally is calcareous, friable, dark yellowish-brown (10YR 4/4) to light olive-brown (2.5Y 5/4) loam that has mottles similar to those in the B horizon. The A1 horizon is slightly acid or medium acid unless limed. The A2 horizon and the upper part of the B horizon are medium acid. The B3 horizon is slightly acid to neutral or mildly alkaline. The C horizon generally is mildly alkaline or moderately alkaline and calcareous, but in places it is neutral and noncalcareous in the upper part.

Lester soils differ from Hayden soils in having a darker and thicker A1 horizon; a generally somewhat darker, less prominent A2 horizon; and a somewhat less clayey B horizon that has weaker structure. They differ from Clarion soils in having a thinner A horizon and a greater increase in clay content from the A to the B horizon. Clarion soils also have an A2 horizon unless cultivated. All of these soils are well drained and formed in glacial till.

Lester loam, 2 to 5 percent slopes (236B).—This soil is mainly on knolls and ridgetops in association with the

Le Sueur, Cordova, and steeper Lester soils. It has the profile described as representative for the series.

Included with this soil in mapping are about 50 acres of a similar soil that is on a similar landscape position but that formed in about 24 to 30 inches of loamy glacial sediment underlain by firm clay loam glacial till. This included soil generally lacks a grayish subsurface layer. The underlying material of these included areas has a stronger brown color than this Lester loam.

This soil is subject to erosion if cultivated. Many areas of this soil have been cleared and are cultivated along with the surrounding soils. Other areas are in grass and trees. The soil is well suited to row crops if erosion is controlled. Tilth generally is good. Capability unit IIe–1; woodland suitability group 2o1.

Lester loam, 5 to 9 percent slopes (236C).—This soil is on knolls and ridgetops and generally is upslope from more sloping Lester soils. In places it is on side slopes. The profile of this soil is similar to the one described as representative for the series, but in most places the subsurface layer of this soil has been incorporated into a very dark grayish-brown plow layer. In some places the surface layer is thinner.

Included with this soil in mapping are about 40 acres of a similar soil on a similar landscape position that formed in about 20 inches of loamy glacial sediment underlain by firm clay loam glacial till. This included soil generally lacks a grayish subsurface layer. The underlying material of this included soil has a stronger brown color than the typical Lester loam.

Most areas of this soil are cultivated. If this soil is associated with less productive soils, it generally is in trees and grass and is used for pasture. This soil is subject to erosion if cultivated, but it is moderately suited to row crops if erosion is controlled. Tilth generally is fair or good. Capability unit IIIe–1; woodland suitability group 2o1.

Lester loam, 9 to 14 percent slopes (236D).—This soil is on side slopes, generally below less sloping Lester soils and above steeper Lester soils. In places it is upslope from areas of Hayden soils or Storden-Hayden complex. Many areas of this soil have a profile similar to the one described as representative for the series, but in places the combined thickness of the surface and subsurface layers is less, and in most places the combined thickness of the surface and subsurface layers and the subsoil is less and depth to calcareous material is less.

Included with this soil in mapping, in almost half of the areas, are areas of a Hayden soil. Also included are a few areas that are similar to this Lester soil, but that generally lack a subsurface layer and that formed in loamy glacial sediment about 20 inches thick and the underlying firm clay loam glacial till.

This soil is subject to erosion and gullying if cultivated. Most areas are in trees and grass and are used for pasture. Cleared areas are moderately suited to row crops. Tilth generally is fair or good. Capability unit IIIe–2; woodland suitability group 2o1.

Lester loam, 14 to 18 percent slopes (236E).—This soil is mainly on side slopes. It generally is associated with other Lester soils, but in places Hayden soils or Storden-Hayden complex are below this soil. The profile of this soil is similar to the one described as representative for the series, but the combined thickness of the surface layer, subsurface layer, and subsoil is less and depth to calcareous material is less.

Included with this soil in mapping are about 60 acres of a soil that has a thinner, somewhat lighter colored surface layer and that is similar to Hayden soils mapped in other places in the county. Also included are about 80 acres of a soil that generally lacks a grayish subsurface layer and that formed in about 20 inches of loamy glacial sediment underlain by firm clay loam glacial till.

Most areas of this soil are in trees and grass and are used for pasture along with the associated soils. A few areas are cultivated. This soil is moderately suited to row crops if erosion is controlled, but most areas are left in hay or rotation pasture most of the time. Capability unit IVe–1; woodland suitability group 2o1.

Lester loam, 18 to 35 percent slopes (236F).—This steep soil is on side slopes. Less sloping Lester soils generally are upslope and Terril or Spillville soils are downslope. Some areas of this soil have a profile similar to the one described as representative for the series, except that the combined thickness of the surface layer, subsurface layer, and subsoil is less and the depth to calcareous material is less.

Included with this soil, in almost half of the area, are areas of a soil that is similar to this soil but that generally lacks a grayish subsurface layer and that formed in about 20 inches of loamy glacial sediment that is underlain by firm clay loam glacial till.

Most areas of these soils are in trees and grasses and are used for pasture. This soil is poorly suited to row crops because it is so steep and is subject to erosion. It is better suited to pasture. Some areas could be cleared and renovated so that more productive pasture plants could be grown, but most soils are so steep or so irregular that usual tillage implements can not be used. This soil is also suited to use as woodland or for wildlife habitat. Capability unit VIe–1; woodland suitability group 3r1.

Le Sueur Series

The Le Sueur series consists of moderately dark colored, somewhat poorly drained soils that formed in glacial till. These soils are on gentle rises on uplands. Slopes are 1 to 3 percent. They are mainly in the Le Sueur-Luther-Hayden soil association in the central and southern part of the county near the valley of the Des Moines River. Individual areas range from about 2 to 50 acres in size. The native vegetation was grasses and trees.

In a representative profile, the surface layer is very dark gray loam about 7 inches thick. The subsurface layer is very dark grayish-brown, friable loam about 5 inches thick. The subsoil is about 30 inches thick. It is dark grayish-brown and grayish-brown, firm clay loam that has grayish-brown and yellowish-brown mottles. The underlying material is mottled light brownish-gray and yellowish-brown loam. Small pebbles and a few stones or boulders are throughout.

The available water capacity is high, and permeability is moderate. The content of organic matter is moderately low. The surface layer and subsurface layer and the upper part of the subsoil are medium acid to slightly acid. The

subsoil is medium in available phosphorus and very low in available potassium.

Le Sueur soils have no serious limitations to their use for crops. These soils generally are used for crops, but a few areas are in pasture and grow trees and grass.

Representative profile of Le Sueur loam, 1 to 3 percent slopes, in a cultivated field 600 feet west of road center and 1,690 feet north of the southeast corner of sec. 2, T. 87 N., R. 28 W.

Ap—0 to 7 inches, very dark gray (10YR 3/1) loam; cloddy parting to weak, fine, granular structure; friable; common clear sand grains; medium acid; abrupt, smooth boundary.

A2—7 to 12 inches, very dark grayish-brown (10YR 3/2) loam; few, fine, yellowish-brown (10YR 5/4) mottles on plates; weak, thick, platy structure parting to weak, fine, subangular blocky structure; friable; few, thin, very dark gray (10YR 3/1) streaks; abundant dark grayish-brown (10YR 4/2) silt coatings; common clear sand grains; slightly acid; clear, smooth boundary.

B1t—12 to 17 inches, dark grayish-brown (10YR 4/2) light clay loam; few, fine, yellowish-brown (10YR 5/4) mottles; moderate, fine and medium, subangular blocky structure; friable; few, thin, discontinuous clay films; few clear sand grains; abundant light-gray silt coatings when dry; few small pebbles; slightly acid; clear, smooth boundary.

B21t—17 to 26 inches, dark grayish-brown (10YR 4/2) and yellowish-brown (10YR 5/4) clay loam; faces of peds dark grayish brown (10YR 4/2) and very dark gray (10YR 3/1), dark grayish brown (10YR 4/2) when kneaded; few, fine, grayish-brown (10YR 5/2) and common, fine, yellowish-brown (10YR 5/6) mottles; weak, medium, prismatic structure parting to moderate and strong, fine and medium, subangular and angular blocky structure; firm; common shale fragments; thick, discontinuous clay films; abundant light-gray silt coatings when dry; few small pebbles; medium acid; clear, smooth boundary.

B22t—26 to 31 inches, dark grayish-brown (2.5Y 4/2) clay loam; faces of peds very dark gray (10YR 3/1) and dark grayish brown (2.5Y 4/2); common, fine, grayish-brown (2.5Y 5/2) and few, fine, yellowish-brown (10YR 5/6) mottles; moderate, medium, prismatic structure parting to strong, medium, angular and subangular blocky structure; firm; thick, continuous clay films; common dark-colored oxides; few small pebbles; slightly acid; clear, smooth boundary.

B23t—31 to 38 inches, grayish-brown (2.5Y 5/2) light clay loam; many, fine, yellowish-brown (10YR 5/6) mottles; moderate, medium, prismatic structure parting to weak, medium, subangular blocky structure; firm; black (10YR 2/1) and very dark gray (10YR 3/1) clay flows and thick, discontinuous clay films; many, soft, dark-colored oxides; few small pebbles; few shale fragments; slightly acid; clear, smooth boundary.

B3t—38 to 42 inches, mottled grayish-brown (2.5Y 5/2) and yellowish-brown (10YR 5/6) light clay loam; weak, medium, prismatic structure parting to weak, medium, subangular blocky structure; friable; thick, discontinuous, black (10YR 2/1) and very dark gray (10YR 3/1) clay films; root channels coated with black (10YR 2/1) clay flows; abundant soft carbonate concretions; few shale fragments; common small pebbles; mildly alkaline; clear, smooth boundary.

C—42 to 52 inches, mottled yellowish-brown (10YR 5/6) and light brownish-gray (2.5Y 6/2) loam; massive but has some vertical cleavage; friable; few clay flows in root channels; numerous, soft, dark-colored oxides; few, fine, soft carbonate concretions; moderately alkaline; strongly effervescent.

The A1 or Ap horizon ranges from 6 to 10 inches in thickness and from black (10YR 2/1) to dark gray (10YR 3/1) in color. The A2 horizon ranges from 2 to 6 inches in thickness, from very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2) in color, and from loam to silt loam in texture. The B horizon is mainly dark grayish brown (10YR or 2.5Y 4/2), but it ranges to very dark grayish brown (10YR 3/2) in the upper part and to brownish gray (2.5Y 6/2) in the lower part. Dark yellowish-brown to strong-brown mottles increase in number with depth. The C horizon is friable, calcareous loam or light clay loam in texture and is yellowish brown (10YR 5/4) to light olive gray (5Y 6/2) in color. In a few places strata of other materials are in this horizon. The A horizon is slightly acid to medium acid, and the B2 horizon is slightly acid to strongly acid.

Le Sueur soils differ from Nicollet soils in having a lighter colored, thinner A1 horizon, in having an A2 horizon, and in having a larger increase in clay content from the A to the B horizon. Le Sueur soils have grayish-brown colors in the B horizon and are not so well drained as the Lester soils.

Le Sueur loam, 1 to 3 percent slopes (325A).—This soil is on gentle rises that commonly are upslope from Cordova soils and downslope from Lester soils.

Included with this soil in mapping are areas of soils that have strata of silt loam or sandy loam in the underlying material. Also included are a few areas in the Marna-Guckeen association in which the upper 18 to 30 inches is finer textured.

Nearly all areas of this soil are cultivated. This soil is used mainly for row crops and is well suited to this use. The hazard of erosion is slight, but the most sloping areas are subject to some sheet erosion. In periods of above average rainfall, a few of the more level areas are slightly wet, but artificial drainage generally is not needed. Tilth generally is good. Capability unit I–1; woodland suitability group 3w1.

Luther Series

The Luther series consists of light-colored, somewhat poorly drained soils that formed in glacial till on uplands. These soils are nearly level to gently sloping and are on knolls or rises. They are in the Le Sueur-Luther-Hayden soil association near the Des Moines River between Fort Dodge and the southern county line. Individual areas are generally 2 to 20 acres in size. The native vegetation was mainly trees.

In a representative profile, the surface layer is very dark grayish-brown loam about 6 inches thick. The subsurface layer is dark grayish-brown, friable loam about 4 inches thick. The subsoil is about 38 inches thick. It is dark grayish-brown and brown, firm clay loam in the upper part and is olive-gray light clay loam in the lower part. The underlying material is yellowish-brown and olive-gray loam glacial till. Pebbles and a few stones or boulders are throughout.

The available water capacity is high, and permeability is moderately slow. The content of organic matter is low. The surface layer and subsurface layer and the upper part of the subsoil are generally slightly acid or medium acid unless limed. The subsoil is medium in available phosphorus and very low in available potassium.

Most areas of Luther soils are used for crops, but some areas are in native trees and forest plants. They have no serious limitations to their use for crops.

Representative profile of Luther loam, 1 to 3 percent slopes, in a cultivated field 40 feet north and 8 feet west

of the southeast corner of the SW¼NE¼SW¼ sec. 23, T. 88 N., R. 28 W.

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) loam, very dark grayish brown (10YR 3/2) when kneaded, light gray (10YR 6/1) when dry; weak, fine, granular structure to fine subangular blocky structure; friable; few small pebbles; neutral; abrupt, smooth boundary.

A2—6 to 10 inches, dark grayish-brown (10YR 4/2) loam, dark grayish brown (10YR 4/2) when kneaded, light gray (5Y 6/1) when dry; weak, medium, platy structure parting to weak, fine, granular and very fine subangular blocky structure; friable; common, fine, dark-colored oxides; few small pebbles; slightly acid; clear, smooth boundary.

B1t—10 to 14 inches, dark grayish-brown (10YR 4/2) and brown (10YR 4/3) light clay loam, faces of peds dark grayish brown (10YR 4/2), dark grayish brown (2.5Y 4/2) when kneaded, light gray (10YR 7/1) and light brownish gray (10YR 6/2) when dry; weak, very fine, subangular blocky structure; friable; thin, discontinuous clay films; few small pebbles; slightly acid; clear, smooth boundary.

B21t—14 to 20 inches, dark grayish-brown (10YR 4/2) and brown (10YR 4/3) clay loam, faces of peds dark grayish brown (10YR 4/2), dark grayish brown (10YR 4/2) to brown (10YR 4/3) when kneaded, light brownish gray (10YR 6/2) and some light gray (10YR 7/1) when dry; moderate, very fine and fine, subangular blocky structure; firm; few small pebbles; thin, discontinuous clay films; slightly acid; gradual, smooth boundary.

B22t—20 to 26 inches, dark grayish-brown (10YR 4/2) and brown (10YR 4/3) clay loam, faces of peds dark grayish brown (10YR 4/2), dark grayish brown (10YR 4/2) and brown (10YR 4/3) when kneaded, pale brown (10YR 6/3) when dry; moderate, fine, subangular blocky structure; firm; thin, discontinuous clay films; few small pebbles; slightly acid; gradual, smooth boundary.

B23t—26 to 31 inches, dark grayish-brown (10YR 4/2) clay loam, dark grayish brown (10YR 4/2) when kneaded, light brownish gray (10YR 6/2) when dry; few, very fine, yellowish-brown (10YR 5/8) mottles; moderate, fine and medium, subangular blocky structure; firm; common, fine, distinct, dark-colored oxides; thin, discontinuous clay films on peds; thick clay flows in voids; few small pebbles; medium acid; gradual, smooth boundary.

B31t—31 to 36 inches, olive-gray (5Y 4/2 and 5/2) and dark grayish-brown (2.5Y 4/2) light clay loam; very fine, strong-brown (7.5YR 5/8) mottles; weak, fine, prismatic structure parting to weak, medium, subangular blocky structure; firm; common, fine, dark-colored oxides; thin, discontinuous clay films on peds; thick clay films in voids; thick dark-colored coatings in pores; few small pebbles; medium acid; gradual, smooth boundary.

B22t—36 to 42 inches, olive-gray (5Y 5/2) light clay loam; many, medium, distinct, yellowish-brown (10YR 5/8) mottles; weak, medium, prismatic structure parting to weak, medium, subangular blocky structure; firm; common, fine, dark-colored oxides; thick dark-colored coatings in pores; thick clay accumulations in voids; thin discontinuous clay films on peds and prisms; few small pebbles; neutral; gradual, smooth boundary.

B33t—42 to 48 inches, olive-gray (5Y 5/2) loam; many, medium, yellowish-brown (10YR 5/8) mottles; weak, medium, prismatic structure parting to weak, medium, subangular blocky structure; friable; few, fine, dark-colored oxides; thin coatings in pores; thick clay accumulations in voids; few small pebbles; mildly alkaline; noncalcareous; clear, smooth boundary.

C—48 to 72 inches, yellowish-brown (10YR 5/8) and olive-gray (5Y 5/2) loam; massive but has some vertical cleavage; friable; few, fine, dark-colored oxides; very thin coatings in pores to a depth of 60 inches; few small pebbles; moderately alkaline; strongly effervescent.

The A1 or Ap horizon ranges from 2 to 6 inches in thickness and from very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2) in color. In cultivated areas the Ap horizon is mainly dark grayish brown (10YR 4/2) or dark gray (10YR 4/1). In places, it is very dark gray (10YR 3/2) or very dark gray (10YR 3/1) when moist but is light gray (10YR 6/1) or light brownish gray (10YR 6/2) when dry. The A2 horizon ranges from 4 to 10 inches in thickness. This horizon is dark gray (10YR 4/1) to grayish brown (10YR 5/2) in color. Texture is loam or silt loam that has a high sand content. The Bt horizon is mostly dark grayish brown (10YR 4/2 or 2.5Y 4/2) or grayish brown (2.5Y 5/2 or 10YR 5/2), but some ped interiors have a chroma of 3, but are not dominant, in some horizons. In places the B3t horizon is olive gray (5Y 6/2). Few to many, yellowish-brown to brown or strong-brown mottles are in this horizon. The B horizon generally extends to a depth of about 36 to 60 inches. The C horizon is light brownish gray (2.5Y 6/2), yellowish brown (10YR 5/6), grayish brown (2.5Y 5/2), and olive gray (5Y 5/2) in color and is loam to light clay loam in texture. Reaction of the A horizon or upper part of the B horizon is generally slightly acid to medium acid. It is neutral or slightly acid in the lower part of the B horizon.

Luther and Le Sueur soils both formed in glacial till and are in similar positions on the landscape. Luther soils differ from Le Sueur soils in having a lighter colored, thinner A horizon and a lighter colored, more prominent A2 horizon. They also lack the very dark gray colors on the faces of peds in the upper part of the B horizon.

Luther loam, 1 to 3 percent slopes (355A).—This nearly level to gently sloping soil is on knolls or rises in association with the Hayden soils and, in places, with the Dundas soils.

Included with this soil in mapping are a few areas of a soil that is similar to this soil, except that the subsoil is about 10 percent higher in clay content and is less permeable. These included areas are adjacent to areas of Marna, Guckeen, or Kamrar soils.

Many areas of these soils are cultivated and are managed along with the surrounding soils, but some are in native vegetation of trees. Some areas have not been cultivated, because deep natural ravines prevent the use of large farm machinery. The more sloping areas erode if rain is intense. Some areas are somewhat wet in wet years, but artificial drainage generally is not needed. This soil is well suited to row crops. Tilth generally is good. Capability unit I–1; woodland suitability group 3w1.

Marna Series

The Marna series consists of dark-colored, poorly drained soils that formed in clayey, lacustrine sediment and underlying glacial till. These soils are nearly level and are on uplands. They are mainly in the southern part of the county in the Marna-Guckeen soil association. The native vegetation was sedges and prairie grasses tolerant of wetness.

In a representative profile, the surface layer is black heavy silty clay loam about 14 inches thick. The subsoil extends to a depth of about 60 inches. It is dark gray and olive gray and contains mottles of yellowish brown and light olive brown. The upper part of the subsoil is firm or very firm silty clay or clay lacustrine sediment and the lower part is heavy loam or light clay loam glacial till. The underlying material is yellowish-brown and gray heavy loam. A few pebbles and stones occur through-

out the profile but are more common in the glacial till.

The available water capacity is high, and permeability is slow. The content of organic matter is high. The surface layer and the upper part of the subsoil are generally slightly acid or neutral. The subsoil is very low in available phosphorus and available potassium. These soils are wet because of a high water table and slow permeability.

The Marna soils are generally cultivated. These soils are difficult to till, and tilth generally is poor.

Representative profile of Marna silty clay loam, in a cultivated field 1,041 feet south and 790 feet east of the northwest corner of sec. 25, T. 86 N., R. 28 W.

Ap1—0 to 6 inches, black (N 2/0) heavy silty clay loam, black (10YR 2/1) when crushed, black (10YR 2/1) to very dark gray (10YR 3/1) when dry; strong, medium, angular blocky structure parting to moderate, fine, subangular blocky structure, has some vertical orientation, probably caused by drying; firm; clean sand grains are evident; slightly acid; clear, smooth boundary.

Ap2—6 to 10 inches, black (N 2/0) heavy silty clay loam, black (10YR 2/1) when crushed, very dark gray (10YR 3/1) when dry; strong, medium and some coarse, angular blocky structure parting to moderate, fine, angular blocky structure caused by plow layer compaction and drying; firm; clean sand grains are evident; slightly acid; abrupt, smooth boundary.

A12—10 to 14 inches, black (N 2/0) light silty clay, black (10YR 2/1) when crushed, very dark gray (10YR 3/1) to dark gray (10YR 4/1) when dry; moderate, very fine, granular and some very fine subangular blocky structure; friable; few ⅛-inch or smaller pebbles; slightly acid; clear, smooth boundary.

B1—14 to 20 inches, black (N 2/0) silty clay, black (10YR 2/1) when crushed, dark gray (10YR 4/1) when dry; moderate, fine and very fine, subangular blocky structure; friable to firm; very few, very fine, soft, dark-brown to brown (7.5YR 4/4) oxides; few very dark gray (5Y 3/1) peds in lower part of horizon; a few ⅛-inch and smaller pebbles; sand grains are evident; neutral; clear, smooth boundary.

B21—20 to 26 inches, olive-gray (5Y 5/2) and dark-gray (5Y 4/1) silty clay to clay, faces of peds very dark gray (10YR 3/13 to black (10YR 2/1); strong, coarse, prismatic structure parting to medium prismatic structure, then parting to strong, fine and very fine, subangular blocky structure; very firm; distinct, discontinuous clay films; few very fine clay peds; very few, very fine, soft, dark-brown (7.5YR 3/2) oxides; very few ¼-inch pebbles and some sand grains; neutral; gradual, smooth boundary.

B22g—26 to 32 inches, olive-gray (5Y 5/2) silty clay, faces of peds about 70 percent very dark gray (5Y 3/1) and about 30 percent black (10YR 2/1); strong, coarse, prismatic structure parting to moderate, fine and medium, subangular blocky structure; very firm; thick, continuous clay films on prisms and subangular blocks; very few, very fine, light olive-brown (2.5Y 5/4) to dark yellowish-brown (10YR 4/4), soft oxides; few, fine, black, soft oxides; few fragments of shale and rotted stones; few sand grains; prism faces are about 30 degrees from horizontal and have fewer pores than vertical faces; neutral; gradual, smooth boundary.

B23g—32 to 40 inches, olive-gray (5Y 5/2) heavy silty clay loam, faces of peds about 50 percent olive gray (5Y 5/2), about 30 percent very dark gray (5Y 3/1), and about 20 percent black (10YR 2/1); common, fine, light olive-brown (2.5Y 5/4) to yellowish-brown (10YR 5/6) mottles; moderate, coarse, prismatic structure parting to moderate, medium, subangular structure; firm; prism faces are 30 degrees from horizontal and have thick, continuous clay films; vertical faces have thin clay films and a somewhat grainy appearance; some of the larger prism exteriors are very dark gray (5Y 3/1) and black (10YR 2/1); smaller faces are olive gray (5Y 5/2) and very dark gray (10YR 3/1); few, fine concretions of a black oxide; few ½-inch pebbles; mildly alkaline; clear, wavy boundary.

IIB31g—40 to 45 inches, olive-gray (5Y 5/2) light clay loam, faces of peds dark gray (5Y 4/1) and olive gray (5Y 5/2); common, fine, yellowish-brown (10YR 5/6) and few, fine, light olive-brown (2.5Y 5/4) mottles; weak, coarse, prismatic structure parting to weak, medium to coarse, subangular blocky structure; firm; few pores coated with very dark gray (10YR 3/1) clay; some 1- to 1½-inch lime rocks; few pebbles; few shale rocks; common black oxide concretions; horizon appears to be glacial till; vertical faces are high in lime; moderately alkaline; strongly effervescent; gradual, wavy boundary.

IIB32g—45 to 49 inches, olive-gray (5Y 5/2) heavy loam, vertical faces of larger peds are dark gray (5Y 4/1) to gray (5Y 5/1); many, medium, yellowish-brown (10YR 5/6) mottles; weak, coarse, prismatic structure parting to very weak, medium, subangular blocky structure; hard when dry, friable when moist; few dark-gray (10YR 4/1) coatings on prism faces and few very dark gray (10YR 3/1) coatings in pores; few, fine concretions of a black oxide; some pebbles; some lime segregated along pores, roots, and large prism faces; several old krotovinas in the pit at this depth and below; moderately alkaline; strongly effervescent; gradual, wavy boundary.

IIB33—49 to 55 inches, mottled olive-gray (5Y 5/2) and yellowish-brown (10YR 5/6) heavy loam; weak, very coarse, prismatic structure or vertical faces; friable; few very dark gray (10YR 3/1) coatings in some pores; distinct lime on large vertical faces; prominent filament lime along pores; some pebbles; moderately alkaline; strongly effervescent, higher in lime than IIB32g horizon; gradual, smooth boundary.

IIB34—55 to 61 inches, mottled olive-gray (5Y 5/2) and yellowish-brown (10YR 5/6) heavy loam; weak, very coarse, prismatic structure or vertical faces; friable; some prism faces are dark gray (5Y 4/1); some pores are coated with dark gray (10YR 3/1); lime on the vertical faces less distinct than in IIB33 horizon, but ¼-inch concretions of lime are common; prominent filament lime along pores; krotovinas are as in the IIB33 horizon; moderately alkaline; strongly effervescent; gradual, smooth boundary.

IIC1—61 to 67 inches, about 70 percent yellowish-brown (10YR 5/6) and about 30 percent gray (5Y 5/1) heavy loam; massive but has some vertical faces with thin coatings of gray (5Y 5/1); friable; some very dark gray (10YR 3/1) coatings on few vertical pores; few lime nodules; few, yellowish-red (5YR 4/6), soft oxides; moderately alkaline; strongly effervescent; gradual, smooth boundary.

IIC2—67 to 72 inches, about 70 percent yellowish-brown (10YR 5/6) and about 30 percent gray (5Y 5/1) heavy loam; massive but has some vertical faces with thin coatings of gray (5Y 5/1); vertical faces less distinct than in IIC1 horizon; friable; some very dark gray (10YR 3/1) coatings on few vertical pores; few lime nodules; few, yellowish-red (5YR 4/6), soft oxides; moderately alkaline; strongly effervescent.

The A horizon ranges from 12 to 24 inches in thickness. This horizon is heavy silty clay loam or light silty clay in texture. It has granular or angular or subangular blocky structure. The B horizon, in most places, is black (10YR 2/1) or very dark gray (10YR 3/1) in the upper part but grades to dark gray (5Y 4/1), gray (5Y 5/1), or olive gray (5Y 4/2 or 5/2). Mottles of brown, yellowish brown, olive brown, or olive are in this horizon. Coatings on the exterior of peds in the upper part of the B horizon commonly are black to gray. The lacustrine sediment of the B1 and B2 horizons generally ranges from 24 to 42 inches in thickness but is as much as 48 or more inches in places. The B1 and

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B2 horizons are heavy silty clay loam to silty clay or clay in texture. The boundary between lacustrine sediment and glacial till ranges from clear to diffuse and generally has few to common small stones. The IIB horizon is light clay loam to loam in texture. The IIC horizon is loam to light clay loam glacial till. It is mottled yellowish brown (10YR 5/4 or 5/6) or light olive brown (2.5Y 5/4) and gray (5Y 5/1) or olive gray (5Y 5/2). It has some oxide concretions and lime accumulations. Reaction of the A horizon ranges from neutral to slightly acid. The lacustrine sediment in the upper part of the B horizon is slightly acid to mildly alkaline, and the glacial till in the lower part of the B horizon and the C horizon is mildly alkaline or moderately alkaline and calcareous.

Marna, Webster, and Canisteo soils are poorly drained and occupy similar positions on the landscape. Marna soils differ from Webster and Canisteo soils in being finer textured in the A and B2 horizons and in having stronger structure in these horizons. These soils differ from Canisteo soils in not being calcareous in the surface layer and the upper part of the subsoil.

Marna silty clay loam (0 to 2 percent slopes) (383).—This soil is nearly level. It generally is associated with Guckeen soils that are on low rises upslope. In many places Webster, Canisteo, Okoboji, or Lanyon soils are near by and generally are in somewhat lower areas.

Included with this soil in mapping are areas of soils in which the underlying material has a zone of stratified loam, silt loam, or sandy loam soil material in the upper part. Also included are areas that have many stones between the lacustrine sediment and the glacial till.

This soil tends to remain cold and wet in spring. Slow permeability restricts water movement and aeration. Most areas of this soil are cultivated. This soil is used mainly for row crops, and it is well suited to this use if drainage is provided. This soil tends to dry out cloddy and hard if tilled when wet, so tilth is poor at times. Power requirements for tillage operations are high. Capability unit IIw–1; woodland suitability group 5w3.

Minnetonka Series

The Minnetonka series consists of dark-colored, poorly drained soils that formed in clayey lacustrine sediment and underlying glacial till. These soils are on uplands. They are nearly level to slightly concave and are in swales in the southeastern part of the county near the Des Moines River. In places the surface water is drained from these soils by a rapidly deepening, steep-sided, stabilized gully. Individual areas generally are small, and many are 2 to 10 acres in size. The native vegetation was trees and prairie grasses tolerant of wetness.

In a representative profile, the surface layer is black silty clay loam about 14 inches thick. The subsoil extends to a depth of about 43 inches. The upper part of the subsoil is dark grayish-brown, firm light silty clay; the middle part is olive-gray, firm silty clay that contains enough sand to have a gritty feel; and the lower part is olive-gray, friable loam. The underlying material is yellowish-brown and light olive-gray loam.

The available water capacity is high, and permeability is slow. The content of organic matter is high. The surface layer and the upper part of the subsoil are slightly acid or medium acid. The subsoil is low in available phosphorus and very low in available potassium.

The Minnetonka soils are generally managed along with other soils. These soils are used for trees, pasture, or cultivated crops. They are wet because of a high water table and slow permeability.

Representative profile of Minnetonka silty clay loam, in a cultivated field 300 feet south and 175 feet west of the northeast corner of the NW¼SE¼ sec. 11, T. 86 N., R. 27 W.

Ap—0 to 7 inches, black (10YR 2/1) light silty clay loam; cloddy parting to weak, fine, subangular blocky and weak, fine, granular structure; friable; medium acid; gradual, smooth boundary.

A1—7 to 14 inches, black (10YR 2/1) silty clay loam; moderate and weak, fine and very fine, subangular blocky structure; friable; slightly acid; gradual, smooth boundary.

B1—14 to 22 inches, black (10YR 2/1) light silty clay; common, fine, distinct, very dark grayish-brown (2.5Y 3/2) mottles; moderate, fine and very fine, subangular blocky structure; firm; common fine and very fine pores; thin, continuous clay films on ped faces; common manganese and iron oxide concretions; slightly acid; gradual, smooth boundary.

B21—22 to 27 inches, dark grayish-brown (2.5Y 4/2) light silty clay loam; common very dark (10YR 3/1 or N 3/0) mottles; faces of peds are very dark gray (N 3/0 and 10YR 3/1) and some dark grayish brown (2.5Y 4/2); weak, medium, prismatic structure parting to moderate, fine, subangular blocky structure that has a few angular blocky peds; firm; common fine and very fine tubular pores; thick, continuous clay films on ped surfaces; some concretions of iron oxide and manganese oxide; neutral; gradual, smooth boundary.

B22—27 to 33 inches, olive-gray (5Y 5/2) gritty silty clay; few, very fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, coarse, prismatic structure parting to weak and moderate subangular blocky structure; firm; common fine tubular pores; some soft concretions of iron oxide and manganese oxide; very dark gray (10YR 3/1) organic streaks on ped faces; moderately thick clay films on faces of peds; neutral; clear, smooth boundary.

IIB3—33 to 43 inches, olive-gray (5Y 5/2) loam; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, coarse, prismatic structure to massive; friable; organic matter and clay movement in root channels and tubular pores; pores abundant; mildly alkaline; gradual boundary.

IIC—43 to 52 inches, mottled, yellowish-brown and light olive-gray (10YR 5/6 and 5Y 6/2) loam; friable; massive; few pores; moderately alkaline; slightly effervescent.

The A1 horizon ranges from 10 to 20 inches in thickness. It has weak to moderate, very fine and fine, subangular blocky or fine granular structure. The B1 horizon is black (10YR 2/1) or very dark gray (10YR 3/1) in color. The B2 horizon is dark grayish brown (2.5Y 4/2) to olive gray (5Y 5/2) in color and has gray, light olive-brown, yellowish-brown, or strong-brown mottles in the lower part. Colors of black (N 2/0 or 10YR 2/1) or very dark gray (N 3/0 or 10YR 3/1) extend well into the B horizon on faces of peds. The B horizon extends to a depth of about 28 to 52 inches. The upper part of the solum generally ranges from about 30 to 42 inches in thickness in most places, but it is thicker in some places. It formed in lacustrine sediment and ranges from silty clay loam to silty clay in texture. The IIB horizon formed in glacial till and is clay loam or loam in texture. The IIC horizon is calcareous, mottled, light olive-gray (5Y 6/2), olive-gray (5Y 5/2), gray (5Y 5/1), yellowish-brown (10YR 5/4 to 5/8), and strong-brown (7.5YR 5/6 or 5/8) light clay loam or heavy loam. Reaction of the A horizon and B2 horizon is neutral to strongly acid. The IIB3 horizon is neutral to moderately alkaline.

Minnetonka soils differ from Marna soils in that they are somewhat less fine textured in the A horizon. Dark colors are on faces and interiors of peds deeper into the B horizon than in the Marna soils. Minnetonka soils tend to have a

somewhat thinner A horizon and to be somewhat more acid in the A horizon and the upper part of the B horizon. These soils formed in similar parent material.

Minnetonka silty clay loam (0 to 1 percent slopes) (583).—This soil is nearly level to slightly concave and is in swales in association with the Luther and Dundas soils.

This soil is wet and has slow permeability. Some areas are cultivated, but most are in woods. This soil is well suited to row crops if drained. Areas are so small that they are managed along with associated soils. Capability unit IIw–1; woodland suitability group 5w3.

Muck

Muck consists of dark-colored, very poorly drained, organic soils that formed in a buildup of dead vegetation. These soils are in depressions on uplands or in shallow lakebeds in the Marna-Guckeen, the Webster-Nicollet-Canisteo, and the Webster-Clarion-Nicollet soil associations. One Muck soil is in seepy areas on side slopes. Individual areas generally are 5 to 75 acres in size. The native vegetation was swamp grasses and sedges.

In a representative profile, the surface layer is black muck about 15 inches thick. The underlying material is black to gray silt loam to clay loam glacial sediment. Thick red coatings are on old root channels in many places.

The available water capacity is high or very high. Permeability is variable and depends on the texture of the underlying mineral soil. The content of organic matter is very high. The subsoil is low in available phosphorus and very low in available potassium.

Muck soils are used for crops if drainage is provided. Partly drained areas are generally used for pasture, and undrained areas are generally used for pasture or wildlife habitat. Muck soils are wet because of a high water table, and they tend to pond in spring and after heavy rains. These soils are in low areas, and crops are subject to frost damage earlier than on surrounding soils. Trace elements are lacking for some crops.

Representative profile of Muck, shallow, in a depression, in a cultivated field 4 feet west of the fence line and 40 feet south of the northeast corner of the SE¼ sec. 23, T. 89 N., R. 27 W.

O—0 to 15 inches, black (N 2/0) muck; massive but slightly laminated; friable; moderately alkaline; slightly effervescent; abrupt, smooth boundary.

IIC1—15 to 19 inches, very dark gray (5Y 3/1) loam; massive but slightly laminated; friable; moderately alkaline; abrupt, smooth boundary.

IIC2—19 to 25 inches, black (5Y 2/1) silt loam; weak, medium, prismatic structure; firm; few, thin coatings of a red oxide in root channels and pores; grayish-brown (2.5Y 5/2) fills in prism cracks; moderately alkaline; slightly effervescent; abrupt, smooth boundary.

IIC3—25 to 33 inches, black (N 2/0) silty clay loam; weak, medium, prismatic structure; firm; common, thick coatings of a red oxide in pores and root channels; moderately alkaline; abrupt, smooth boundary.

IIC4g—33 to 43 inches, gray (5Y 5/1) clay loam, streak of sandy clay loam is at a depth of 33 to 35 inches; weak, medium, prismatic structure; firm; common, thick coatings of a red oxide in root channels and pores; moderately alkaline; slightly effervescent; clear, smooth boundary.

IIC5g—43 to 48 inches, gray (5Y 5/1) and brown (7.5YR 4/4) heavy loam; massive; firm; few small pebbles; moderately alkaline; slightly effervescent; abrupt, smooth boundary.

IIICg—48 to 72 inches, olive-gray (5Y 4/2) clay loam glacial till; massive; firm; brown (7.5YR 4/4) and yellowish-brown (10YR 5/4) oxide stains; few small pebbles; moderately alkaline; slightly effervescent.

The O horizon ranges from 10 to 20 inches in thickness and from black (10YR 2/1 or N 2/0) to very dark brown (10YR 2/2) in color. The IIC horizon consists of glacial sediment. It ranges from black (N 2/0 or 10YR 2/1) to gray (5Y 5/1) or olive gray (5Y 4/2 or 5/2) in color and from silt loam to silty clay loam, loam, or clay loam in texture. In a few places this horizon has sandy layers. The IIIC horizon is glacial till. In some places it is at a depth as shallow as about 3½ feet, but in other places it is much deeper. It is clay loam or loam in texture. Reaction is slightly acid to moderately alkaline throughout.

Muck soils differ from the Okoboji soils in having at least 10 inches of muck over the underlying mineral material. Muck and Okoboji soils occupy similar positions on the landscape.

Muck, shallow (21).—This soil is in depressions that formerly contained water. It is surrounded in some places by narrow areas of highly calcareous Harps soils. In other places it is surrounded by Canisteo or Webster soils.

Included with this soil in mapping are areas where the muck is about 20 to 30 inches thick. Also included are a few areas that are highly calcareous. These areas are shown on the soil map by a symbol for calcareous soil.

This soil is very poorly drained. Unless it is artificially drained, it is ponded, and most areas tend to pond, even if drained. Small grains generally lodge badly, and the quality of the grain generally is poor. In places trace elements are needed. Crop damage because of early frost is a hazard.

Most areas of Muck soils are cultivated and are used mainly for row crops. This soil is moderately suited to row crops. Partly drained areas are suited to pasture. Undrained areas are generally suited only to wildlife habitat. This soil is easy to till, and tilth is good. A few areas are cropped separately, but most are managed along with the associated soils. Capability unit IIIw–2; woodland suitability group 5w4.

Muck, shallow, 5 to 14 percent slopes (21D).—This soil is gently sloping to strongly sloping and generally is on the lower parts of escarpmentlike areas between benches or between benches and bottom lands. It consists of seepy areas where mucky soil material has accumulated. These areas formed because of a difference in permeability of two geological strata. Water percolates through a permeable upper layer faster than through the less permeable material beneath. A perched water table builds up and overflows to an outlet. The outlet is these wet, seepy areas. A few of these areas are in the valley of the Des Moines River, but most are in the lower part of the valley of Lizard Creek. Individual areas are generally 2 to 10 acres in size, and the total acreage is small.

Nearly all of this soil is in native vegetation of sedges, swamp grasses, and cattails. One area, in the northwestern part of the county, has been tile drained and is cultivated. The organic material is spread over other soils. Draining these areas is very difficult. The water causing the seepiness must be intercepted before it emerges on the landscape. The perched water table generally is too deep to be reached for drainage by normal means. Some areas have been tapped for a water supply for livestock, but in most areas it is hard to intercept enough

water to provide much volume. Some types of wildlife use these areas. Capability unit VIIw–1; woodland suitability group 5w4.

Nicollet Series

The Nicollet series consists of dark-colored, somewhat poorly drained soils that formed in glacial till. These soils are on uplands. They are nearly level to gently sloping and are on rises in the Webster-Clarion-Nicollet and the Webster-Nicollet-Canisteo soil associations. Individual areas are irregular in shape and range from about 3 to 100 acres or more in size. These soils occupy a large acreage in the county. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black heavy loam and light clay loam about 15 inches thick. The subsoil extends to a depth of about 32 inches. It is friable clay loam. It is very dark grayish brown in the upper part, dark grayish brown in the middle part, and grayish brown and light olive brown in the lower part. It has yellowish-brown and strong-brown mottles in the lower part. The underlying material is mottled light-gray, grayish-brown, and yellowish-brown loam. Pebbles and a few stones or boulders are in these soils.

The available water capacity is high, and permeability is moderate. The content of organic matter is high. The surface layer and subsoil are neutral or slightly acid. The subsoil is very low in available phosphorus and available potassium.

Most areas of Nicollet soils are cultivated. Limitations to their use for crops are slight.

Representative profile of Nicollet loam, 1 to 3 percent slopes, in a cultivated field 200 feet west and 230 feet south of the northeast corner of sec. 4, T. 89 N., R. 28 W.

Ap—0 to 6 inches, black (10YR 2/1) heavy loam; cloddy parting to weak, fine, subangular blocky structure; friable; few pebbles; slightly acid; abrupt, smooth boundary.

A12—6 to 11 inches, black (10YR 2/1) light clay loam; weak, fine, subangular blocky structure; friable; few pebbles; slightly acid; gradual, smooth boundary.

A3—11 to 15 inches, black (10YR 2/1) light clay loam; weak and moderate, fine, subangular blocky structure; friable; few dark grayish-brown (10YR 3/2) peds; few pebbles; slightly acid; gradual, smooth boundary.

B1—15 to 20 inches, very dark grayish-brown (10YR 3/2) light clay loam; moderate, fine, subangular blocky structure; friable; nearly continuous black (10YR 2/1) coatings on peds and fills in worm channels; few pebbles and stones; neutral; gradual, smooth boundary.

B2—20 to 26 inches, dark grayish-brown (2.5Y 4/2) light clay loam, faces of peds very dark grayish brown (2.5Y 3/2); weak, medium, prismatic structure parting to moderate, fine, subangular blocky structure; friable; very dark gray (10YR 3/1) coatings and fillings in worm channels; few pebbles and stones; neutral; gradual, smooth boundary.

B3—26 to 32 inches, grayish-brown (2.5Y 5/2) to light olive-brown (2.5Y 5/4) light clay loam; few, distinct, strong-brown (7.5Y 5/6) and yellowish-brown (10YR 5/6 and 10YR 5/8) mottles; weak, medium, prismatic structure parting to weak, fine, subangular blocky structure; friable; few, fine, very dark gray (10YR 3/2) coatings in root channels; few, soft, black oxides; few pebbles and stones; mildly alkaline; clear, smooth boundary.

C1g—32 to 42 inches, gray (5Y 5/1) and light-gray (5Y 6/1) loam; few to common, fine, distinct, yellowish-brown (10YR 5/6 and 10YR 5/8) mottles; massive with some vertical cleavage; friable; few, soft, black oxides; few pebbles and stones; moderately alkaline; slightly effervescent; gradual, smooth boundary.

C2g—42 to 60 inches, grayish-brown (2.5Y 5/2) and yellowish-brown (10YR 5/6) loam; very few, fine, faint, olive-brown (2.5Y 4/4) oxides; massive; friable; common black oxides; many soft accumulations of lime; few vertical faces of gray (5Y 5/1) and light gray (5Y 6/1); moderately alkaline; strongly effervescent.

The A horizon ranges from 12 to 24 inches in thickness and from loam to light clay loam in texture. This horizon has granular or subangular blocky structure. The A1 horizon is black (10YR 2/1) or very dark gray (10YR 3/1) in color. The A3 horizon is black (10YR 2/1) to very dark grayish brown (10YR 3/2) in color. The B horizon generally ranges from 12 to 20 inches in thickness. This horizon is mainly light clay loam in texture, but it ranges to loam and medium clay loam. The lower part of the B2 horizon or the B3 horizon is dark grayish brown (10YR 4/2 or 2.5Y 4/2) to light olive brown (2.5Y 5/4) in color. Grayish-brown (10YR 5/2 or 2.5Y 5/2) to yellowish-brown (10YR 5/6 or 5/8) or strong-brown (7.5YR 5/6) mottles are in the lower part of the B horizon. The C horizon is mottled olive gray (5Y 5/2), gray (5Y 5/1), grayish brown (2.5Y 5/2), and olive brown (2.5Y 4/4) or yellowish brown (10YR 5/4 or 5/8) in color. Reaction of the A and B2 horizons is slightly acid or neutral. The B3 horizon is neutral or mildly alkaline, and the C horizon is mildly alkaline or moderately alkaline and is calcareous.

Nicollet and Le Sueur soils formed in similar parent material. Nicollet soils lack a grayish A2 horizon, have a somewhat thicker, darker colored A1 horizon, and have less clay in the B horizon than Le Sueur soils. Nicollet and Cylinder soils have similar drainage, and Nicollet soils are not underlain by sand and gravel as are Cylinder soils.

Nicollet loam, 1 to 3 percent slopes (55A).—In most places, this soil is on slightly convex areas below Clarion soils on knolls and above nearly level Webster or Canisteo soils. In some places, however, it is associated mainly with Webster or Canisteo soils. This soil has the profile described as representative for the series. In a few places, below areas of undulating Storden or Clarion soils, slopes are concave.

Nearly all areas of this soil are cultivated and are used mainly for row crops. Erosion is a slight hazard on long slopes. Soil blowing is a hazard if large areas of this soil are plowed in fall. In years of above-average rainfall, some areas of this soil that border Webster or Canisteo soils are slightly wet. Some areas are artificially drained to improve timeliness of field operations. Tilth generally is good. Capability unit I–1; woodland suitability group 3w1.

Nicollet loam, benches, 3 to 6 percent slopes (55B).—This soil is on benches, generally between uplands and flood plains along the Des Moines River. It generally is below Storden-Hayden soils and above Hanlon or Spillville soils on bottom lands. The profile of this soil is similar to the one described as representative for the series, but it is leached more deeply in many places. Individual areas are long and narrow and are generally less than 20 acres in size. Most areas are in the valley of the Des Moines River, but some are along the larger creeks.

Included with this soil in mapping are a few areas of a similar soil on a similar landscape that has a less permeable, gray and yellowish-brown clay loam underlying layer at a depth of 30 to 50 inches. These areas are wetter

and are indicated on the soil map by a symbol for a wet spot. Also included are areas of soils that have slopes of 1 to 9 percent.

Many areas of this soil are cultivated. Other areas are in permanent pasture. This soil is subject to erosion. Because it receives runoff from upslope, it is subject to rilling and, in places, to gullying. This soil is well suited to row crops if erosion is controlled. Tilth generally is good. Some larger areas are managed alone in small fields, and other areas are managed along with adjacent soils. Capability unit IIe–1; woodland suitability group 3w1.

Okoboji Series

The Okoboji series consists of very poorly drained soils that formed in alluvial sediment derived from glacial till. These soils are in small to large depressions on uplands. These depressions vary from small potholes, just large enough to be shown on the soil map by a special symbol, to former small, shallow lakes. These areas are mostly in the Webster-Clarion-Nicollet and the Webster-Nicollet-Canisteo soil associations that occupy much of the county. Individual areas are less than an acre to about 50 acres in size. The native vegetation was swamp grasses and sedges.

In a representative profile, the surface layer is black silty clay loam about 32 inches thick. The subsoil is mainly dark-gray and olive-gray silty clay loam about 22 inches thick. It is firm in the upper part and friable in the lower part. The underlying material is dark-gray and gray, friable light silty clay loam.

Available water capacity is high, and permeability is slow. The content of organic matter is high or very high. The surface layer is neutral or mildly alkaline. The subsoil is very low in available phosphorus and available potassium.

Okoboji soils generally are drained and used for crops. A few areas are in grass and are used for pasture. These soils are wet. They have a high water table, and runoff from surrounding soils ponds on these soils in places.

Representative profile of Okoboji silty clay loam, in a depression, in a cultivated field 220 feet east and 10 feet north of the north gate post that is approximately one-fourth mile south of the northwest corner of sec. 26, T. 88 N., R. 29 W.

Ap—0 to 6 inches, black (N 2/0) medium silty clay loam; cloddy parting to weak, fine, granular and very fine subangular blocky structure; friable; mildly alkaline; abrupt, smooth boundary.

A12—6 to 16 inches, black (N 2/0) medium silty clay loam; weak, fine, granular and very fine subangular blocky structure; friable; mildly alkaline; gradual, smooth boundary.

A13—16 to 26 inches, black (10YR 2/1) heavy silty clay loam; few, very fine, olive (5Y 4/3) mottles; weak, fine, granular and very fine subangular blocky structure; friable; mildly alkaline; gradual, smooth boundary.

A14—26 to 32 inches, black (10YR 2/1) heavy silty clay loam; very few, fine, olive (5Y 4/3) and few, medium, olive-gray (5Y 5/2) mottles; weak, very fine, subangular blocky structure; firm; mildly alkaline; gradual, smooth boundary.

B1g—32 to 36 inches, very dark gray (10YR 3/1 to N 3/0) heavy silty clay loam; common, fine, olive-gray (5Y 5/2) mottles; very weak, very fine, prismatic structure parting to weak, very fine, subangular blocky structure; firm; very few, fine, dark-colored oxides; mildly alkaline; clear, smooth boundary.

B2g—36 to 48 inches, dark-gray (5Y 4/1) and olive-gray (5Y 5/2) medium silty clay loam; very weak, fine, prismatic structure parting to weak, very fine, subangular blocky structure; firm; common, medium, dark-colored oxides; few dark krotovinas; mildly alkaline; slightly effervescent; gradual, smooth boundary.

B3g—48 to 56 inches, dark-gray (5Y 4/1) and olive-gray (5Y 5/2) light silty clay loam; common, coarse, olive-brown (2.5Y 4/4) mottles; very weak, medium, prismatic structure parting to very weak, medium, subangular blocky structure; friable; few, very fine, dark-colored oxides; few krotovinas; mildly alkaline; slightly effervescent; clear, smooth boundary.

Cg—56 to 60 inches, dark-gray (5Y 4/1) and gray (5Y 5/1) light silty clay loam; few, medium, olive-brown (2.5Y 4/4) mottles; some vertical cleavage; friable; few, very fine, dark-colored oxides; moderately alkaline; strongly effervescent.

The A horizon ranges from 24 to 36 inches in thickness. Grayish-brown to olive-gray mottles are in this horizon in places. In some places the upper part of this horizon is silt loam in texture. About 8 inches of mucky silt loam or muck is on the surface of the Okoboji mucky silt loam. The Bg horizon ranges from black (N 2/0 or 10 YR 2/1) to very dark gray (10YR to 5Y 3/1) in color in the upper part and is dark gray (5Y 5/1), olive gray (5Y 5/2), or olive (5Y 5/4) in the lower part. In many places yellowish-brown to light olive-brown mottles are in this horizon. This horizon is generally medium to heavy silty clay loam in texture, but ranges to light silty clay. The solum ranges from 40 to 60 inches in thickness. The C horizon is dark gray (5Y 4/1) to olive gray (5Y 5/2) in color. Mottles range from brown (10YR 4/3) to strong brown (7.5YR 5/8) and to light olive brown (2.5Y 5/4). This horizon is light silty clay loam or silt loam in texture, but in places it ranges to loam or clay loam. The A horizon is neutral to mildly alkaline, and it is calcareous at a depth of 20 to about 48 inches.

Okoboji soils are on similar positions on the landscape to Wacousta and Lanyon soils. They have a thicker A horizon and solum than Wacousta and Lanyon soils. Okoboji soils are similar to Colo soils in having a thick, dark-colored A horizon and in forming in alluvial material. They are finer textured in the 10- to 40-inch zone than Colo soils.

Okoboji mucky silt loam (0 to 1 percent slopes) (90).—This soil is in depressions that in many places are surrounded by narrow areas of highly calcareous Harps soils. In other places Canisteo or Webster soils surround these areas. The profile of this soil is similar to the one described as representative for the series, except that it has about 8 inches of muck or mucky silt loam on the surface.

Included with this soil in mapping are a few areas of soils that are calcareous at the surface and throughout.

This soil is wet. It has a high water table, and after heavy rains water tends to pond in the depressions. Tillage commonly is delayed, and plants are damaged in many places by wetness or standing water.

Nearly all areas of this soil are cultivated and are used mainly for row crops. The soil is moderately suited to row crops if drained. Partly drained areas are suited to pasture. Undrained areas are generally suited only to wildlife habitat. Tilth generally is fair or good. Nearly all areas are managed along with the surrounding soils. Capability unit IIIw–2; woodland suitability group 5w3.

Okoboji silty clay loam (0 to 1 percent slopes) (6).—This soil is in depressions that in many places are surrounded by narrow areas of highly calcareous Harps soils. In other places Canisteo or Webster soils are associated with it. In some places Marna soils are adjacent to this soil. This soil has the profile described as representative for the series.

Included with this soil in mapping are depressional areas in the Marna-Guckeen association that are somewhat higher in clay content than this soil. Also included are areas of soils that have a surface layer of heavy silt loam and some areas that are calcareous at the surface and throughout the profile.

This soil is wet. It has a high water table, and water tends to pond in the depressions after heavy rains. Tillage commonly is delayed, and plants are damaged in many places by wetness or standing water.

Nearly all areas of this soil are cultivated and are used mainly for row crops. The soil is moderately suited to row crops if drained. Partly drained areas are suited to pasture, and undrained areas are generally suited only to wildlife habitat. This soil is easily puddled by tilling it when it is wet. It dries out cloddy and hard, and tilth is poor. Most areas are managed along with the associated soils. Capability unit IIIw–2; woodland suitability group 5w3.

Rock Land and Steep Sandy Land

Rock land and Steep sandy land, 20 to 40 percent slopes (478G), is a steep land type that consists of some sandy soils and some loamy soils. Also in the unit are about 70 acres of strongly sloping to steep soils that are underlain by limestone bedrock at a depth of less than 20 inches. This land type is mainly on side slopes adjacent to the valleys of Lizard Creek and the Des Moines River.

This soil to too steep, too cut up by gullies, or too shallow to bedrock to cultivate. The available water capacity is variable, depending upon the texture of the soil or the depth to bedrock, but it is very low in many areas. Water runs off fairly rapidly in most places. This land is subject to erosion if vegetation is sparse.

If this land type is in a field, it generally determines the management of that particular field. Most areas are in grass and are used for pasture. This land is suited to this use. It is also suited to use as woodland or as wildlife habitat. Capability unit VIIe–1; woodland suitability group 5s1.

Rockton Series

The Rockton series consists of dark-colored, well-drained soils that formed in loamy alluvium that is underlain by fractured limestone at a depth of 20 to 40 inches. These gently sloping soils are on benches, mainly along the Des Moines River north of Fort Dodge and near the Humboldt County line. Individual areas are generally 2 to 30 acres in size. The native vegetation was prairie grasses and a few scattered trees.

In a representative profile, the surface layer is very dark grayish-brown loam about 13 inches thick. The subsoil is friable loam about 11 inches thick. It is dark brown in the upper part and yellowish brown in the lower part. The underlying material is yellowish-brown, fragmented limestone. Some loam and clay loam is intermingled with the fragments.

The available water capacity is low or moderate, and permeability is moderate. The content of organic matter is low. The surface layer and the upper part of the subsoil generally are medium acid. The subsoil is very low in available phosphorus and available potassium.

Most areas of Rockton soils are cultivated, but a few are used for pasture. These soils are subject to erosion.

Representative profile of Rockton loam, 2 to 5 percent slopes, in a cultivated field 150 feet south of the road fence and 100 feet west of the northeast corner of the NW¼NW¼ sec. 13, T. 90 N., R. 29 W.

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

A3—8 to 13 inches, very dark grayish-brown (10YR 3/2) to dark-brown (10YR 3/3) loam, dark grayish brown (10YR 4/2) when dry; weak, thick, platy structure parting to fine granular and very fine subangular blocky structure; friable; common uncoated sand grains; medium acid; clear, smooth boundary.

B1—13 to 17 inches, dark-brown (10YR 3/3) loam, very dark grayish brown (10YR 3/2) and brown (10YR 5/3) when dry; common, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, fine, subangular blocky structure; friable; medium acid; clear, smooth boundary.

B2—17 to 21 inches, yellowish-brown (10YR 5/4) loam, brown (10YR 5/3) when dry; common, fine, distinct, yellowish-brown (10YR 5/8) mottles; moderate, fine, subangular blocky structure; friable; few, small, unweathered residual fragments; slightly acid; clear, smooth boundary.

B3—21 to 24 inches, yellowish-brown (10YR 5/6 and 5/8) loam; moderate, fine, subangular blocky structure; friable; common, small, brownish-yellow (10YR 6/6) residual fragments; slightly acid; abrupt boundary.

IIC—24 to 40 inches, yellowish-brown (10YR 5/6) fragmented limestone, contains variable material including loam and clay loam textures and silty clay shale intermingled with the fragments; slightly acid.

The A horizon ranges from 10 to 18 inches in thickness and from black (10YR 2/1) to very dark grayish brown (10YR 3/2) in color. The B horizon is dark brown (10YR 3/3) to brown (10YR 4/3) in the upper part. The middle and lower parts of the B horizon are dark yellowish brown (10YR 4/4) to yellowish brown (10YR 5/6) in color. In places the lower part of the B horizon has common to many pebbles and stones just above the IIC horizon. In other places the texture of the lower part of the B horizon is sandy clay loam just above the IIC horizon. Limestone is at a depth of 20 to 40 inches. Reaction of the A and B horizons is medium acid to neutral.

The Rockton soils in Webster County do not have the clay increase from the A to the B horizon that is recognized in the defined range of the Rockton series, and they lack a layer of clayey limestone residuum above the limestone. These differences do not affect the use and management of the soils.

Rockton soils are on similar landscape positions to Jacwin and Wadena soils, and all of these soils have layers of contrasting underlying material. The Rockton soils are better drained than Jacwin soils and have browner colors in the B horizon. They are underlain by limestone, but Wadena soils are underlain by sand and gravel.

Rockton loam, 2 to 5 percent slopes (214B).—This soil is on benches along the Des Moines River. It is associated with the Jacwin soils that have shale in the substratum. The total acreage is small.

Included with this soil in mapping are a few areas of soil that have slopes of as much as 9 percent. Also included are a few areas of soil that have limestone at a depth of 40 to 48 inches. A few areas of soil have similar slopes but are underlain by sandstone. These areas are shown on the soil map by a symbol for rock outcrop. They are associated with the steeper Boone soils.

Areas of this soil are partly cultivated and partly in permanent pasture. This soil is subject to erosion. This soil is well suited to row crops if erosion is controlled, but lack of adequate available water is a limitation to crop growth. Tilth generally is good. Capability unit IIe–2; woodland suitability group 3s1.

Rolfe Series

The Rolfe series consists of dark-colored, poorly drained soils that formed in glacial sediment and glacial till. These soils are in slight depressions on uplands and generally are at slightly higher elevations than other poorly drained soils. They are in the Marna-Gukeen, the Webster-Clarion-Nicollet, and the Webster-Nicollet-Canisteo associations. Individual areas are as much as 5 acres in size. Many areas are so small that they are located by a special symbol on the soil map. The native vegetation was swamp grasses and sedges.

In a representative profile, the surface layer is black silt loam about 9 inches thick. The subsurface layer is very dark gray, friable silt loam about 5 inches thick. The subsoil extends to a depth of about 42 inches. It is mainly very dark gray, firm heavy silty clay loam in the upper part; dark-gray, firm heavy silty clay loam in the middle part; and olive-gray, friable clay loam in the lower part. The underlying material is olive-gray light clay loam that has yellowish-brown mottles. A few stones and pebbles are in the lower part of the subsoil and in the underlying material in places.

The available water capacity is high, and permeability is slow. The content of organic matter is high. The surface layer and subsurface layer are generally slightly acid, the subsoil is neutral or slightly acid. The subsoil generally is very low in available phosphorus and available potassium.

Most areas of Rolfe soils are cultivated. These soils are wet and tend to pond surface water after rains.

Representative profile of Rolfe silt loam, in a small depression, in a cultivated field 400 feet west and 300 feet north of the southeast corner of the SW¼SE¼ sec. 19, T. 87 N., R. 27 W.

A1p—0 to 9 inches, black (10YR 2/1) heavy silt loam, dark gray (10YR 4/1) when dry; cloddy parting to weak, fine, granular structure; friable; slightly acid; abrupt, smooth boundary.

A2—9 to 14 inches, very dark gray (10YR 3/1) heavy silt loam, very dark grayish brown (10YR to 2.5Y 3/2) when kneaded, gray (5Y 5/1) and light gray (10YR 6/1) when dry; light gray (10YR 6/1) silt coatings; weak, medium, platy structure parting to weak, fine, subangular blocky structure; friable; common, fine, soft, light olive-brown (2.5Y 5/4) oxides; slightly acid; clear, smooth boundary.

B1g—14 to 19 inches, very dark gray (10YR to 2.5Y 3/1) silty clay loam, faces of peds very dark gray (10YR 3/1) and black (10YR 2/1); moderate, very fine, subangular blocky structure; friable; slightly acid; clear, smooth boundary.

B21tg—19 to 25 inches, black (10YR 2/1) to very dark gray (10YR 3/1) heavy silty clay loam, very dark gray (10YR 3/1) when kneaded; weak, fine, prismatic structure parting to strong, very fine, subangular blocky structure; firm; thick, continuous clay films on peds and prisms; neutral; clear, smooth boundary.

B22tg—25 to 30 inches, dark-gray (5Y 4/1) and very dark gray (10YR 3/1) heavy silty clay loam, dark gray (5Y 4/1) when kneaded; weak, medium, prismatic structure parting to moderate, fine, subangular blocky structure; firm; thin, nearly continuous clay films; neutral; gradual, smooth boundary.

B31tg—30 to 35 inches, olive-gray (5Y 5/2) and dark-gray (5Y 4/1) clay loam, olive gray (5Y 5/2) when kneaded; few, fine, yellowish-brown (10YR 5/6) mottles; moderate, medium, prismatic structure parting to moderate, fine, subangular blocky structure; firm, thin, discontinuous clay films on peds and thick clay films on prisms; dark crawfish hole fills; few pebbles; neutral; gradual, smooth boundary.

B32t—35 to 42 inches, olive-gray (5Y 5/2) light clay loam; common, very fine, light olive-brown (2.5Y 5/4) and yellowish-brown (10YR 5/6) mottles; weak, medium, prismatic structure parting to weak, medium, subangular blocky structure; friable, thin, discontinuous clay films on some prisms; few pebbles; few, fine and medium, hard, carbonate concretions; mildly alkaline; gradual boundary.

C—42 to 60 inches, olive-gray (5Y 5/2) light clay loam; common, fine, yellowish-brown (10YR 5/6) and light olive-brown (2.5Y 5/4) mottles; massive, some vertical cleavage; friable, fine, soft, light-gray accumulations of lime; few pebbles; moderately alkaline; slightly effervescent to a depth of 53 inches and strongly effervescent below.

The A1 horizon ranges from 6 to 12 inches in thickness, from black (10YR 2/1) to very dark gray (10YR 3/1) in color, and is silt loam or loam in texture. The A2 horizon is very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2) in color when moist and is gray (10YR 5/1) or light gray (10YR 6/1) in color when dry. This horizon ranges from 2 to 6 inches in thickness and is friable silt loam or loam in texture. The B2 horizon ranges from dark gray (5Y 4/1) to olive gray (5Y 5/2) in color, but the upper part of the horizon has very dark gray (N 3/0 or 10YR 3/1) colors as part of the matrix or on faces of peds. The upper part of the B horizon ranges from heavy silty clay loam to light clay in texture, and the B3 horizon ranges from clay loam to loam in texture. The C horizon ranges from olive gray (5Y 5/2) to light gray (10YR 6/1 to 5Y 6/1) or light olive gray (5Y 6/2) in color and is light clay loam or heavy loam in texture. Yellowish-brown (10YR 5/6) to olive-brown (2.5Y 4/4) mottles are in this horizon. Reaction of the A horizon and the upper part of the B horizon is slightly acid to neutral. The lower part of the B3 horizon is neutral to mildly alkaline. The C horizon ranges from neutral and noncalcareous to moderately alkaline and calcareous.

The Rolfe soils in Webster County in most places have a darker and less prominent A2 horizon than is recognized in the defined range of the Rolfe series, and they tend to be less acid. These differences do not affect the use and management of the soils.

Rolfe and Okoboji soils occupy similar positions on the landscape. Rolfe soils have an A2 horizon that is lacking in Okoboji soils, and black or very dark gray colors do not extend so deep as in Okoboji soils. Rolfe and Dundas soils formed in similar parent material, but Rolfe soils have a less prominent A2 horizon, are less acid, and are typically darker colored in the upper part of the subsoil than Dundas soils.

Rolfe silt loam (0 to 1 percent slopes) [274].—This soil is in small depressions that generally are surrounded by Webster or Nicollet soils.

Included with this soil in mapping are about 60 acres of soils similar to Rolfe soils but that are on high benches near the lower end of North Lizard Creek. These areas have a thicker and grayer subsurface layer than this Rolfe soil. Their subsoil has more sand, and they are underlain, at a depth of 24 to 30 inches, by sand and gravel. These included soils are associated with Cylinder and Biscay soils.

This soil is wet, and water ponds on the surface. The major concern of management is to remove excess moisture from the surface layer and subsoil before crops are stunted or drowned out. The areas are so small that this soil is managed along with the surrounding soils. Wetness of this soil commonly affects the timeliness of field operations on the surrounding soils.

Nearly all areas of this soil are cultivated. They are used mainly for row crops and are moderately suited to this use if adequately drained. Capability unit IIIw–1; woodland suitability group 5w3.

Sandy Alluvial Land

Sandy alluvial land (0 to 2 percent slopes) (715) consists of sandy material deposited by stream overflow. It is mainly loamy sand or sand in texture, but some areas are sandy loam. Most areas are along the major streams (fig. 13), and these areas are ponded by flood waters.

Included with this land type in mapping are areas of old cutoff channels.

Most areas of this soil are in native vegetation. Some are in pasture. The vegetation of trees and weeds controls the flood waters and helps to prevent excessive stripping away of soil material or excessive deposition of new material. Removing trees and using this soil for crops generally allows the flood waters to increase their speed and strip away much of the soil material. These areas are better suited to deep-rooted, close-growing plants that can tolerate flooding or to suitable trees than to other uses. Well-managed pasture, wildlife habitat, or recreation areas are suitable uses for this land. Capability unit Vw–1; woodland suitability group 5w2.

Spillville Series

The Spillville series consists of dark-colored, moderately well drained to somewhat poorly drained soils that formed in loamy alluvium. These soils are on bottom lands, low benches, and foot slopes. They are nearly level or gently sloping, and the gently sloping soils generally are on concave foot slopes. These soils are in the valleys of all large rivers and streams in the county. Individual areas are mostly 5 to 50 acres in size. The native vegetation was trees and grasses.

In a representative profile, the surface layer is loam about 40 inches thick. It is black in the upper part and very dark brown in the lower part. The underlying material is very dark gray and very dark grayish-brown, friable sandy loam.

The available water capacity is high, and permeability is moderate. The content of organic matter is high. Reaction is neutral throughout. The subsoil is low in available phosphorus and very low in available potassium.

Most areas of Spillville soils are used for crops, but a few areas are in trees and grasses and generally used for pasture. Nearly level Spillville soils generally are subject to some degree of flooding. The areas on foot slopes are subject to erosion, rilling, and gullying caused by runoff water from upslope.

Representative profile of Spillville loam, 0 to 2 percent slopes, in a cultivated field west of the farm lane about 300 feet north and 700 feet east of the southwest corner of the SE¼ sec. 30, T. 90 N., R. 30 W.

Ap—0 to 9 inches, black (10YR 2/1) loam; cloddy parting to very weak, fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

A12—9 to 26 inches, black (10YR 2/1) loam; very weak, medium, subangular blocky structure; neutral; gradual, smooth boundary.

A13—26 to 35 inches, black (10YR 2/1) loam, very dark brown (10YR 2/2) to very dark gray (10YR 3/1) when kneaded; very weak, medium, subangular blocky structure; friable; neutral; gradual, smooth boundary.

A14—35 to 40 inches, very dark brown (10YR 2/2) to very dark gray (10YR 3/1) loam, very dark brown (10YR 2/2) when kneaded; very weak, medium, subangular blocky structure; friable; neutral; gradual, smooth boundary.

AC—40 to 60 inches, very dark gray (10YR 3/1) and very dark grayish-brown (10YR 3/2) sandy loam; very weak, medium, subangular blocky structure; friable; neutral.

The A horizon ranges from 36 to 48 inches in thickness. It is black (10YR 2/1) and very dark brown (10YR 2/2) in color and in places is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2) in the lower part. This horizon has granular or subangular blocky structure that is weak or very weak. The AC horizon, or the C horizon if present, generally is loam or sandy loam in texture but in places is light clay loam. In places sand or gravel is below a depth of 50 inches. This horizon is very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2 or 2.5Y 4/2) in color. In places a few dark-brown, brown, and yellowish-brown mottles are below a depth of 40 inches. Reaction is neutral to slightly acid to a depth of 40 inches or more. These soils generally are not calcareous within a depth of 48 inches.

Spillville soils formed in parent material similar to that in which Turlin and Terril soils formed, and all of these soils are in similar positions on the landscape. Spillville soils are slightly better drained than Turlin soils and lack the dark grayish-brown color in the subsoil that is in Turlin soils. They are darker colored to a greater depth and are not so well drained as Terril soils.

Spillville loam, 0 to 2 percent slopes (485A).—This soil has the profile described as representative for the series. It is nearly level and is on bottom lands and low benches. It is generally associated with the Colo or Hanlon soils on bottom lands and with Turlin soils on low benches.

This soil generally is subject to some degree of flooding, but in many places the flooding occurs early in spring or is of short duration so that crops are not seriously damaged. The risk involved in using this soil for crops generally is not great enough to discourage cultivation.

Most of the areas of this soil are cultivated and used for row crops. This soil is well suited to this use. A few of the smaller areas are in permanent pasture or trees and are managed along with less productive soils as pasture. Tilth generally is very good. Capability unit IIw–3; woodland suitability group 5w2.

Spillville loam, 2 to 5 percent slopes (485B).—This soil is gently sloping and is mainly on foot slopes, but it is also rises on bottom lands and low benches. Clarion or Storden soils generally are upslope, but in places Terril soils are upslope. Colo or other Spillville soils generally are downslope.

This soil is subject to erosion and to rilling and gullying where runoff water from upslope concentrates. Some areas are subject to flooding of short duration, but damage generally is slight and is not great enough to discourage cultivation.

Most areas of this soil are cultivated. This soil is well suited to row crops if erosion is controlled. A few smaller areas are in permanent pasture or trees and are managed along with less productive soils as pasture. Tilth generally is very good. Capability unit IIe–3; woodland suitability group 2o1.

Storden Series

The Storden series consists of moderately dark colored, well-drained soils that formed in glacial till. These soils are on uplands. They commonly are the steepest soils on a knoll or hill or on the sides of a valley. The soils are moderately sloping to very steep. The very steep soils are in a complex with Hayden soils and occupy sides of valleys along the Des Moines River and tributary streams. Individual areas are mainly 5 to 20 acres in size. The

Figure 13.—Area of Sandy alluvial land along the Des Moines River.

native vegetation was mainly prairie grasses, but a few trees and some brush were near streams.

In a representative profile, the surface layer is very dark grayish-brown loam about 7 inches thick. The underlying material is friable, yellowish-brown to light olive-brown loam.

The available water capacity is high, and permeability is moderate. Runoff is rapid, however, and these soils are commonly below their full moisture capacity. The content of organic matter is very low or low. The surface layer is calcareous and mildly alkaline or moderately alkaline in reaction. It is very low in both available phosphorus and available potassium.

Many areas of the moderately sloping to moderately steep Storden soils are cultivated or have been cultivated in the past. Most areas of the steep or very steep Storden soils are in permanent pasture. The soils are subject to erosion and gullying. Water runs off rapidly, especially on the steeper soils.

Representative profile of Storden loam, 18 to 25 percent slopes, moderately eroded, in a cultivated field 150 feet east and 200 feet north of the southwest corner of the SE¼ sec. 1, T. 90 N., R. 29 W.

Ap—0 to 7 inches, very dark grayish-brown (10YR 3/2) loam, some dark grayish brown (10YR 4/2) and grayish brown (10YR 5/2); weak, fine, subangular blocky structure; friable; common small pebbles; moderately alkaline; strongly effervescent; abrupt, smooth boundary.

C1—7 to 21 inches, yellowish-brown (10YR 5/4) loam; weak, medium, subangular blocky structure; friable; common small pebbles; moderately alkaline; strongly effervescent; gradual, smooth boundary.

C2—21 to 34 inches, yellowish-brown (10YR 5/4) to light olive-brown (2.5Y 5/4) loam; very weak, fine and medium, subangular blocky structure with elongated peds; friable; common small pebbles; common, soft, small, light-gray accumulations of lime; few red and dark-colored oxides; moderately alkaline; strongly effervescent; gradual, smooth boundary.

C3—34 to 58 inches, yellowish-brown (10YR 5/4) to light olive-brown (2.5Y 5/4) loam; very weak, fine and medium, subangular blocky structure; friable; common small pebbles; few, soft, small, light-gray accumulations of lime; few red and dark-colored oxides; moderately alkaline; strongly effervescent.

The A horizon generally ranges from very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2) in color, but in places it is dark brown (10YR 3/3). This horizon is about 7 inches thick in most places, but in some areas it is as much as about 10 inches thick. In places there is an AC horizon that is brown (10YR 4/3), dark grayish brown (10YR 4/2), or dark yellowish brown (10YR 4/4). This horizon is as much as 6 inches thick. The C horizon ranges from dark yellowish brown (10YR 4/4) to light olive brown (2.5Y 5/4) in color and is loam in texture. Below a depth of about 24

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to 36 inches, mottles that range from grayish brown to gray, olive gray, or strong brown are in many places. Storden soils are mildly alkaline or moderately alkaline, and they are generally calcareous in all layers. In places they are leached and are neutral in the upper few inches of the A horizon.

Storden soils are associated on the landscape with Clarion soils and formed in similar parent material. Storden soils are calcareous at or near the surface, but Clarion soils are leached to a depth of 2 feet or more.

Storden loam, 5 to 9 percent slopes, moderately eroded (62C2).—This soil is mainly on knolls and on the upper parts of steeper side slopes. Slopes are generally short and irregular. Clarion, Nicollett, Webster, or other Storden soils are the main associated soils (fig. 14).

Included with this soil in mapping are a few areas that are leached to a depth of about 18 inches. Also included are a few calcareous, gravelly areas that have similar slopes. These areas are indicated on the soil map by a symbol for gravel.

Most areas of this soil are cultivated. Some areas are in pasture. Controlling erosion, improving fertility, and getting as much moisture as possible into the soil are the main concerns of management. The soil is moderately suited to row crops if erosion is controlled. Tilth is generally fair. In many places the irregular slopes make control of erosion difficult. Capability unit IIIe–1; woodland suitability group 5t1.

Storden loam, 9 to 14 percent slopes, moderately eroded (62D2).—This soil is mainly on short, convex side slopes. Individual areas generally are less than 10 acres in size, but some areas are larger. This soil generally is adjacent to Clarion soils. Steeper Storden soils and Spillville soils are downslope.

Included with this soil in mapping are a few severely eroded areas in which the surface layer is dark brown to yellowish brown. These areas are indicated on the soil map by a symbol for severe erosion. Also included are a few pastured areas of soils that have a thicker, darker surface layer. A few calcareous, gravelly areas that have similar slopes are also included and are indicated on the soil map by a symbol for gravel.

In most areas this soil is cultivated. It is moderately suited to row crops if erosion is controlled and fertility is improved. Some areas are used for permanent pasture. Most of the rainfall from intense rains runs off unless a plant cover is present. Crops grow poorly in many places because moisture is not adequate in dry periods. Tilth is generally fair. Capability unit IIIe–2; woodland suitability group 5t1.

Storden loam, 14 to 18 percent slopes, moderately eroded (62E2).—This soil is mainly on short convex side slopes. Individual areas are generally 5 to 20 acres in size. This soil generally is downslope from Clarion soils and upslope from Spillville or Colo soils.

Included with this soil in mapping are severely eroded areas where the yellowish-brown underlying material is exposed on the surface. These areas are indicated on the soil map by a symbol for severe erosion. A few calcareous, gravelly spots are also included, and these are indicated on the soil map by a symbol for gravel. Also included are a few areas where the surface layer is somewhat thicker and darker.

Most areas of this soil have been or are cultivated, but some areas have always been in pasture. This soil is subject to erosion and gullying, and rainfall tends to run off rapidly unless there is adequate plant cover. This soil is moderately suited to row crops if erosion is controlled, but most farmers grow a row crop only when grasses and legumes used for hay and pasture need reseeding. Because of rapid runoff, this soil lacks adequate available water for good plant growth in periods of low rainfall. Capability unit IVe–1; woodland suitability group 5t1.

Storden loam, 18 to 25 percent slopes, moderately eroded (62F2).—This soil is on short, convex side slopes. It has the profile described as representative for the series. Individual areas generally are 5 to 20 acres in size. This soil is generally downslope from Clarion soils or less sloping Storden soils and upslope from Spillville or Colo soils.

Included with this soil in mapping are a few areas where the yellowish-brown underlying material is exposed on the surface. These areas are indicated on the soil map by a symbol for severe erosion. Also included are a few calcareous, gravelly areas, and these are indicated on the soil map by a symbol for gravel.

A few acres of this soil have been cultivated, but most areas are now in permanent pasture that has a few scattered trees. This soil is poorly suited to row crops. It is better suited to pasture. It is subject to severe erosion. Because much of the rainfall runs off rapidly, this soil lacks adequate available water for good plant growth in periods of low rainfall. Low fertility also limits plant growth. In some areas tillage equipment can be used to renovate pastures and seed more productive pasture plants. In others, uneven slopes and gullies prevent the safe use of equipment. Capability unit VIe–1; woodland suitability group 5t1.

Storden loam, 25 to 45 percent slopes, moderately eroded (62G2).—This steep soil is on short, convex side slopes along stream valleys (fig. 15). It is generally downslope from less sloping Storden soils and upslope from Terril or Spillville soils.

Included with this soil in mapping are a few acres of a gravelly, calcareous soil. These areas are indicated on the soil map by a symbol for gravel.

Areas of this soil are in permanent pasture that has scattered trees. This soil is suited to limited pasture or to wildlife habitat. It is too steep and too erodible to be used for cultivated crops or unlimited grazing. Runoff is rapid, and this soil lacks adequate available water for good plant growth in periods of low rainfall. Low fertility also limits plant growth. This soil is too steep for tillage equipment to be used safely. Capability unit VIIe–1; woodland suitability group 5t1.

Storden-Hayden loams, 25 to 70 percent slopes (356G).—This complex consists of very steep soils in the Storden-Hayden-Wadena soil association, mainly in the southeastern part of the county. These soils are on side slopes in the valley of the Des Moines River and in deep, V-shaped, actively eroding, short, side valleys. Slopes are irregular. Storden loam makes up 65 to 70 percent of the complex, and Hayden loam makes up the remaining 30 to 35 percent. Storden loam is on most of the side slopes in the valleys of the tributaries. Individual areas are large and are long and narrow. In places they extend for several miles along the river.

Most areas of these soils are in trees, but these areas are idle or used for pasture rather than for timber production. A few areas have been cleared of trees and are

Figure 14.—**Field of Storden and Clarion soils. The Storden soils are in the small light-colored areas on the crests of the knolls.**

used as permanent pasture. These soils are suited to limited pasture or to timber production. They are also suited to recreational uses or to wildlife habitat. Capability unit VIIe–1; woodland suitability group 5t1.

Talcot Series

The Talcot series consists of dark-colored, poorly drained, calcareous soils that formed in loamy alluvium that is underlain by sand and gravel at a depth of 24 to 40 inches. These soils are on benches and in some low areas on uplands. They are mostly in the Webster-Clarion-Nicollet and Storden-Hayden-Wadena soil associations. Individual areas range from as small as 2 acres to as large as 100 acres, but most are between 5 and 30 acres in size. The native vegetation was prairie grasses tolerant of wetness.

In a representative profile, the surface layer is black light clay loam about 15 inches thick. The subsoil is friable clay loam about 22 inches thick. It is very dark gray in the upper part, dark gray in the middle part, and gray and olive gray in the lower part. It has few to common light olive-brown and gray mottles. The underlying material is olive-gray, loose sand and gravel.

The available water capacity is low or moderate. Permeability is moderate in the upper part and rapid or very rapid in the underlying sand and gravel. The content of organic matter is high. Reaction generally is moderate, and this soil is calcareous throughout. The subsoil is very low in available phosphorus and available potassium.

Most areas of Talcot soils are cultivated. These soils are poorly drained and commonly are wet because of a high water table and slow runoff.

Representative profile of Talcot clay loam, deep, in a cultivated field 288 feet east and 135 feet south of the northwest corner of the SW¼NW¼ sec. 32, T. 90 N., R. 29 W.

Ap—0 to 8 inches, black (N 2/0) light clay loam; cloddy parting to weak, fine, granular structure; friable; moderately alkaline; slightly effervescent; abrupt, smooth boundary.

A1—8 to 15 inches, black (N 2/0) light clay loam; moderate, fine, granular structure; friable; moderately alkaline; slightly effervescent; gradual, smooth boundary.

B1—15 to 23 inches, very dark gray (N 3/0) light clay loam, black (N 2/0) peds in upper part, few dark-gray (5Y 4/1) peds in lower part; weak, very fine, subangular blocky structure; friable; moderately alkaline; strongly effervescent; gradual, wavy boundary.

B2g—23 to 28 inches, dark-gray (5Y 4/1) light clay loam; few, fine, light olive-brown (2.5Y 5/4) and common, fine, gray (5Y 5/1) mottles; weak, medium, prismatic structure parting to weak, very fine, subangular blocky structure; friable; few very dark gray (5Y 3/1) peds; moderately alkaline; strongly effervescent; clear, smooth boundary.

B3g—28 to 37 inches, gray (5Y 5/1) to olive-gray (5Y 5/2) sandy clay loam; common, medium, light olive-brown (2.5Y 5/4) mottles; weak, medium, prismatic structure; friable; black krotovina at a depth of 34 to 36 inches; moderately alkaline; strongly effervescent; abrupt, smooth boundary.

Figure 15.—Areas of Storden loam, 25 to 45 percent slopes, moderately eroded, on side slopes along the edges of the valley of the Des Moines River north of Fort Dodge.

IICg—37 to 52 inches, olive-gray (5Y 5/2) coarse sand and fine gravel; distinct strong-brown (7.5YR 5/6 to 5/8) iron band at a depth of 45 to 48 inches; single grain; loose; moderately alkaline; slightly effervescent.

The A horizon ranges from 12 to 24 inches in thickness. This horizon has granular or subangular blocky structure. The B horizon is very dark gray (10YR 3/1 or N 3/0) to gray (5Y 4/1) in the upper part and is gray (5Y 4/1) to olive gray (5Y 4/2 or 5/2) in the lower part. The B3 horizon ranges from clay loam to loam, sandy clay loam, or sandy clay in texture. Dark yellowish-brown to light olive-brown and strong-brown mottles are in the B3 horizon in many places. The IIC horizon is generally at a depth of 24 to 40 inches. It ranges from olive gray (5Y 4/2 or 5/2) to gray (5Y 5/1) or grayish brown (2.5Y 5/2) in color. In many places this horizon has bands of dark yellowish brown (10YR 4/4) to strong brown (7.5YR 5/6). This horizon is sand and gravel. In some areas the IIC horizon consists mainly of sand-sized material. It is mildly alkaline or moderately alkaline and calcareous throughout.

Talcot soils are similar in drainage to Biscay and Canisteo soils. Talcot soils differ from Biscay soils in being calcareous throughout. They differ from Canisteo soils in being underlain by sand and gravel.

Talcot clay loam, deep (0 to 2 percent slopes) (559).—This soil is on benches and in some low areas on uplands. This soil has the profile described as representative for the series. Most areas are nearly level to slightly concave. This soil generally is associated with Wadena, Cylinder, Biscay, or moderately deep Talcot soils.

Included with this soil in mapping are a few areas that are similar but that are 40 to 50 inches deep to sand and gravel. Also included are a few areas, mostly near Lizard Creek, that are underlain by sand and gravel but that have glacial till within a depth of 48 inches. Also included are a few areas of similar soils in or near section 1 of Douglas Township that are highly calcareous.

This soil is wet because of a high water table and slow runoff. Most areas are cultivated. This soil is used mainly for row crops. It is well suited to this use if adequately drained. Tilth generally is fair to good. Capability unit IIw–1; woodland suitability group 5w3.

Talcot clay loam, moderately deep (0 to 2 percent slopes) (558).—This soil is on benches and in some low areas on uplands. Most areas are nearly level to slightly concave. This soil is mainly associated with Wadena, Cylinder, Biscay, or deep Talcot soils. The profile is similar to that described as representative for the series, but this soil is underlain by sand and gravel at a depth of about 24 to 32 inches.

Included with this soil in mapping are similar soils that are highly calcareous. These highly calcareous areas are mostly in or near section 1 of Douglas Township.

This soil generally is wet because of a high water table or slow runoff. In very dry years plant growth is limited more severely by inadequate available water on this soil than on deep Talcot soils. Most areas are cultivated and used for row crops. This soil is well suited to this use if drainage is adequate. Tilth generally is fair to good. Capability unit IIw–1; woodland suitability group 5w3.

Terril Series

The Terril series consists of dark-colored, moderately well drained soils that formed in loamy local alluvium. These soils are moderately to strongly sloping and are on concave foot slopes. They are mainly in the Storden-Hayden-Wadena soil association in the valley of the Des Moines River. Individual areas are generally 2 to 10 acres in size and are long and narrow in shape. The native vegetation was prairie grasses.

In a representative profile, the surface layer, about 31 inches thick, is loam. It is black in the upper part and very dark grayish brown in the lower part. The subsoil extends to a depth of about 56 inches. It is brown, friable loam, except in the lower few inches where it is light clay loam. The underlying material is brown light clay loam.

The available water capacity generally is high, but it is moderate in the Terril soil that has a sandy substratum. Permeability generally is moderate, but it is rapid in the substratum of the Terril soil that has a sandy substratum. The content of organic matter is high. The surface layer is neutral or slightly acid. The subsoil is very low or low in available phosphorus and very low in available potassium.

Some areas of Terril soils are cultivated, but in many places they are managed along with the steeper soils on uplands and are in pasture. These soils are subject to erosion and to rilling and gullying caused by runoff waters from upslope that are concentrated as they run across these soils.

Representative profile of Terril loam, 9 to 14 percent slopes, in a bluegrass pasture 200 feet west and 400 feet north of the southeast corner of sec. 28, T. 88 N., R. 27 W.

A1—0 to 15 inches, black (10YR 2/1) loam, black (10YR 2/1) when kneaded; weak, fine, granular structure; friable; neutral; gradual, smooth boundary.

A12—15 to 21 inches, black (10YR 2/1) loam, black (10YR 2/1) when kneaded; weak, fine, granular structure; friable; slightly acid; gradual, smooth boundary.

A3—21 to 31 inches, very dark grayish-brown (10YR 3/2) loam, very dark grayish brown (10YR 3/2) when kneaded; weak, fine, granular and very fine subangular blocky structure; friable; few brown (10YR 4/3) peds; few small pebbles; slightly acid; clear, smooth boundary.

B1—31 to 36 inches, brown (10YR 4/3) loam, faces of peds dark grayish brown (10YR 4/2), brown (10YR 4/3) to dark grayish brown (10YR 4/2) when kneaded; weak, fine, subangular blocky structure; friable; few small pebbles; slightly acid; gradual, smooth boundary.

B2—36 to 42 inches, brown (10YR 4/3) loam, brown (10YR 4/3) when kneaded; weak, fine, subangular blocky structure; friable; thin coats on peds; slightly acid; gradual, smooth boundary.

B31—42 to 48 inches, brown (10YR 4/3) loam; weak, medium, subangular blocky structure; friable; thin, discontinuous coatings on peds; few small pebbles; slightly acid; gradual, smooth boundary.

B32—48 to 56 inches, brown (10YR 4/3) light clay loam; weak, medium, prismatic structure; friable; thin, discontinuous coatings on peds; few small pebbles; neutral; gradual, smooth boundary.

C—56 to 72 inches, brown (10YR 4/3) light clay loam; massive but some weak vertical cleavage; friable; few small pebbles; neutral.

The A horizon ranges from 24 to 36 inches in thickness. This horizon is black (10YR 2/1) or very dark brown (10YR 2/2) in the upper part and very dark brown (10YR 2/2) or very dark grayish brown (10YR 3/2) in the lower part. In places a dark grayish-brown (10YR 4/2) transitional layer is between the A and B horizons. These soils are within the defined range for the Terril series if the chroma increases with depth and if mottles are lacking.

The B horizon generally is at a depth of about 36 inches and extends to a depth of more than 48 inches. Peds that have very dark grayish brown (10YR 3/2) or dark brown (10YR 3/3) colors on the faces are common to a depth of 40 inches. Ped interiors have colors of dark brown (10YR 3/3) or brown (10YR 4/3) within a depth of 40 inches. The B horizon ranges from loam to light clay loam in texture. It generally has subangular blocky structure but in places is prismatic.

The C horizon is brown (10YR 4/3) to dark yellowish brown (10YR 4/4) in color. It is loam to light clay loam in texture, except in Terril loam, sandy substratum, where it is loamy sand or sand below a depth of about 40 inches. Faint mottles are in the lower part of the B horizon and C horizon in places. Reaction if the A and B horizons is neutral or slightly acid.

Terril, Spillville, and Terril, thin surface variant, soils have similar drainage and texture and formed in similar parent material. Terril soils differ from Spillville soils in having a higher chroma in colors above a depth of 40 inches. They differ from Terril, thin surface variant, soils in having a much thicker surface layer.

Terril loam, 5 to 9 percent slopes (27C).—This soil is in long, narrow areas on foot slopes. Storden or Storden-Hayden soils are generally upslope. In a few places more sloping Terril soils are upslope. Spillville or Colo soils on bottom lands are generally downslope. This soil has a profile similar to the one described as representative for the series, but the dark-colored surface layer is a few inches thicker and depth to brown colors generally is a few inches greater.

Included with this soil in mapping are soils that have similar slopes but that are somewhat poorly drained. These inclusions have a dark grayish-brown subsoil and are moderately eroded in places. Some of these inclusions are on escarpments adjacent to other less sloping soils rather than on foot slopes.

Some areas of this soil are cultivated. Other areas are in permanent pasture. A few trees and some brush are in some areas. The areas in pasture generally are managed along with the steeper soils upslope. This soil is subject to erosion. In places runoff water from upslope concentrates and causes rilling and gullying. This soil is moderately suited to row crops if erosion is controlled. Tilth generally is good. Capability unit IIIe–1; woodland suitability group 2o1.

Terril loam, 9 to 14 percent slopes (27D).—This soil has the profile described as representative for the series. It is in long, narrow areas on foot slopes. Storden or Storden-Hayden soils generally are downslope, but in places less sloping Terril soils are downslope.

Included with this soil in mapping are areas of soils that have similar slopes but that are somewhat poorly drained. These included soils have a dark grayish-brown subsoil and are moderately eroded in a few places. They are generally on escarpments of benches rather than on foot slopes.

A few areas of this soil are cultivated. Most areas are in permanent pasture and are managed with the steeper soils upslope. This soil is subject to erosion. In places runoff water from upslope concentrates and causes rilling and gullying. This soil is moderately suited to row crops if erosion is controlled. Tilth generally is good. Capability unit IIIe–2; woodland suitability group 2o1.

Terril loam, sandy substratum, 2 to 5 percent slopes (323B).—This soil is on foot slopes of benches. It is downslope from Clarion and Storden soils. It is also associated with the Wadena and Estherville soils that are downslope on the benches. This soil has a profile similar to the one described as representative for the series, except that it is underlain by loamy sand at a depth of about 40 inches.

Some areas of this soil are cultivated. Some areas are in pasture, and these areas have a few scattered trees. The soil is subject to erosion, and in places runoff water from upslope causes gullying. This soil is well suited to row crops if erosion is controlled. Tilth generally is good. Capability unit IIe–1; woodland suitability group 2s1.

Terril Series, Thin Surface Variant

Soils of the Terril series, thin surface variant, are dark colored and well drained. They formed in loamy alluvium on foot slopes. These soils are moderately sloping to moderately steep and are on benches in the valleys of the major streams of the county. Individual areas are 2 to 30 acres in size. The native vegetation was prairie grasses.

In a representative profile, the surface layer is very dark grayish-brown loam about 15 inches thick. The subsoil is brown, friable loam that extends to a depth of about 58 inches. The underlying material is brown loam.

The available water capacity is high, and permeability is moderate. The surface layer is medium acid, and the subsoil is slightly acid. The subsoil is very low or low in available phosphorus and very low in available potassium.

The Terril, thin surface variant, soils generally are cultivated, but some areas, especially the steeper areas, are in pasture. These soils are subject to erosion.

Representative profile of Terril loam, thin surface variant, 5 to 9 percent slopes, in a cultivated field 150 feet east and 200 feet south of the northwest corner of the SW¼SW¼ sec. 22, T. 86 N., R. 27 W.

Ap—0 to 7 inches, very dark brown (10YR 2/2) loam, dark gray (10YR 4/1) when dry; cloddy parting to weak, fine, subangular blocky to weak, fine, granular structure; friable; few, clear, uncoated sand grains; medium acid; clear, smooth boundary.

A3—7 to 15 inches, very dark grayish-brown (10YR 3/2) heavy loam. grayish brown (10YR 5/2) when dry; moderate, medium, subangular blocky structure; friable; common, clear, uncoated sand grains on faces of peds; medium acid; gradual, smooth boundary.

B1t—15 to 22 inches, brown (10YR 4/3) heavy loam, faces of peds dark brown (10YR 3/3); moderate, medium, subangular blocky structure; friable; very few, clear, uncoated sand and silt grains on faces of peds; thin, continuous clay films on faces of peds; slightly acid; gradual, smooth boundary.

B21t—22 to 30 inches, brown (10YR 4/3) heavy loam; moderate and strong, fine, subangular blocky structure; friable; thin, continuous clay films on faces of peds; slightly acid; gradual, smooth boundary.

B22t—30 to 40 inches, brown (10YR 4/3) heavy loam, faces of peds dark brown (10YR 3/3); weak and moderate, coarse, prismatic structure parting to weak and moderate, coarse, subangular blocky structure; friable; faint, discontinuous clay films on faces of peds; neutral; gradual, smooth boundary.

B31t—40 to 50 inches, brown (10YR 4/3) heavy loam; weak, coarse, prismatic structure parting to weak, medium, subangular blocky structure; friable; very dark gray (10YR 3/1) clay flows in root channels and cleavage faces; few clay films on faces of peds; gradual, smooth boundary.

B32—50 to 58 inches, brown (10YR 4/3) heavy loam; massive; friable; neutral.

The A horizon ranges from 10 to 24 inches in thickness. This horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark gray (10YR 3/1) in color. The B horizon is dark brown (10YR 3/3), brown (10YR 4/3), or dark yellowish brown (10YR 4/4) in color. It extends to a depth of 40 to 70 inches. In places the B3 horizon is sandy clay loam in texture. The C horizon is brown (10YR 4/3), dark yellowish brown (10YR 4/4), or yellowish brown (10YR 5/4) in color. It is loam, light clay loam, or sandy clay loam in texture and is calcareous. Reaction of the A horizon and the upper part of the B horizon is medium acid to neutral. The B3 horizon is neutral to mildly alkaline. The C horizon is moderately alkaline and is calcareous.

Terril, thin surface variant, soils are similar in drainage to Clarion soils, but they formed in local alluvium rather than glacial till and are somewhat more acid than Clarion soils. Terril, thin surface variant, and normal Terril soils formed in similar parent material, but these soils have a thinner A horizon than normal Terril soils.

Terril loam, thin surface variant, 5 to 9 percent slopes (566C).—This soil is mainly on foot slopes in the valley of the Des Moines River between the uplands or high benches and the flood plain of the nearby Des Moines River. A few areas are in the valleys of large creeks that are tributaries of the Des Moines River. This soil has the profile described as representative for the series. Areas of this soil generally are long and narrow in shape. Storden or Storden-Hayden soils generally are upslope. Spillville and Colo soils generally are downslope.

Included with this soil in mapping are about 100 acres of a similar soil that has slopes of 2 to 5 percent and a few acres that formed under trees and prairie grasses. The soils in these areas have grayish grainy coatings on soil aggregates in the surface layer and upper part of the subsoil, and they have other characteristics that were influenced by forming partly under trees.

This soil is subject to erosion. In places runoff water from upslope concentrates and causes rilling and gullying. Some areas are in pasture. This soil is moderately suited to row crops if erosion is controlled. Soils upslope generally are in pasture, and in many places this soil is managed along with them. In other places it is managed along with adjacent bottom lands and is cultivated. Tilth generally is good. Capability unit IIIe–1; woodland suitability group 2o1.

Terril loam, thin surface variant, 9 to 14 percent slopes (566D).—This soil is mainly on foot slopes in the valley of the Des Moines River between the uplands or high benches and the flood plains of the Des Moines River. A few areas are in the valleys of large creeks that are tributaries of the Des Moines River. Areas of this soil generally are long and narrow. Storden or Storden-Hayden soils generally are upslope. Colo or Spillville soils on bottom lands generally are downslope.

Included with this soil in mapping are about 70 acres of a soil that has similar slopes but that has a grayish-brown subsoil.

Some areas of this soil are cultivated, and other areas are in pasture. This soil is subject to erosion. In places runoff water from upslope concentrates and causes rilling and gullying. This soil is moderately suited to row crops part of the time if erosion is controlled. In many places this soil is managed along with soils upslope as pasture. In other places it is managed along with the soils down-

slope and is cultivated. Tilth generally is good. Capability unit IIIe–2; woodland suitability group 2o1.

Terril loam, thin surface variant, 14 to 18 percent slopes (566E).—This soil is mainly in the valley of the Des Moines River. It is on foot slopes between the uplands and the flood plain of the river. Areas of this soil generally are long and narrow in shape. Storden or Storden-Hayden soils generally are upslope. Such soils as Colo or Spillville generally are downslope. This soil has a profile similar to the one described as representative for the series, but the surface layer is a few inches thinner in most places.

Most areas of this soil are in permanent pasture. These areas have a few scattered trees. A few areas are cultivated. This soil is subject to erosion. In places runoff water from upslope causes rilling and gullying. If erosion is controlled, this soil is moderately suited to row crops, but these areas generally are used for hay. Most areas are managed along with the soils upslope. Capability unit IVe–1; woodland suitability group 2o1.

Turlin Series

The Turlin series consists of dark-colored, somewhat poorly drained soils that formed in loamy alluvium. These soils are on low benches and are mostly gently sloping in nearly level or convex areas. They are in the Storden-Hayden-Wadena soil association along the valleys of the Des Moines River and Lizard Creek. Individual areas generally are 5 to 30 acres in size. The native vegetation was prairie grasses and a few trees.

In a representative profile, the surface layer is loam about 34 inches thick. It is black, but is very dark grayish brown in the lower few inches. The subsoil is dark grayish-brown, friable loam about 20 inches thick. The underlying material is dark grayish-brown loam.

The available water capacity is high, and permeability is moderate. The content of organic matter is high. The surface layer and subsoil generally are neutral. The subsoil is low in available phosphorus and available potassium.

Most areas of Turlin soils are cultivated. Some areas are small and are managed with less productive soils. Some areas are inaccessible. These soils are subject to erosion, but the hazard is not severe.

Representative profile of Turlin loam, 2 to 5 percent slopes, in a cultivated field 850 feet east and 400 feet south of the center of sec. 16, T. 88 N., R. 28 W.

Ap—0 to 8 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) when dry; cloddy parting to weak, fine, granular and very fine subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A12—8 to 19 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) to dark gray (10YR 4/1) when dry; weak, fine, granular and very fine subangular blocky structure; friable; neutral; gradual, smooth boundary.

A13—19 to 29 inches, black (10YR 2/1) loam, dark gray (10YR 4/1) when dry; weak, very fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

A3—29 to 34 inches, very dark grayish-brown (10YR 3/2) loam; weak, very fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

A3—29 to 34 inches, very dark grayish-brown (10YR 3/2) loam; weak, very fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

B2—34 to 44 inches, dark grayish-brown (10YR 4/2) loam, faces of peds very dark grayish brown (10YR 3/2); weak, fine, prismatic structure parting to weak, fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

B3—44 to 54 inches, dark grayish-brown (10YR 4/2) loam; weak, medium, prismatic structure; friable; neutral; gradual, smooth boundary.

C—54 to 66 inches, dark grayish-brown (10YR 4/2) loam; massive but has some weak vertical cleavage; friable; neutral.

The A horizon ranges from 24 to 36 inches in thickness. The A1 horizon is black (10YR 2/1) or very dark brown (10YR 2/2) in color. The A3 horizon is very dark gray (10YR 3/1) or very dark grayish brown (10YR 3/2). The B horizon generally is dark grayish brown (10YR 4/2 or 2.5Y 4/2), but the chroma is as much as 3 if mottles are common or if exteriors of peds are gray or olive gray. This horizon has weak subangular blocky structure or, in places, weak prismatic structure. In places mottles of dark brown (10YR 3/3) to yellowish brown (10YR 5/6) or strong brown (7.5Y 5/6) are in the B horizon. The C horizon is dark grayish brown (10YR 4/2 or 2.5Y 4/2), dark brown (10YR 3/3), or brown (10YR 4/3) in color. In places sandy strata occur at a depth of more than 4 feet. Reaction of the A and B horizons is neutral or slightly acid.

Turlin, Spillville, and Terril soils all have similar texture and formed in similar parent material. Turlin soils have grayish-brown colors in the B horizon that are lacking in Spillville and Terril soils. Turlin soils are somewhat poorly drained, but Terril soils are moderately well drained.

Turlin loam, 2 to 5 percent slopes (96B).—This soil is mainly on low benches. Areas are slightly convex and border the nearby stream. They are generally adjacent to and associated with the Spillville or Hanlon soils.

Included with this soil in mapping are areas of soils that have stratified fine sandy soil material in the lower part of the subsoil and the underlying material. Also included are soils that have slopes of as little as 1 percent.

Most areas of this soil are cultivated. This soil is subject to erosion. It has no other serious hazards. It is well suited to row crops if erosion is controlled. Tilth generally is good. Capability unit IIe–3; woodland suitability group 2o1.

Wacousta Series

The Wacousta series consists of dark-colored, very poorly drained soils that formed in silty lacustrine sediment. These soils are in large depressions on uplands. These depressions were once shallow lakebeds. These areas are mostly in th Webster-Clarion-Nicollet and the Webster-Nicollet-Canisteo soil associations that occupy a large part of the county. Individual areas vary widely in size and range from about 5 acres to as large as 500 acres in size. The native vegetation was swamp grasses and sedges.

In a representative profile, the surface layer is black silt loam about 14 inches thick. The subsoil is gray and light-gray, friable silty clay loam about 14 inches thick. The underlying material is olive-gray and yellowish-brown loam.

The available water capacity is high, and permeability is moderate or moderately slow. The content of organic matter is high. The surface layer is neutral or mildly alkaline, and the subsoil and underlying material are moderately alkaline and are calcareous. The subsoil is very low in available phosphorus and available potassium.

Most areas of Wacousta soils are drained and used for crops. A few undrained areas are in native grass and are used for pasture. These soils are very wet because of a high water table and ponded surface water.

Representative profile of Wacousta silt loam, in a depression, in a cultivated field 30 feet east of road fence, 5 feet north of a tile intake that is 105 feet north of the southwest corner of the NW¼SW¼ sec. 29, T. 89 N., R. 27 W.

Ap1—0 to 4 inches, black (N 2/0) silt loam, very dark gray (10YR 3/1) when dry; cloddy parting to weak, fine, granular structure; friable; neutral; abrupt, smooth boundary.

Ap2—4 to 8 inches, black (N 2/0) silt loam, very dark gray (10YR 3/1) when dry; cloddy parting to weak, fine, granular structure; friable; mildly alkaline; abrupt, smooth boundary.

A3—8 to 14 inches, black (5Y 2/1) medium silty clay loam, dark gray (10YR 4/1) when dry; weak, medium, subangular blocky structure; friable; common red (2.5YR 4/8) organic coatings in old root channels; mildly alkaline; abrupt, smooth boundary.

Bg—14 to 28 inches, gray (5Y 5/1) and light-gray (5Y 6/1) light silty clay loam; weak, medium, prismatic structure; friable; few, large, olive-brown (2.5Y 4/4) oxides; calcareous; 1½-inch lens of sandy loam that has large amount of stones at bottom of horizon; moderately alkaline; strongly efferverscent; abrupt, smooth boundary.

C1g—28 to 39 inches, olive-gray (5Y 5/2) and yellowish-brown (10YR 5/8) loam; massive but has some vertical cleavage; friable; common, thin, yellowish-red (5YR 4/6) organic coatings in old root channels; common pebbles; moderately alkaline; strongly effervescent; gradual, smooth boundary.

C2g—39 to 48 inches, olive-gray (5Y 5/2) and yellowish-brown (10YR 5/8) loam; massive but has some vertical cleavage; friable; common pebbles; very thin coatings in old root channels; fine sand in cleavage voids; moderately alkaline; strongly effervescent; gradual, smooth boundary.

C3g—48 to 56 inches, gray (5Y 5/1) and yellowish-brown (10YR 5/8) loam; massive; friable; few dark-colored oxides; moderately alkaline; strongly effervescent.

The A horizon ranges from 10 to 18 inches in thickness. It is silt loam or silty clay loam in texture. The B horizon is not in all places. If present it ranges from 2 to 15 inches in thickness, from dark gray (5Y 4/1) to light olive gray in color, and is silty clay loam in texture. The C horizon is calcareous silty clay loam, silt loam, or loam. In places, strata of fine sandy loam are in this horizon. It generally is olive gray (5Y 5/2) or light olive gray (5Y 6/2) in color. High-chroma mottles, oxides, and coatings in old root channels are in the B and C horizons. Reaction generally is neutral to mildly alkaline above the calcareous material that is at a depth of 14 to 20 inches.

Wacousta soils have a thinner A horizon and solum than Okoboji soils. They are not as clayey to a depth of 40 inches or more as Lanyon soils.

Wacousta silt loam (0 to 1 percent slopes) (506).—This soil is in large depressions. It generally is surrounded by narrow areas of the highly calcareous Harps soils or by Canisteo soils.

Included with this soil in mapping are areas of soils that have a thinner surface layer than this soil. Plowing mixes the underlying material with the surface layer and causes these areas to be calcareous at the surface. Also included are a few areas that have about 8 inches of muck or mucky silt loam on the surface. Some areas that have strata of moderately coarse textured material in the underlying material are also included.

This soil is wet because of a high water table and ponding of surface water from surrounding soils. Crops are damaged in many places. Nearly all areas of this soil are cultivated. They are used mainly for row crops and are well suited to this use. The main concern of management is to provide adequate drainage. Tilth generally is fairly good. Some areas are large enough to be managed separately, but most are managed along with the surrounding soils. Capability unit IIIw–2; woodland suitability group 5w3.

Wadena Series

The Wadena series consists of dark-colored, well-drained soils. These soils formed in loamy alluvium that is underlain by sand and gravel at a depth of 24 to 40 inches. These nearly level to moderately sloping soils are on benches, mainly along the Des Moines River and Lizard Creek in the Storden-Hayden-Wadena soil association. A few scattered areas are in other associations. Individual areas generally range from 2 to 20 acres in size. The native vegetation was prairie grasses.

In a representative profile, the surface layer is black and very dark brown loam about 12 inches thick. The subsoil is about 22 inches thick. It is very dark grayish-brown and dark yellowish-brown loam in the upper part. The middle part is brown sandy clay loam and sandy loam. The lower part of the subsoil is dark yellowish-brown loamy sand and gravel. The underlying material is brown sand and gravel.

The available water capacity is low or moderate. Permeability is moderate in the upper part and rapid or very rapid in the underlying sand and gravel. The content of organic matter is moderate. The surface layer and subsoil generally are neutral. The subsoil is very low in available phosphorus and available potassium.

Most areas of Wadena soils are cultivated. Some areas are in pasture and are managed with steeper or sandier, less productive soils. The Wadena, moderately deep, soils generally lack adequate available water for good plant growth in dry years. Wadena, deep, soils have the same limitation, but to a lesser degree. The sloping soils are subject to erosion if vegetation is sparse.

Representative profile of Wadena loam, moderately deep, 2 to 5 percent slopes, in a pasture 400 feet south and 300 feet east of the northwest corner of the SE¼NW¼ sec. 24, T. 90 N., R. 29 W.

A1—0 to 8 inches, black (10YR 2/1) loam; weak, fine, granular and very fine subangular blocky structure; friable; neutral; gradual, smooth boundary.

A3—8 to 12 inches, very dark brown (10YR 2/2) loam; weak, fine, granular and weak, very fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

B1—12 to 16 inches, very dark grayish-brown (10YR 3/2) loam; weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

B21—16 to 21 inches, dark yellowish-brown (10YR 4/4) loam, faces of peds brown (7.5Y 4/4); weak, fine, subangular blocky structure; friable; few gravel-size pebbles; neutral; gradual, smooth boundary.

B22—21 to 26 inches, brown (7.5YR 4/4) sandy clay loam; weak, fine and medium, subangular blocky structure; friable; some clay bridging; common gravel-size pebbles; neutral; abrupt, smooth boundary.

B23—26 to 30 inches, brown (7.5YR 4/4) coarse sandy loam; weak, fine and medium, subangular blocky structure; friable; abundant clay bridging; mildly alkaline; abrupt, wavy boundary.

IIB3—30 to 34 inches, dark yellowish-brown (10YR 4/4) loamy sand and gravel; mostly structureless but some cementing; loose; mildly alkaline; abrupt, wavy boundary.

IIC—34 to 52 inches, brown (10YR 5/3) sand and gravel; loose; moderately alkaline; weakly effervescent.

The A horizon ranges from 10 to 16 inches in thickness in most places. The A1 horizon is black (10YR 2/1) or very dark brown (10YR 2/2) in color. In places a very dark brown

(10YR 2/2) or very dark grayish-brown (10YR 3/2) A3 horizon occurs. The B horizon is brown (10YR 4/3 or 7.5YR 4/4) to yellowish brown (10YR 5/6) in color. The texture of this horizon is loam that in many places grades to sandy clay loam or sandy loam in the lower part. In places the B3 horizon contains gravel, and in places the B1 horizon is dark brown (10YR 3/3) or very dark grayish brown (10YR 3/2) in color. The IIC horizon is at a depth of 24 to 40 inches. This horizon is loamy sand, sand, and gravel. It generally ranges from brown (10YR 5/3) to yellowish brown (10YR 5/4) or grayish-brown in places. Reaction of the solum is neutral or slightly acid. The IIC horizon is mildly alkaline or moderately alkaline and is calcareous.

Wadena soils differ from Estherville soils in having a loam rather than a sandy loam B horizon and in generally being deeper to calcareous sand and gravel. They are better drained and have a browner B horizon than Cylinder soils. These soils formed in similar parent material and are associated on the landscape.

Wadena loam, deep, 0 to 2 percent slopes (308A).—This soil is mainly on benches. It generally is associated with moderately deep Wadena or Cylinder soils. The profile of this soil is similar to the one described as representative for the series, but the underlying sand and gravel is at a depth of 32 to 40 inches.

Included with this soil in mapping are areas of soils that have sand and gravel at a depth of about 40 to 48 inches. Also included are a few small areas that have glacial till at a depth of about 40 to 48 inches.

Most areas of this soil are cultivated. The soil is used mainly for row crops, and it is well suited to this use. This soil has no serious limitations to its use. It is somewhat low in available water during prolonged dry periods. Tilth generally is good. Capability unit I–2; woodland suitability group 2s1.

Wadena loam, deep, 2 to 5 percent slopes (308B).—This soil is generally on benches. Slopes are short and convex. It is generally associated with other Wadena soils or Cylinder. In places Biscay or Estherville soils are nearby. The profile of this soil is similar to the one described as representative for the series, but the underlying sand and gravel is at a depth of about 32 to 40 inches.

Included with this soil in mapping are areas, mostly in section 6 of Cooper Township, that are stratified, very fine sandy loam and silt loam in the underlying material. These areas have a few pockets of gravel within this fine sandy loam and silt loam material. A few acres of this included soil have slopes of 5 to 9 percent. In places the sand and gravel is at a depth of about 40 to 48 inches.

Most areas of this soil are cultivated. This soil is subject to erosion. In very long, dry periods crops are damaged by lack of available water. This soil is well suited to row crops if erosion is controlled. Tilth generally is good. Capability unit IIe–1; woodland suitability group 2s1.

Wadena loam, moderately deep, 0 to 2 percent slopes (108A).—This soil is mainly on benches, but it is on uplands in a few places. It is generally associated with and at a slightly higher elevation than Cylinder, Biscay, and Talcot soils. In some places more sloping Wadena soils are downslope. This soil has the profile described as representative for the series. Sand and gravel generally is at a depth of 24 to 32 inches.

Included with this soil in mapping are a few areas of soils that have glacial till at a depth of 42 to 48 inches. Most of these included areas are in the valley of Lizard Creek. Also included are a few areas of soils that have sandy loam or loamy sand underlying material.

Crops are commonly stunted on this soil because of limited available water capacity. Even in years when rainfall is normal, moisture limits plant growth in places late in July and in August.

Most areas of this soil are cultivated. This soil is well suited to row crops, but plant population needs to be limited to anticipated moisture supply. The growth of crops is only moderate in many places. Tilth is good. Capability unit IIs–1; woodland suitability group 3s1.

Wadena loam, moderately deep, 2 to 5 percent slopes (108B).—This sloping soil is mainly on stream benches. Slopes are generally short. This soil generally is adjacent to other Wadena soils but is also associated with Cylinder, Biscay, and Talcot soils. In some places Estherville soils are nearby. The profile of this soil is similar to the one described as representative for the series, except that in many places the surface layer is slightly thinner. In most places sand and gravel are at a depth of 24 to 32 inches.

Included with this soil in mapping are a few areas of soils that have glacial till at a depth of 42 to 48 inches.

This soil is subject to erosion. Crops are generally stunted because of limited available water capacity. Even in years when rainfall is normal, moisture limits plant growth in places late in July and in August.

Most areas of this soil are cultivated. It is well suited to row crops if erosion is controlled, but plant population needs to be limited to anticipated moisture supply. Crop growth is only moderate in many places. Most areas are managed along with the surrounding soils. Tilth is good. Capability unit IIe–2; woodland suitability group 3s1.

Wadena loam, moderately deep, 5 to 9 percent slopes (108C).—This soil is on side slopes that border stream benches. Slopes are short and convex. In places this soil is on breaks or escarpments between bench levels. Less sloping Wadena soils or Cylinder soils generally are upslope. In places Spillville or Colo soils on bottom lands are downslope. In other areas, Cylinder, Biscay, or Talcot soils are downslope. The profile of this soil is similar to the one described as representative for the series, but the surface layer generally is a few inches thinner. Also, the depth to sand and gravel generally is slightly less.

Included with this soil in mapping are areas of soils that are similar to Estherville soils but that are shallower to sand and gravel. Also included are a very few small areas of soils that have glacial till at a depth of about 42 to 48 inches. Also included are a few areas of soils that have slopes of as much as 11 percent.

This soil is subject to erosion. Crops are subject to damage because of limited available water capacity and rapid runoff.

Some areas of this soil are cultivated, and some are in permanent pasture. A few areas are idle. This soil is moderately suited to row crops if erosion is controlled, but the growth of crops generally is only moderate. Tilth is good. Capability unit IIIe–1; woodland suitability group 3s1.

Wadena Series, Thin Surface Variant

Soils of the Wadena series, thin surface variant, are moderately dark colored and well drained. They formed

in loamy alluvium and are underlain by sand and gravel at a depth of 24 to 40 inches. These soils are gently sloping and are on high and medium benches in the Storden-Hayden-Wadena soil association. They are along the valley of the Des Moines River, mainly south of Fort Dodge. Individual areas generally are only 2 to 10 acres in size. The native vegetation was trees and grasses.

In a representative profile, the surface layer is very dark brown loam about 8 inches thick. The subsoil is brown, friable loam, light clay loam, and sandy clay loam about 20 inches thick. The underlying material is loose gravelly sand.

The available water capacity is low or moderate. Permeability is moderate in the upper part and is rapid or very rapid in the underlying sand and gravel. The content of organic matter is low. The surface layer and the upper part of the subsoil generally are slightly acid or neutral. The subsoil is low or medium in available phosphorus and very low in available potassium.

Some areas of these soils are cultivated and used for crops. Some areas have been cleared of trees but are in permanent pasture. Some are in native vegetation of grasses and trees. These soils are suited to cultivation if erosion is controlled. Moderately deep Wadena, thin surface variant, soils generally lack adequate available water for good plant growth in dry years. Deep Wadena, thin surface variant soils have the same limitation, but to a lesser degree.

Representative profile of Wadena loam, thin surface variant, moderately deep, 2 to 5 percent slopes, on the edge of a gravel pit, 150 feet south and 300 feet west of the northeast corner of the NW¼SE¼ sec. 22, T. 88 N., R. 28 W.

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

B1—8 to 10 inches, brown (10YR 4/3) loam; weak, very fine, subangular blocky structure; friable; silt coatings on peds; common small pebbles; neutral; clear, smooth boundary.

B21t—10 to 16 inches, brown (7.5YR 4/4) light clay loam; weak, very fine, subangular blocky structure; friable; thin clay films on peds; common small pebbles; neutral; gradual, smooth boundary.

B22t—16 to 24 inches, brown (7.5YR 4/4) sandy clay loam; weak, very fine, subangular blocky structure; friable; many small pebbles; thin clay films on peds; neutral; gradual, wavy boundary.

B3t—24 to 28 inches, brown (7.5YR 4/4) and dark reddish-brown (5YR 3/4) sandy clay loam; weak, very fine, subangular blocky structure; very friable; clay bridging between sand grains; neutral; abrupt, wavy boundary.

IIC—28 to 60 inches, brown (10YR 4/3) gravelly sand; structureless; loose; moderately alkaline; weakly effervescent.

The A1 or Ap horizon ranges from 6 to 10 inches in thickness and from very dark brown (10YR 2/2) to very dark grayish brown (10YR 3/2) in color. In places an A2 horizon occurs that ranges from 2 to 6 inches in thickness and from very dark gray (10YR 3/1) to dark grayish brown (10YR 4/2) in color. The B horizon ranges from friable to firm in consistence and is heavy loam, clay loam, or sandy clay loam in texture. It is brown (10YR 4/3 to 7.5YR 4/4) or dark yellowish brown (10YR 4/4) in color and has weak to moderate subangular blocky structure. Clay films and clay bridging between sand grains are evident in this horizon. The IIC horizon is at a depth of 24 to 40 inches. It is sand and gravel that varies considerably in the depth to carbonates. In some places this horizon is calcareous throughout. In other areas tongues of leached sand and gravel extend several feet into the IIC horizon. This horizon ranges from dark grayish brown (10YR 4/2) to strong brown (7.5YR 5/6) in color. Reaction of the solum ranges from neutral to medium acid.

Wadena, thin surface variant, soils differ from normal Wadena soils in having a thinner A horizon. They have a somewhat more strongly developed B horizon and are more variable in the depth of leaching the sand and gravel. These soils formed in similar parent material.

Wadena loam, thin surface variant, deep, 2 to 5 percent slopes (778B).—This soil is in narrow areas on benches along the valley of the Des Moines River. It generally is downslope from Hayden soils, and it generally is upslope from steep Storden and Hayden soils that are mapped as a complex or, in a few places, is upslope from Boone soils. The profile of this soil is similar to the one described as representative for the series, except that sand and gravel is at a depth of about 32 to 40 inches. Also, a grayish subsurface layer is in places.

Included with this soil in mapping are a few areas of similar soils that are nearly level and a few soils that are moderately to strongly sloping. Also included are a few areas of soils that are underlain by fine sand rather than by sand and gravel.

This soil is subject to erosion. In prolonged dry periods the underlying sand and gravel causes it to be more affected by low available water than are similar soils on uplands. Some areas are cultivated and used for row crops, and other areas are in wooded pasture. This soil is well suited to row crops if erosion is controlled. Tilth is good. Capability unit IIe–1; woodland suitability group 2s1.

Wadena loam, thin surface variant, moderately deep, 2 to 5 percent slopes (777B).—This soil is on benches along the valley of the Des Moines River. It generally is downslope from Hayden or Storden soils. It generally is upslope from areas of Gosport or Boone soils. This soil has the profile described as representative for the series. Some areas, however, have a thinner surface layer, and in places a grayish subsurface layer is present.

Included with this soil in mapping are a few areas of similar soils that are nearly level and a few that are moderately sloping.

This soil lacks adequate available water capacity and is subject to erosion. Some areas are cultivated and used for row crops, small grain, and hay. Other areas are in wooded pasture. This soil is well suited to row crops if erosion is controlled, but plant growth is limited in many places in dry periods. Plant population needs to be adjusted to anticipated moisture supply. Tilth is good. Capability unit IIe–2; woodland suitability group 3s1.

Webster Series

The Webster series consists of dark-colored, poorly drained soils that formed in loamy glacial till sediment and glacial till. These nearly level soils are in irregular-shaped swales, draws, and flats on uplands. They are in the Webster-Clarion-Nicollet and the Webster-Nicollet-Canisteo soil associations that occupy a large part of the county. Individual areas generally range from 10 to 200 acres in size. The native vegetation was sedges and prairie grasses tolerant of wetness.

In a representative profile, the surface layer is silty clay loam that contains enough sand to have a gritty feel. It is about 18 inches thick. The subsoil is mainly olive-gray clay loam that has olive, yellowish-brown, and

strong-brown mottles. It is about 18 inches thick. It is firm in the upper part and friable in the lower part. The underlying material is mottled light olive-gray and yellowish-brown loam. A few pebbles, stones, or boulders are throughout.

The available water capacity is high, and permeability is moderate to moderately slow. The content of organic matter is high. The surface layer and subsoil are neutral. The subsoil is very low in available phosphorus and available potassium.

Most areas of Webster soils are cultivated. They are wet unless artificially drained. In spring and in wet periods they have a high water table. Areas that are plowed in the fall are subject to soil blowing.

Representative profile of Webster silty clay loam, in a cultivated field 500 feet west of the east fence and 160 feet south of the north fence in the northeast corner of sec. 4, T. 87 N., R. 28 W.

Ap—0 to 7 inches, black (N 2/0) gritty silty clay loam; cloddy parting to weak, fine, subangular blocky structure; friable; few pebbles; neutral; clear, smooth boundary.

A12—7 to 13 inches, black (N 2/0) gritty silty clay loam; moderate, very fine, subangular blocky and moderate, fine, granular structure; friable; few pebbles; neutral; gradual, smooth boundary.

A3—13 to 18 inches, black (10YR 2/1) gritty silty clay loam; few olive-gray (5Y 5/2) mottles; weak and moderate, very fine, subangular blocky structures; friable; few pebbles; neutral; gradual, smooth boundary.

B1—18 to 24 inches, very dark gray (N 3/0) gritty silty clay loam; common, fine, faint, olive (5Y 4/3) mottles or mixings from below; weak, medium, prismatic structure parting to moderate, very fine, subangular blocky structure; firm; few pebbles; neutral; smooth, gradual boundary.

B2g—24 to 30 inches, olive-gray (5Y 4/2) clay loam; few, very fine, yellowish-brown (10YR 5/6) mottles; weak, medium, prismatic structure parting to weak, fine, subangular blocky structure; firm; few very dark gray (N 3/0) ped faces; few pebbles and stones; many, soft, dark-colored oxides; neutral; gradual, smooth boundary.

B3g—30 to 36 inches, olive-gray (5Y 5/2) light clay loam; many, medium, distinct, strong-brown (7.5YR 5/6) mottles and coatings in root channels; weak, medium, prismatic structure; friable; few pebbles and stones; neutral; clear, smooth boundary.

C1g—36 to 50 inches, olive-gray (5Y 5/2) to light olive-gray (5Y 6/2) loam; common, fine, distinct, yellowish-brown (10YR 5/6) mottles; massive but some weak vertical cleavage; friable; many white concretions of lime; few pebbles and stones; moderately alkaline; weakly effervescent; gradual, smooth boundary.

C2g—50 to 65 inches, light olive-gray (5Y 6/2) loam; many, medium, prominent, yellowish-brown (10YR 5/6) mottles; massive; friable; few black iron-manganese concretions; few pebbles and stones; moderately alkaline; strongly effervescent.

The A horizon ranges from 12 to 24 inches in thickness, from friable to firm in consistence, and from light to medium gritty silty clay loam or clay loam in texture. In places the lower part of this horizon is very dark gray (10YR 3/1) in color. The B horizon ranges from 16 to 24 inches in thickness, and it is gritty silty clay loam or clay loam in texture. The B1 horizon ranges from very dark gray (N 3/0 or 10YR 3/1) to very dark grayish brown (2.5Y 3/2) in color. The rest of the B horizon ranges from dark gray (5Y 4/1) to gray (5Y 5/1) or olive gray (5Y 4/2 or 5Y 5/2) in color. Olive (5Y 5/3) to yellowish-brown (10YR 5/6) and strong-brown (7.5YR 5/6) mottles are in the B horizon. The C horizon is typically loam in texture, but it ranges to light clay loam in places. It is pale olive (5Y 6/3), light olive gray (5Y 6/2), olive gray (5Y 5/2), gray (5Y 5/1), or light gray (5Y 6/1) in color. Mottles in this horizon are similar to those in the B horizon, but they are more common. Thin strata of silty or sandy material are in the underlying material in places. Reaction of the A horizon and the upper part of the B horizon is neutral. The B3 horizon is mildly alkaline and is calcareous. The C horizon is mildly or moderately alkaline and is calcareous. The depth to carbonates generally ranges from 24 to 40 inches.

Webster soils differ from Biscay soils in not being underlain by sand and gravel. They differ from Canisteo soils in not being calcareous throughout. These soils are similar in drainage. Webster and Canisteo soils formed in similar parent material.

Webster silty clay loam (0 to 2 percent slopes) (107).—This soil is in swales, draws, and flats on uplands. It generally is associated with Nicollet or Clarion soils at a higher elevation and with Canisteo and Harps soils at a lower elevation. Areas generally are large in size. This soil occupies the largest acreage of any soil in the county. It has the profile described as representative for the series.

Nearly all of this soil is cultivated. It is used mainly for row crops. It is well suited to row crops if artificial drainage is provided. If tilled when wet, this soil tends to dry out cloddy and hard and to have poor tilth, but tilth generally is fair or good. Many areas are subject to soil blowing in spring, especially if areas are large and relatively level. Some areas are large enough that they occupy all or most of a field and can be managed separately. Others are managed along with associated soils. Capability unit IIw–1; woodland suitability group 5w3.

Webster silty clay loam, benches, 0 to 3 percent slopes (107B).—This soil is on benches between uplands or between higher benches and the flood plain of the nearby Des Moines River. The profile of this soil is similar to the one representative for the series, except that it is underlain by firm, less permeable clay loam glacial till at a depth of 4 feet or more. Individual areas generally are long and narrow in shape and range from 5 to 30 acres in size. Small to large boulders are on the surface. Slopes are straight or slightly convex and incline toward the nearby stream.

Included with this soil in mapping are areas of soils that have less permeable glacial till at a depth of 2 to 4 feet. Also included are some areas that are calcareous at the surface and throughout. These areas are indicated on the soil map by a symbol for calcareous spots. Also included are some areas a few miles upstream and downstream from the Badger Bridge on the Des Moines River that are underlain by shaly limestone or limestone at a depth of 30 to 50 inches. These areas are indicated on the soil map by a symbol for bedrock in the subsoil. In a few included spots limestone outcrops on the surface.

This soil is wet. The rocks on the surface limit cultivation. Some areas of this soil have been cleared of rocks and are cultivated. Many others are in permanent pasture. Many of these areas have enough slope that surface water runs off, but wetness is a limitation, even though the less permeable layer is at a depth of 4 to 5 feet. Tile or interceptor tile installed at the contact of the underlying, less permeable layer generally are used to achieve drainage. If drainage is adequate, this soil is moderately well suited to row crops. The nature of the associated soils and the difficulties in providing drainage generally determine the use of this soil. Capabiilty unit IIIw–3; woodland suitability group 5w3.

Use and Management of the Soils

This section discusses use and management of the soils for crops and pasture. It explains the system of capability classification used by the Soil Conservation Service, discusses the use and management of groups of soils, or capability units, and provides a table showing predicted yields of the major crops for the soils in the county. It also gives facts about uses of the soils for woodland, for wildlife habitat and recreation, and for engineering construction and land use planning.

Use of the Soils for Crops and Pasture

In Webster County about 326,000 acres, or about 71 percent of the county, is used for crops, mainly corn, soybeans, oats, and legume and grass-legume hay. A large acreage is used intensively for row crops, but acreage of other crops is minor. Minor crops include such grasses as sudangrass, which is used for pasture, and sorghum, which is mainly harvested for silage. Rye, flax, barley, and wheat are also grown on small acreages, but some of these crops are not grown every year.

Many soils in the county are wet, and artificial drainage is needed if these soils are cultivated. Among these are soils of the Webster, Canisteo, Talcot, Biscay, Okoboji, Wacousta, and Lanyon series and the shallow land type, Muck. Installing tile drains is the main drainage practice. Shallow surface ditches are used to drain some soils in depressions, and large drainage ditches are commonly used to provide tile outlets.

Erosion is a hazard on the sloping soils in the county. These are mainly the Clarion, Storden, Lester, and Hayden soils. On these soils, contour tillage and terracing are conservation practices used to control erosion. The practice commonly called minimum tillage, or mulch tillage, has received considerable interest in recent years as a means of controlling erosion on sloping soils and cutting down the number of tillage operations for growing row crops on all soils. At this time, however, this practice is used on only a minor acreage in the county.

Gully control structures and grassed waterways are used to control gullying in water courses. Farm ponds provide water for livestock and recreation. Levees have been built in only a few places to protect soils from flooding.

About 50,000 acres, or about 11 percent of the county, is in pasture. Most of this is bluegrass pasture, but a large acreage of timbered pasture is included. The timbered pastures are mainly on steep soils along the sides of the valley of the Des Moines River and in areas that extend a short distance up some of the major tributaries of this river. Grass-legume mixtures, such as alfalfa-bromegrass, are also used for pasture. A few permanent pastures have been renovated, and such plants as birdsfoot trefoil have been introduced in these areas.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The soils are grouped according to their limitations when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for range, for trees, or for engineering uses.

In the capability system, the kinds of soil are grouped at three levels: the capability class, the subclass, and the unit. These are discussed in the following paragraphs.

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

Class I soils have few limitations that restrict their use.

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

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

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

Class V soils are subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife habitat.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture, range, woodland, or wildlife habitat.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture, range, woodland, or wildlife habitat.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife habitat, or water supply, or to esthetic purposes. (None in Webster County.)

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *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, but not in Webster County, shows that the chief limitation is a climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion.

though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife habitat, or recreation.

CAPABILITY UNITS are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe–1 or IIIe–3. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph; and the Arabic numeral specifically identifies the capability unit within each subclass.

Management of the soils by capability units

In the following pages, the capability units, or groups of soils that have similar management requirements, are described; some soil limitations are given; and suitable management is briefly discussed. The names of soil series represented are mentioned in the description of each capability unit, but this does not mean that all soils of a given series appear in the unit. To find the names of all the soils in any given capability unit, refer to the "Guide to Mapping Units" at the back of this survey. The practical grouping of soils shown in this guide are subject to change as new methods are discovered or new information becomes available.

CAPABILITY UNIT I–1

This capability unit consists of somewhat poorly drained, nearly level and gently sloping soils that are loamy. These soils are of the Cylinder, Guckeen, Jacwin, Le Sueur, Luther, and Nicollet series. They are on uplands and benches.

These soils have a thin to moderately thick surface layer of loam or clay loam. Their subsoil is mainly friable to firm clay loam and loam, but the Guckeen subsoil contains some layers of silty clay or clay. The Cylinder soil has sand and gravel in its substratum at a depth of about 32 to 40 inches, and the Jacwin soil is underlain by shale at a depth of about 30 to 40 inches.

Most soils of this unit have moderate or moderately slow permeability, but some horizons in the Guckeen soil are slowly permeable. All of the soils, except those of the Cylinder series, have high available water capacity, but the Cylinder soil has moderate available water capacity. In all of the soils, the subsoil is very low in available potassium. In most of them, the subsoil is very low in available phosphorus, but the Luther and Le Sueur soils are medium in available phosphorus. For soils of this unit, the content of organic matter ranges from low to high. Reaction ranges from neutral to medium acid in the surface layer and in the upper part of the subsoil.

Soils of this unit have no serious limitations to use for crops. Some of the soils contain areas that tend to be somewhat wet during wet periods, but drainage is generally not needed. Also, the Cylinder soil tends to lack adequate available water for good plant growth in some years. Soils of this unit generally are in good tilth.

Most of these soils are cultivated, but some areas, especially of Le Sueur and Luther soils, are in timbered pasture or woods. The soils are well suited to corn and soybeans, and these are the main crops grown. The soils are also suited to oats and to such plants grown for hay and pasture as alfalfa, clover, and mixtures of alfalfa or clover with grasses. In a few places, gravel pits are partly or wholly within areas of the Cylinder soil.

In most places soils of this capability unit are only slightly susceptible to erosion. Contour tillage is desirable on long slopes, however, if row crops are grown intensively. Generally, available water is adequate. Seeding a high population of plants, using a high rate of fertilization, and chemically controlling weeds and insects are practices that are likely to be profitable.

Additions of fertilizer, especially nitrogen and phosphorus, are needed when the cropping system consists mostly of row crops. Lime is needed for some of the soils, especially for the Luther and Le Sueur soils.

CAPABILITY UNIT I–2

This capability unit consists of well-drained, nearly level soils that are loamy. These soils are of the Clarion and Wadena series. They are on uplands and benches.

These soils have a surface layer and subsoil of friable loam. The Wadena soil has sand and gravel at a depth of about 32 to 40 inches.

The soils in this unit have moderate permeability. The Clarion soil has high available water capacity, but the sand and gravel that underlies the Wadena soil reduces the root zone and available water capacity. The available water capacity is about moderate for the Wadena soil. In both of these soils, the subsoil is generally very low in available phosphorus and available potassium. The content of organic matter in these soils is moderate. Reaction generally ranges from slightly acid to neutral in the surface layer.

The soils of this unit have no serious limitations to use for crops. The hazard of erosion is slight in most places, but erosion can occur on very long slopes of the Clarion soil. The Wadena soil of this unit lacks adequate available water for good plant growth in some years, because the underlying sand and gravel does not hold much available water. Soils of this unit generally are in good tilth and are easy to work.

These soils are mostly cultivated. The soils are well suited to corn and soybeans, and these are the main crops. They are suited to oats and to such plants grown for hay and pasture as alfalfa, clover, and mixtures of alfalfa or clover with grass. Grain sorghum is grown occasionally, especially on the Wadena soil. In a few places, gravel pits are within areas of the Wadena soil.

In most places these soils are only slightly susceptible to erosion. Contour tillage, however, is desirable on long slopes of the Clarion soil if row crops are grown intensively. Generally, available moisture is adequate, but it is limited in some years in the Wadena soil. Seeding a moderately high or high population of plants, using a high rate of fertilization, and chemically controlling weeds and insects are practices that are likely to be profitable.

Additions of fertilizer, especially nitrogen and phosphorus, are needed when the cropping system consists mostly of row crops. Lime is needed for some of the soils, generally in small amounts.

CAPABILITY UNIT IIe-1

This capability unit consists of well-drained to somewhat poorly drained, gently sloping soils. These soils are of the Clarion, Hayden, Kamrar, Lester, Nicollet, Terril, and Wadena series and Wadena series, thin surface variant. These soils are on uplands and benches.

These soils have a thin to moderately thick surface layer of loam or clay loam. Uncultivated areas of Hayden, Lester, and Wadena, thin surface variant, soils have a thin grayish subsurface layer of similar texture between the surface layer and subsoil. Their subsoil is friable or firm loam to heavy clay loam. The Wadena, thin surface variant, and Wadena soils have sand and gravel at a depth of about 32 to 40 inches, and the Terril soil has loamy sand or sand at about the same depth.

Most of the soils in this unit have moderate to moderately slow permeability, but the underlying layers of the Wadena, thin surface variant, Wadena, and Terril soils have rapid or very rapid permeability. Most of the soils have high available water capacity, but the Terril, Wadena, thin surface variant, and Wadena soils have moderate available water capacity. In all of the soils, the subsoil is mainly very low in available potassium. In most of them, the subsoil is very low in available phosphorus, but the Hayden and Lester soils are about medium in available phosphorus, and the thin surface variant of the Wadena soil is low or medium. The content of organic matter in all of these soils is low to moderate. Reaction ranges from neutral to medium acid in the surface layer and in the upper part of the subsoil.

The soils of this unit are subject to erosion. The Terril soil is on foot slopes and is subject to rilling and gullying where water from upslope runs off and concentrates. The Terril, Wadena, and Wadena, thin surface variant, soils lack adequate available water for good plant growth in some years. The Nicollet soil is somewhat wet in very wet periods. These soils generally dry out fairly soon after rains, have good tilth, and are easy to till.

These soils are mostly cultivated, but some areas are in permanent pasture. Many areas of Lester, Hayden, and Wadena, thin surface variant, soils are wooded but are used for pasture. A few areas are managed as woodland. The soils in this unit are well suited to row crops if erosion is controlled. In cultivated areas corn and soybeans are the main crops, but oats are grown and alfalfa, clover, or alfalfa-grass mixtures are used for hay or pasture.

Terracing and contour tillage are suitable practices for controlling erosion (fig. 16). Contour tillage generally is used, without terracing, on Wadena, Terril, and Wadena, thin surface variant, soils because they are underlain by sand and gravel, and in terrace channels their available water capacity and productivity are reduced. In places regular or diversion terraces can be used in soils upslope from the Terril soils to divert runoff and reduce rilling and gullying.

Corn and other crops generally respond well to applications of fertilizer. Large amounts of nitrogen and phosphorus and smaller amounts of potassium are generally needed. Lime is commonly needed, especially for Lester, Hayden, and Wadena, thin surface variant, soils.

CAPABILITY UNIT IIe-2

This capability unit consists of well-drained, gently sloping soils that have sand and gravel or limestone in their substratum. These soils are of the Rockton and Wadena series and Wadena series, thin surface variant. They are on benches.

Figure 16.—**Grassed back-slope terraces established in a field of Clarion soils to protect them from erosion.**

These soils have a surface layer of friable loam and a subsoil of friable loam or clay loam. They have sand and gravel in their substratum at a depth of about 24 to 32 inches, except for the Rockton soil, which is underlain by limestone at about the same depth.

These soils have moderate permeability in the surface layer and subsoil. They have low to moderate available water capacity. In all of the soils, the subsoil is very low in available potassium. In most of them, the subsoil is generally very low in available phosphorus, but in the thin surface variant of the Wadena series it is low or medium. The content of organic matter in all the soils is generally moderate. Reaction ranges from neutral to medium acid in the surface layer and in the upper part of the subsoil.

The soils of this unit have limited available water capacity and are subject to erosion, but they absorb water readily, dry out soon after rains, and generally are in good tilth and easy to till.

Some of the soils are cultivated, and others are in pasture. Many areas of Wadena, thin surface variant, soil are wooded but are used for pasture. Corn, soybeans, oats, and plants used for hay and pasture, such as alfalfa and clover and mixtures of alfalfa or clover with grasses, are generally the main crops. Grain sorghum is grown in some places. The soils are well suited to other row crops if erosion is controlled. In places, gravel pits are within areas of Wadena or Wadena, thin surface variant, soil. Crop growth, however, is commonly only moderate because of lack of adequate available water and the limited root zone. Plant growth needs to be adjusted to the anticipated water supply.

Contour tillage is generally used to control erosion. Terraces are not constructed on these soils because the cuts

made during construction further reduce the available water capacity.

Crop response to applications of fertilizer is generally fair to good, depending upon the water available. Large amounts of nitrogen and phosphorus and smaller amounts of potassium are generally needed. Lime is needed in some areas.

CAPABILITY UNIT IIe-3

This capability unit consists of moderately well drained and somewhat poorly drained, gently sloping soils that are loamy. These soils are of the Spillville and Turlin series. They are on benches and bottom lands.

These soils have a thick surface layer of friable loam. Their subsoil is loam.

These soils have moderate permeability and high available water capacity. In all of the soils, the subsoil is generally very low in available potassium and available phosphorus. The content of organic matter in these soils is high. Reaction is neutral or nearly neutral in the surface layer and subsoil.

The soils of this unit are subject to slight sheet erosion and to gullying where runoff from adjacent slopes concentrates. A few areas flood for short periods, but damage to crops is generally slight and not enough to discourage cultivation. Sediment from upslope collects in some areas and is a hazard to young plants. In places there is slight wetness because of seepiness or local runoff. These soils generally are in very good tilth.

Areas of these soils are generally long and narrow in shape and are small in size. They are generally managed along with adjacent soils on the bottom lands or benches. They are commonly used for corn and soybeans. In some places the soils are in pasture along with steeper or less productive soils. Oats and rotation hay and pasture are also commonly grown.

These soils are well suited to row crops if they are protected from sheet erosion, gullying, and sedimentation. Where adjacent uplands are used for crops, contour tillage and terracing help to protect these soils from runoff and sedimentation. In places diversion terraces at the base of the adjacent slopes on uplands can be used to protect these soils. Where runoff concentrates, grassed waterways need to be constructed across areas of these soils.

Crops generally respond well to applications of fertilizers. Nitrogen and phosphorus are most likely to be needed, but potassium is also needed in places. Lime is generally not needed, or it is needed only in small amounts.

CAPABILITY UNIT IIw-1

This capability unit consists of poorly drained, nearly level soils. These soils are of the Biscay, Canisteo, Cordova, Harps, Marna, Minnetonka, Talcot, and Webster series. They are on uplands and benches.

These soils have a thick surface layer of light clay loam to heavy silty clay loam that is friable or firm. Their subsoils are mainly friable or firm clay loam. Marna and Minnetonka soils, however, are firm silty clay in some layers, and Harps soils are loam in the subsoil. Biscay and the deep Talcot soils are underlain by sand and gravel at a depth of about 32 to 40 inches. The moderately deep Talcot soil has sand and gravel at a depth of about 24 to 32 inches.

These soils mainly have moderate or moderately slow permeability, but the Marna and Minnetonka soils have slow permeability, and the Biscay and Talcot soils have rapid or very rapid permeability in the underlying gravel. Most of the soils have high available water capacity, but the Biscay and Talcot soils have moderate to low available water capacity. In all of the soils, the subsoil generally is very low in available potassium and low or very low in available phosphorus. The content of organic matter in these soils is high. The range in reaction is wide. Reaction for some of the soils is neutral to slightly acid. Minnetonka soil, however, ranges up to strongly acid in the surface layer and in the upper part of the subsoil. In addition, the Canisteo and Talcot soils are calcareous throughout, and the Harps soil is very calcareous throughout.

The soils of this unit are wet unless they are artificially drained, and they generally have a seasonal high water table at a depth of about 4 feet or less. Runoff is slow, and a few soils in slightly depressed areas tend to pond during periods of heavy rainfall. These soils tend to dry out slowly after rains and warm up slowly in spring. They tend to dry out cloddy and hard if they are worked when wet.

The soils are mostly cultivated. Corn and soybeans are the main crops grown, but oats and forage crops are grown in places. These soils are well suited to row crops if they are drained. Seeding a high population of plants, using a high rate of fertilization, and chemically controlling weeds and insects are among the practices that are likely to provide good crop growth on the soils in this unit.

In most areas of these soils tile drainage systems are needed (fig. 17) to enhance the timeliness of field operations, prevent crop damage because of excess wetness, and improve development of roots and aeration of the soils. Satisfactory crop growth is difficult to obtain without the use of artificial drainage. Tile drains work well in most of these soils, but slow permeability limits their use in Marna and Minnetonka soils. Tile ditches are subject to cave-in while tile is being installed in Biscay and Talcot soils, which are underlain by sand and gravel. Drainage ditches are also used to help drain these and other soils in many parts of the county. Soils of this unit are commonly plowed in fall so that freezing and thawing in winter can help to improve soil tilth and allow more timely operations in spring.

Crops respond well to applications of fertilizer if drainage is adequate. Potassium is especially needed on Canisteo, Talcot, and Harps soils. Harps soils need the addition of minor nutrients, such as iron, to obtain proper growth of some crops. Only the Minnetonka and Cordova soils in this unit generally need additional lime.

CAPABILITY UNIT IIw-2

This capability unit consists of poorly drained, nearly level and gently sloping soils. These soils are of the Calco, Colo, and Spillville series. They are on bottom lands and low benches and in drainageways on uplands.

These soils have a thick surface layer of loam or silty clay loam. They have similar textures in the underlying layer and are generally friable throughout.

These soils have moderate to moderately slow permeability and high available water capacity. In these soils,

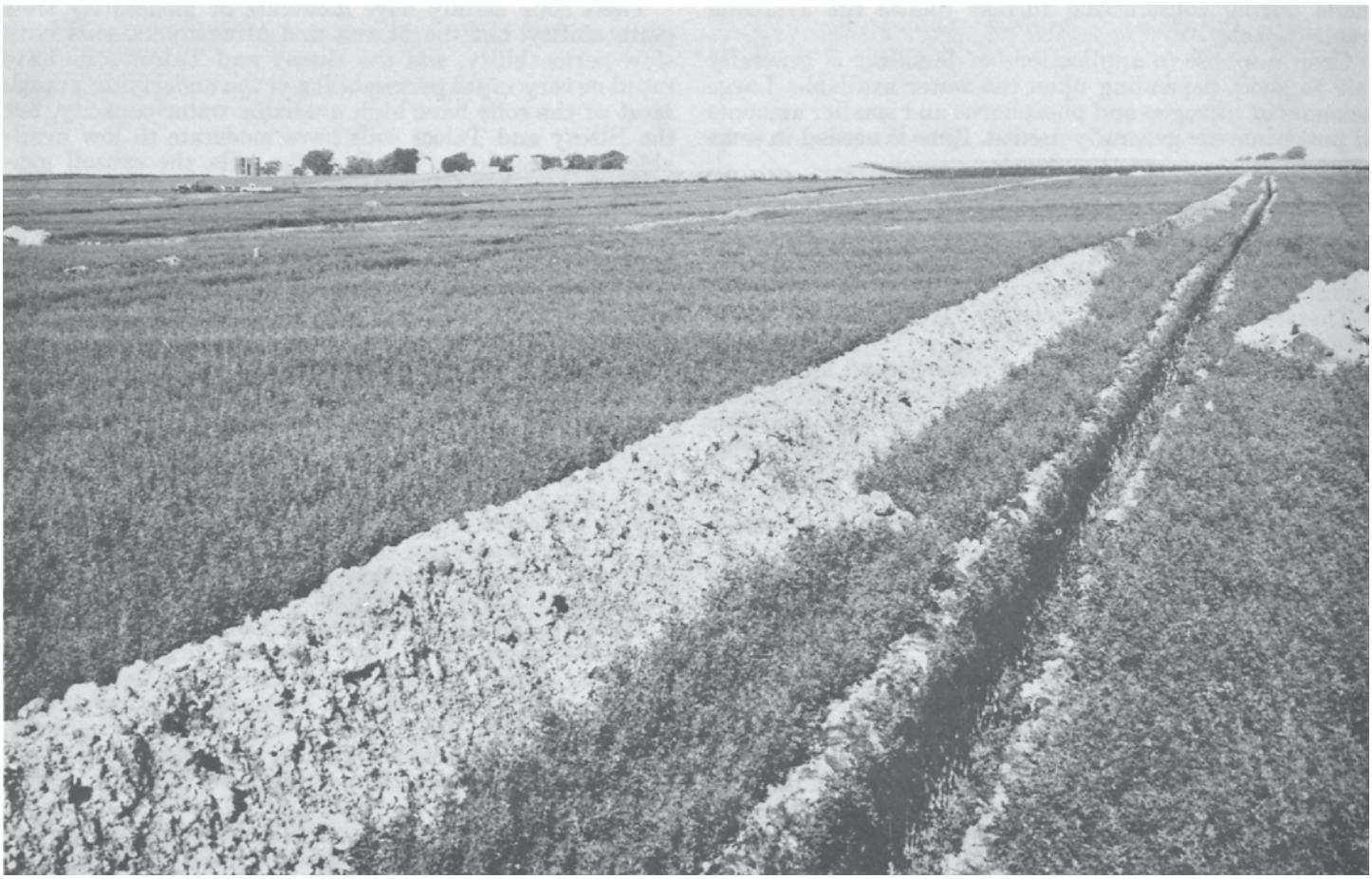

Figure 17.—Tile drainage system installed to drain soils of capability unit IIw–1.

the subsoil is very low in available potassium and very low in available phosphorus. The content of organic matter is high. Reaction of Colo soils is generally neutral, but Calco soils are mildly alkaline to moderately alkaline. Calco soils are calcareous.

The soils of this unit are wet because of a high water table or flooding, or both. Commonly, flooding is of short duration, or it occurs early in spring. In most places this hazard is not great enough to hinder growing crops. In places water ponds and stands in old channels, and in places streambank cutting occurs. The soils in this unit generally are in good tilth, but the Colo and Calco soils tend to dry out cloddy and hard if they are tilled when wet. These soils generally dry out fairly slowly, and tillage is generally delayed in spring and during rainy seasons.

These soils are mostly cultivated, but some of the most frequently flooded or inaccessible areas are in pasture. Areas of Colo and Spillville soils that are mapped in a complex generally occur with steeper soils, and many areas are in pasture. In some places Colo soils are in areas that are large enough to be managed separately, but most soils in this unit are managed along with other soils. Cultivated areas are generally used for row crops, and they are well suited to this use if drainage is adequate and if the hazard of flooding is not too severe. Corn and soybeans are the main crops, but occasionally oats or forage crops, such as alfalfa, red clover, or mixtures of alfalfa or red clover with grasses are grown.

Tile drains are commonly used in areas of Calco and Colo soils if adequate outlets are available, but some areas are farmed without artificial drainage. Generally crops grow better and soils are easier to manage if the soils are drained. In some places dikes or improved channels can be used to protect the soils from flooding. Installing surface drains and leveling and filling old channels reduces wetness and ponding in some depressed areas. In some places diversion terraces can be used upslope from these soils to prevent runoff from uplands from spreading across areas of these soils. Grassed waterways are used in some areas of the Colo and Spillville soils that are mapped as a complex. Soils of this unit are commonly plowed in fall so that freezing and thawing in winter can help to improve tilth and reduce the need for tillage early in spring.

Crops respond well to applications of fertilizer if drainage is adequate and if damage from flooding is minimal. Nitrogen, phosphorus, and potassium are generally needed. Lime is not needed for soils in this unit.

CAPABILITY UNIT IIw–3

This unit consists of moderately well drained to somewhat poorly drained, nearly level soils that are loamy and silty. These soils are of the Dorchester and Spillville series. They are mainly on bottom lands, but some areas of Spillville soil are on low benches.

These soils have a surface layer of friable silt loam or loam and are similar in texture to a depth of 40 inches or more.

These soils have moderate permeability and high available water capacity. In these soils, the subsoil is low in available potassium and available phosphorus. The content of organic matter in the Dorchester soils is moderately low to moderate. The Spillville soil is dark-colored to a depth of 40 inches or more and is high in content of organic matter. Reaction is neutral in the Spillville soil. It is mildly alkaline to moderately alkaline in the Dorchester soils, and they are calcareous.

The soils of this unit are subject to flooding when snow melts and runs off in spring or when rainfall is excessive. Flooding generally occurs early in spring before crops are planted, or it is of short duration. In some places, however, it causes crops to be damaged or drowned out. These soils have enough slope that water does not generally pond, but it does collect in old oxbows or bayous in places. These soils are easy to till and are generally in good tilth.

These soils are mostly cultivated, but some areas are in pasture. There are scattered trees and brush in places. These soils are well suited to corn and soybeans, and these are the main crops.

Seeding a high population of plants, using a high rate of fertilization, and chemically controlling weeds are practices that are likely to obtain good crop growth on these soils. Generally, available moisture is adequate. In places old bayous can be filled to reduce ponding.

Additions of fertilizer, especially nitrogen and phosphorus, are needed where the cropping system consists mostly of row crops. Lime is seldom needed on the Spillville soil and is never needed on Dorchester soils.

CAPABILITY UNIT IIs–1

This capability unit consists of well-drained to somewhat poorly drained, nearly level soils that are loamy and sandy. Some of these soils are underlain by sand and gravel. These soils are of the Cylinder, Hanlon, and Wadena series. They are on benches and bottom lands.

The Cylinder and Wadena soils have a surface layer of friable loam and a subsoil of heavy loam. They are underlain by sand and gravel at a depth of about 24 to 32 inches. The Hanlon soil has a thick surface layer of sandy loam and is similar in texture to a depth of 40 inches or more.

These soils have low or moderate available water capacity. Cylinder and Wadena soils have moderate permeability in the upper part and rapid or very rapid permeability in the underlying sand and gravel. Hanlon soils have moderately rapid or rapid permeability. In all of the soils, the subsoil is generally very low in available potassium and in available phosphorus. The content of organic matter in these soils is about moderate. Reaction generally ranges from slightly acid to neutral in the surface layer.

In many places crops are damaged by lack of available water. The Cylinder soil is somewhat wet in places during wet periods, but drainage is seldom needed. Areas of Hanlon soil are subject to flooding, and, if barren of vegetation, they are subject to soil blowing. Young plants are subject to damage by blowing sand. Some Hanlon soils have slopes of up to about 3 percent and are subject to slight erosion. Generally these soils have good tilth.

Most of the soils of this unit are used to grow field crops, but some areas, especially of the Hanlon soil, are in pasture. Corn, soybeans, oats, alfalfa, red clover, or mixtures of alfalfa or clover with grasses are the main crops. Grain sorghum is grown in places. The soils in this unit are well suited to row crops, but because they have limited available water capacity they are not so well suited to high stand levels of corn or to heavy fertilization as some of the other nearly level soils in the county. Gravel pits are in some areas of the Cylinder and Wadena soils. These are a source of sand and gravel for roads and construction.

The response of crops to additions of fertilizer is limited in some years by the lack of available moisture. Nitrogen and phosphorus are likely needed, and some potassium is generally needed. Lime is generally not needed, or it is needed only in small amounts.

CAPABILITY UNIT IIIe–1

This capability unit consists of well-drained, moderately sloping soils that are loamy. These soils are of the Clarion, Hayden, Lester, Storden, Wadena, and Terril series and Terril series, thin surface variant. They are mainly on uplands, but some are on foot slopes and benches.

These soils have a surface layer of friable loam. Uncultivated areas of Lester and Hayden soils have a thin, grayish subsurface layer of similar texture. The subsoil of soils in this unit is friable or firm loam and clay loam. The Wadena soil has sand and gravel at a depth of about 24 to 32 inches.

Most of these soils have high available water capacity, but the Wadena soil has low or moderate available water capacity. These soils have moderate permeability, but the sand and gravel that underlies the Wadena soil has rapid or very rapid permeability. In most of the soils the subsoil is very low in available phosphorus and in available potassium, but the Hayden and Lester soils are about medium in available phosphorus. The content of organic matter in the Hayden and Lester soils and in the moderately eroded soils in the unit ranges from low to moderately low. The content of organic matter in the other soils is about moderate, except for the Terril soil, in which it is high. Reaction in the Storden soil is moderately alkaline, and it is calcareous throughout. All the other soils are neutral to medium acid in the surface or subsurface layer and in the upper part of the subsoil.

Soils of this unit are subject to erosion. In a few places gullies have formed. The Wadena soil, on benches, is underlain by sand and gravel and has a limited available water capacity. The Terril soils are subject to sedimentation, rilling, and gullying where water from upslope runs off and concentrates. The moderately eroded soils are generally in fair tilth, and the other soils are in good tilth.

Most of these soils are cultivated, but some areas, especially of the Hayden, Storden, Lester, and slightly eroded Clarion soils, are in pasture. The Lester and Hayden soils are commonly wooded, but they are generally used as pasture. Corn, soybeans, oats, alfalfa, red clover, and mixtures of alfalfa and red clover with grasses are the main crops. These soils are suited to row crops if erosion is controlled. The frequency with which row crops can be safely grown without excessive soil loss depends on the conservation practices used. Terracing, contour tillage, and shaping and seeding existing gullies for waterways are suitable practices for controlling erosion. Terraces are not generally constructed on the Wadena soil because cuts made during terrace construction reduce the available water capacity. In places diversion terraces can be used to protect the Terril soils. Additions of organic matter, such as green manure, crop residue, or animal manure, help to protect erosion and to maintain or improve the organic matter content and tilth of the soil. This practice is especially suitable for moderately eroded soils in the unit.

Corn and other crops generally respond well to applications of fertilizer, but on the Wadena soil the response is commonly only moderate because of limited available water. Nitrogen and phosphorus are especially likely to be needed for row crops. Some potassium is generally needed, especially on Storden soils. Storden soils do not need lime, but many areas of the other soils need lime.

CAPABILITY UNIT IIIe-2

This capability unit consists of well-drained, strongly sloping soils that are loamy. These soils are of the Clarion, Lester, Storden, and Terril series and Terril series, thin surface variant. They are mainly on side slopes on uplands, but some are on foot slopes between the uplands and bottom lands or benches.

These soils have a surface layer of friable loam. In most places the Lester soil has a thin, grayish subsurface layer of similar texture that is between the surface layer and subsoil. The subsoil is mostly friable loam, but the Lester soil has firm clay in some layers.

These soils have moderate permeability and high available water capacity. Rain runs off rapidly, however, if the surface has no plant cover. This is especially true of the moderately eroded Storden and Clarion soils. So in dry seasons some of the soils are not at water capacity in places, and crops grow poorly from lack of moisture. In most of these soils the subsoil is very low in available phosphorus and in available potassium, but the Lester soil is medium in available phosphorus. The content of organic matter is low to moderately low in most of the soils, but the Terril soils are moderate to high. Reaction in the Storden soil is moderately alkaline, and it is calcareous throughout. Reaction in the other soils is neutral or slightly acid or medium acid in the surface layer and in the upper part of the subsoil.

Some of these soils are moderately eroded, but they all are subject to erosion. Soil losses are likely to be excessive if they are not protected by vegetation or conservation measures. In some places gullying is a hazard. The Terril soils are subject to rilling and gullying where water from upslope runs off and concentrates. If left barren in winter, some areas are subject to soil blowing in spring. The tilth of moderately eroded soils is generally fair and of the other soils is generally good.

These soils are used for crops and pasture. In places the Lester soils are wooded but are generally managed as pasture. In cultivated areas corn, oats, alfalfa, red clover, or mixtures of alfalfa or clover with grasses are the main crops. These soils are moderately suited to row crops if erosion is controlled. The frequency with which crops can safely be grown without excessive soil loss depends on the conservation practices used. Terracing, contour tillage, and shaping and seeding existing gullies for waterways are suitable practices for controlling erosion. In places diversion terraces can be used to protect areas of the Terril soils. Additions of organic matter, such as green manure, crop residue, or animal manure, help to prevent erosion and maintain or improve the content of organic matter and soil tilth. This practice is especially suitable for the moderately eroded soils in the unit.

Corn and other crops generally respond well to additions of fertilizer. Nitrogen, phosphorus, and some potassium are generally needed for row crops. Crops grown on Storden soils generally respond well to phosphorus. Storden soils are calcareous and do not need lime. Of the other soils, only Lester soils generally need lime in substantial amounts.

CAPABILITY UNIT IIIe-3

This capability unit consists of well-drained, gently sloping to moderately sloping soils that are loamy. These soils are of the Billett and Estherville series. They are on benches and on escarpments between benches, but they are also on knobs and low hills.

These soils have a surface layer of friable sandy loam or fine sandy loam. Their subsoils are similar to the surface layer in texture. The Estherville soil is underlain by sand and gravel, generally at a depth of 15 to 30 inches.

These soils have low to moderate available water capacity. The Billett soil has moderately rapid permeability. The Estherville soil has moderately rapid permeability in the upper part and rapid or very rapid permeability in the underlying sand and gravel. In most of these soils the subsoil is very low in available phosphorus and in available potassium, but the Billett soil is low in available phosphorus. The content of organic matter in all of these soils is low to moderately low. Reaction ranges from neutral to slightly acid in the surface layer. The subsoil is generally slightly acid, but ranges to neutral in the Estherville soil and to medium acid in the Billett soil.

These soils have limited available water capacity and are subject to erosion. Crop growth is poor if rainfall is not timely, because these soils do not store enough water to supply plants during extended dry periods. These soils dry out and can be tilled fairly soon after rains. Tilth is generally good. In places soil blowing is a hazard.

These soils are mostly in permanent pasture, but a few areas are cultivated and used for growing corn, oats, and alfalfa, or other forage crops for hay or pasture. A few areas that were formerly cultivated are now idle and are used for wildlife habitat or pasture. The use of these soils is often affected by the accessibility of the areas, the suitability of the associated soils for growing crops, and the size of areas and length of slopes. Many of the areas are small, and many of the slopes are short and irregular. These soils are moderately well suited to row crops, but

because production is commonly poor, forage crops are generally grown.

Contour tillage is generally used to control erosion. Terraces are not generally built in these sandy and gravelly soils because of the difficulties involved in construction and maintenance and because of the very low available water capacity and low productivity in areas where cuts are made during construction. When row crops are grown, plant population needs to be adjusted to the available moisture.

Because these soils lack adequate available water, the response of crops to additions of fertilizer is generally only moderate. Heavy rates of application are seldom economical. Some areas need lime in places.

CAPABILITY UNIT IIIw–1

This capability unit consists of poorly drained soils in nearly level areas or in depressions. These soils are of the Rolfe and Dundas series. They are on uplands.

These soils have a surface layer of friable silt loam and a thin subsurface layer of grayish, friable silt loam. Their subsoil is firm heavy silty clay loam or clay loam.

These soils have moderately slow or slow permeability and have high available water capacity. The content of organic matter is moderate or high. The subsoil is very low or low in available phosphorus and very low in available potassium. Reaction generally is slightly acid or medium acid in the surface layer and subsurface layer.

These soils are wet. In some areas, especially in the Rolfe soil, water tends to pond in spring or after heavy rains. Crops are damaged in places if drainage is not adequate. These soils warm up slowly in spring, and tillage operations are delayed in these and surrounding soils in places.

Most areas of these soils are small enough that the use made of the associated soils determines the use of these soils. Most of the areas of the Rolfe soil are cultivated. The Dundas soil is partly cultivated, but some areas are in timber or timbered pasture. Undrained areas are better suited to pasture than to crops. Corn and soybeans are the major crops, but oats and alfalfa and other hay and pasture plants are also grown. Alfalfa and clover do not grow well in many places, because of wetness or winterkilling. These soils are moderately well suited to row crops if they are adequately drained. Tile drains generally remove excess water fairly well, but they generally do not work so well as in more permeable soils. In places surface intakes are used in addition to tile drains or shallow drainage ditches to improve drainage and remove ponded water.

The response of crops to additions of fertilizer generally is good if drainage is adequate. Lime is needed in some places.

CAPABILITY UNIT IIIw–2

This capability unit consists of very poorly drained soils on uplands. These soils are in shallow depressions. They are of the Dorchester, Okoboji, Lanyon, and Wacousta series and Muck. The Dorchester soil and the areas of Muck are on bottom lands in bayous.

The Okoboji soils in the unit have a thick surface layer that is mainly silty clay loam, but one Okoboji soil has a few inches of mucky silt loam on the surface. Lanyon and Wacousta soils have a thinner surface layer. Lanyon soils are light silty clay, and Wacousta soils are silt loam in this layer. Muck soil has about 15 inches of muck on the surface. Beneath the surface layer of the soils, the texture ranges from silty clay in the Lanyon soil to silty clay loam or silt loam in the others.

These soils have moderate to slow permeability and have very high or high available water capacity. The content of organic matter is high, except in Muck, shallow, where it is very high, and in Dorchester soil, where it is about moderate. The subsoil generally is low or very low in available phosphorus and very low in available potassium. Trace elements are low for some crops in the Muck, shallow, soil. Reaction is mainly neutral in the surface layer and becomes mildly alkaline or moderately alkaline with depth. The Dorchester soil is calcareous throughout.

These soils are wet because of a high water table and ponding of surface runoff from surrounding soils. This ponding generally occurs in spring or after heavy rains. The Dorchester soil is wet because of flooding. Crops are damaged or drowned out in places. The soils warm up slowly in spring, and tillage operations are delayed in many places in these and surrounding soils. These soils are in low areas where crop damage caused by early frosts is a hazard. Some areas, especially of the Lanyon soils, tend to have poor tilth if tilled when wet.

Most areas of these soils are small and are used and managed with the surrounding soils. Most areas are cultivated. Corn and soybeans are the major crops and are grown most of the time, but oats and crops for hay or pasture are grown occasionally. Alfalfa and red clover commonly are not well suited, because of wetness or winterkilling. The soils are moderately well suited to row crops if they are adequately drained. Partly drained areas are suited to pasture. Undrained areas are generally suitable only for wildlife habitat. Tile drains, open intakes to tile drains, and shallow drainage ditches are used to achieve drainage and remove ponded water. In places large open ditches, which are used as outlets for tile drains, cross areas of these soils. These soils commonly are plowed in fall to allow freezing and thawing in winter to improve soil tilth and to allow more timely tillage operations in spring.

The response of crops to additions of fertilizer is generally good if drainage is adequate. Phosphorus is especially likely to be needed. Muck, shallow, soil needs additions of trace elements for some crops in places. Lime is not needed.

CAPABILITY UNIT IIIw–3

This capability unit consists of poorly drained, nearly level to gently sloping soils on foot slopes and benches. These soils are of the Calamine and Webster series.

These soils have a thick surface layer of silty clay loam. Their subsoil is clay loam or silty clay loam in texture and is friable or firm in consistence. The Calamine soil has firm silty clay loam shale at a depth of about 3 feet. The Webster soil is underlain by firm clay loam glacial till at a depth of about 4 feet.

These soils have moderate or high available water capacity. Permeability is restricted in the underlying shale or firm glacial till. The content of organic matter is high. The subsoil generally is very low in available phosphorus and available potassium. Reaction is generally neutral in the surface layer.

These soils are wet because of a high water table and seepiness. Unless these soils are artificially drained, crops generally do not grow well. Undrained areas are boggy and hummocky in many places. Some areas have scattered stones and boulders. These areas generally are in permanent pasture. The hazard of erosion is slight on the gently sloping soils. The surface layer tends to dry out cloddy and hard and have poor tilth if it is tilled when wet.

Most areas of these soils are in permanent pasture. In some areas drainage has been improved and rocks have been removed, and these areas are cultivated. These soils are used for all crops commonly grown in the county, but corn and soybeans are the main crops. These soils are moderately suited to row crops if drainage is adequate. Providing drainage for the Calamine soil is difficult because the water that keeps these soils wet needs to be intercepted upslope. The shale in the substratum is too shallow for tile drains to function effectively. Tile is difficult to install in places in the Webster soil because of the boulders and stones in the substratum. The hazard of erosion is slight, and it genrally can be controlled by tilling across the slope.

The response of crops to additions of fertilizer and other good management is variable and depends on how well drainage has been achieved. Lime is not needed.

CAPABILITY UNIT IIIs–1

This capability unit consists of nearly level to gently sloping, well-drained, loamy soils on benches. These soils are of the Ankeny, Billett, Buckney, and Estherville series.

These soils have a surface layer of friable fine sandy loam or sandy loam. The texture in the subsoil is similar. The Estherville soils in the unit are underlain by sand and gravel, generally at a depth of 15 to 30 inches.

These soils have low or moderate available water capacity. Permeability generally is moderately rapid or rapid, but it is rapid or very rapid in the underlying sand and gravel in the Estherville soils. The content of organic matter is about medium. The subsoil generally is very low or low in available phosphorus and low in available potassium. Reaction is mainly neutral or slightly acid in the surface layer, but Buckney soils are mildly alkaline and are calcareous.

Crop growth is poor if rainfall is not timely, because these soils do not store enough water to supply plants during extended dry periods. In places on the Buckney soils, very deep-rooted crops, such as alfalfa, can reach the water table that is fairly close to the surface because of the nearby river. Water erosion is a hazard on the gently sloping soils. At times, in some places, soil blowing is a hazard, and blowing sand injures young plants. The nearly level Buckney soil in the unit is subject to occasional flooding. These soils dry out and can be tilled soon after rains. Tilth is generally good.

These soils are used for field crops but are also used for pasture. In cultivated areas corn, oats, and alfalfa or alfalfa-grass mixtures are the main crops. Grain sorghum, soybeans, and other hay and pasture plants are also suited to these soils. Soybeans are generally not so profitable as other row crops. Row crops can be grown often, but plant population needs to be adjusted to the available moisture. The gently sloping areas need to be tilled on the contour. Crop residue left on the surface helps to control soil blowing. Additions of organic matter in the form of green manure or animal manure helps improve fertility, increase the content of organic matter, and prevent soil blowing.

Because these soils lack adequate available water, the response of crops to additions of fertilizers is generally only moderate. Heavy rates of application generally are not economical. Buckney soils do not need lime, but the other soils need lime in places.

CAPABILITY UNIT IVe–1

This capability unit consists mainly of moderately steep, well-drained, loamy soils on uplands. These soils are of the Clarion, Lester, and Storden series. Also in the unit are a moderately steep Terril, thin surface variant, soil on foot slopes and a strongly sloping Estherville soil on short escarpments between benches.

These soils generally have a surface layer and subsoil of friable loam, but the Lester soil is firm clay loam in some layers, and in most places it has a thin subsurface layer of grayish, friable loam. Also, the Estherville soil has a surface layer and subsoil of sandy loam. This Estherville soil is underlain by sand and gravel, generally at a depth of about 15 to 30 inches.

These soils generally have moderate permeability, but the Estherville soil has rapid or very rapid permeability in the underlying sand and gravel. The available water capacity generally is high, but it is low in the Estherville soil. In cultivated areas runoff is rapid if plant cover is sparse. Some of these areas are not at water capacity in dry periods, and crops grow poorly from lack of moisture in places. The content of organic matter generally is low or moderately low. The subsoil generally is very low in available phosphorus and potassium, but the subsoil of the Lester soil is about medium in potassium. The Storden soil is moderately alkaline and calcareous throughout. Reaction in the other soils is neutral to medium acid in the surface layer and the upper part of the subsoil.

The Clarion and Storden soils in this unit are moderately eroded. All of the soils are subject to erosion, and soil losses are likely to be excessive if these soils are not protected by plant cover or conservation measures. In places gullying is a hazard. The thin surface variant of the Terril soil is subject to rilling and gullying caused by water from soils upslope that runs off and concentrates. The Estherville soil has limited available water capacity. The tilth of the moderately eroded soils is generally fair. The other soils generally have good tilth.

Part of the soils of this unit are cultivated. Some areas are in permanent pasture. Lester soils are wooded in many places but generally are used for pasture. Some formerly cultivated areas have been allowed to revert to bluegrass and are used for pasture. A few areas are idle or are used mainly as wildlife habitat. These soils are moderately suited to row crops if erosion is controlled, but they are left in hay or pasture much of the time. Row crops are grown when stands of hay or pasture plants become poor and need reseeding. Terracing and contour tillage are suitable practices to control erosion. The Estherville soil is not suited to terracing, however, because of the underlying sand and gravel. In places gullies need to be filled,

shaped, and seeded for grassed waterways. These soils are also suited to permanent pasture, and in a few places woodland or wildlife habitat are better uses.

Crops generally respond fairly well to additions of fertilizers. Large amounts generally are not economical on the Estherville soil, because it has limited available water capacity. The response of legumes to additions of phosphorus generally is good. Storden soils are calcareous and do not need lime, but the other soils need additions of lime in places.

CAPABILITY UNIT IVe–2

Calamine silty clay loam, 5 to 14 percent slopes, is the only soil in this capability unit. It is a poorly drained soil and is in long, narrow areas of foot slopes.

This soil has a thick surface layer of friable and firm silty clay loam. It is underlain, at a depth of about 2 to 3 feet, by dark-gray, silty clay loam shale.

Permeability is severely restricted in the underlying shale. The content of organic matter is high. Natural fertility is medium to low. Reaction generally is about neutral in the surface layer.

This soil is subject to erosion if cultivated. The difference in the permeability of the upper part of the profile and the underlying shale generally causes a perched water table in many places and a tendency for the soil to be seepy and wet. This soil is also subject to gullying if water from soils upslope runs off and concentrates.

Most areas of this soil are in permanent pasture and have a few scattered trees. This soil is suited to limited use for crops if it is protected from erosion and adequately drained. It is generally difficult to provide drainage because the shale is generally too near the surface for tile to be effective. This soil is better suited to permanent or semipermanent pasture, woodland, or wildlife habitat than to field crops. Soils that are upslope generally are not suited to crops.

Controlling brush, removing trees, planting more productive grasses and legumes, and adding fertilizer help to improve pasture on this soil. Combinations of legumes and grasses tolerant of wetness are better than other grasses for pasture renovation.

CAPABILITY UNIT Vw–1

This capability unit consists of nearly level to gently undulating areas of Alluvial land and Sandy alluvial land. These areas are on bottom lands near streams.

Sandy alluvial land is mainly loamy sand or sand in texture, but some areas are sandy loam. Alluvial land consists of loamy or sandy material deposited by overflowing streams. Almost half of Alluvial land is similar to Hanlon soil, but it is more variable in texture than this soil.

These lands generally have low available water capacity and shallow-rooted plants do not grow well. A water table is generally near the level of nearby stream channels. Some species of trees and plants that have root systems that are deep enough to reach this water table can be very productive. These lands are subject to flooding when the adjacent streams overflow, and this generally occurs frequently.

Most areas are in pasture. In places the vegetation is mainly grass, brush, and willows. In some places it serves little use other than as wildlife habitat. It is suited to pasture and to wildlife habitat or woodland. Attempts to clear these areas, fill channels, and use the land for cultivated crops generally cause increased velocity of the floodwaters and cause stripping of soil material and gouging of holes and channels. Stream-channel straightening generally results in increasing the gradient and causes rapid widening and deepening of the channel.

Pastures commonly can be improved by planting deep-rooted legumes and grasses that can tolerate some flooding and by removing brush and trees. The value of existing timber in these areas is generally low, but most areas have potential for producing trees of commercial value. These areas can also be used for recreation or wildlife habitat. Plantings or improvements generally can be made that enhance the usefulness of the soils for these purposes.

CAPABILITY UNIT VIe–1

This capability unit consists of steep, loamy soils. These soils are of the Lester and Storden series. They generally are on sides of the valleys of rivers and creeks on uplands.

These soils have a surface layer of friable loam. The texture of the Storden soil is similar below the surface layer, but Lester soils have firm clay loam in some layers of the subsoil and in most places have a thin, grayish, friable loam subsurface layer between the surface layer and the subsoil.

These soils have moderate permeability and have high available water capacity. Much of the rain runs off, so the amount of moisture available for use of plants commonly is limited. The content of organic matter generally is low or moderately low. In all of the soils, the subsoil is very low in available potassium. In the Storden soil, the subsoil is very low in available phosphorus, and in the Lester soil it is medium.

The soils of this unit are poorly suited to row crops. They are better suited to hay or pasture. A few areas of the Storden soil have been cultivated, but almost all areas are now in permanent pasture. The Lester soil is used mainly for pasture and generally is in trees and grass. These soils are suited to pasture. They are also suited to woodland or wildlife habitat. Inaccessible areas that are of little value for other purposes are especially suitable for use or improvement as wildlife habitat. These soils have properties suitable for construction, and they commonly are in areas that have sites suitable for ponds. These ponds are used to supply water for livestock, to control gullying, or for recreation.

On some sloping areas, tillage equipment can be used to fertilize and renovate pasture and seed more productive pasture plants, but most areas are too steep, irregular, or gullied to use ordinary farm equipment. In some places, brush and trees can be removed to improve pasture. Good management of grazing is also important to increase the growth of pasture. In places existing gullies need to be shaped and seeded to grass for waterways. If areas now in trees are to be managed as woodland, they need to be protected from grazing. Undesirable trees can be cut to permit better growth of desirable ones, and adapted trees can be planted. Names of trees suitable for planting are given in the section "Use of the Soils for Woodland."

CAPABILITY UNIT VIIe-1

This capability unit consists of steep and very steep soils that vary greatly in texture and drainage. These soils are of the Boone, Gosport, Storden, and Hayden series and the land types. Rock land and Steep sandy land. They are mainly on sides of the valleys of the Des Moines River and Lizard Creek.

The Boone soil is very sandy in texture and is underlain by sandstone bedrock at a depth of about 24 inches. It is excessively drained. The Gosport soil is silty clay in texture and is underlain by shale. The Storden and Hayden soils are mainly loam in texture but range to clay loam. They are well drained. Rock land and Steep sandy land consist partly of soils that have limestone at shallow depths and partly of land that is variable in texture but that is generally sandy.

Permeability is rapid in the Boone soil, very slow in the Gosport soil, and moderate in the other soils. Available water capacity ranges from low in the Boone soil to high in the Storden and Hayden soils. Runoff is rapid in all of these soils, however, so that moisture available for use of plants commonly is limited. Natural fertility of these soils is low. Reaction ranges from moderately alkaline to strongly acid. These soils are calcareous in areas that are moderately alkaline.

Most areas of these soils are in permanent pasture or woodland. Most of the woodland is used for pasture rather than being managed as woodland, but production of forage is low. A few areas are idle and are used mainly for wildlife habitat. A few areas are in recreational areas, such as Dolliver State Park.

These soils are not suited to cultivation. Some areas are suited to pasture. Many areas are poorly suited to pasture and are better suited to woodland, wildlife habitat, or recreation. The Storden and Hayden soils in this unit have properties favorable for pond construction for water supply, gully control, or recreation. There are suitable sites in many places. Many areas of these soils are large and can be managed separately from other soils.

Steepness, rough topography, and gullies make the use of farm machinery hazardous. Renovation of pasture generally is impractical without special machinery. Bulldozers can be used, however, to remove brush and scattered trees to increase the growth of forage in some places. Control of grazing is an important management practice. Grazing animals establish trails in places that later erode and become gullies. If areas now in trees are to be managed as woodland, they need to be protected from grazing. Undesirable trees can be cut to permit better growth of desirable ones, and adapted trees can be planted. Names of trees suitable for planting are given in the section "Use of the Soils for Woodland."

CAPABILITY UNIT VIIw-1

Muck, shallow, 5 to 14 percent slopes, is the only soil in this capability unit. It is generally on the lower parts of areas that resemble escarpments and that are between benches or between benches and areas of bottom land. This gently sloping to strongly sloping soil has an accumulation of mucky organic matter of variable thickness on the surface. It is wet and seepy. Areas generally are 2 to 10 acres in size.

Nearly all of this soil has a natural vegetation of sedges, cattails, and swamp grasses. Most areas are in permanent pasture, but a few are used for crops. This soil, however, provides little or no usable forage, and it generally is idle except for providing habitat for certain kinds of wildlife. A few areas have been tapped for a water supply for livestock, but in most places it is difficult to intercept enough water to provide a satisfactory volume. Attempts to drain these areas are expensive and only partly successful. Generally, leaving these areas in natural vegetation for wildlife habitat is a better use.

Predicted yields

In table 2 the average yields per acre of the principal crops are predicted for soils of the county under a high level of management. Under this level of management, seedbed preparation, planting, and tillage practices provide for adequate stands of adapted varieties; erosion is controlled; the organic-matter content and soil tilth are maintained; the level of fertility for each crop is maintained (as indicated by soil tests and field trials); the water level in wet soils is controlled; excellent weed and pest control are provided; and operations are timely.

Yield estimates were based on information obtained from the Federal census, the Iowa farm census, data from experimental farms and cooperative experiments with farmers, and from on-farm experience by soil scientists, extension workers, and others.

Predictions of yields are only approximate and are meant to serve only as a guide. Of more value than actual yield figures are the comparative yields between soils. These relationships are likely to remain consistent over a period of years. On the other hand, actual yields have been increasing in recent years. If they continue to increase as expected, predicted yields in this table will soon be too low.

Use of the Soils for Woodland

Most wooded areas in Webster County are along the Des Moines River and its larger tributaries. In 1954 about 26,000 acres was in woodland (*2*). This acreage has not changed significantly in recent years. Some woodland, mainly in bottom lands, has been converted to use for crops, and some woodlots and windbreaks associated with vacant farmsteads have been cleared and used for crops. Most farmers are concerned with the planting of trees for windbreaks and landscaping, rather than for the production of wood.

Much of the existing woodland is subjected to grazing and is used as timbered pasture rather than being managed as woodland. Many timbered pastures produce little grazing for livestock and are generally no more than a source of shade for livestock or a habitat for wildlife. Some timbered areas might produce more income if they were managed properly as woodland. Proper management includes protection from livestock and fire, improving the composition of the woodland by removing inferior trees, and regulating the harvest of trees to balance the growth.

Assistance in managing new or old stands of trees can be obtained from farm foresters of the State Conservation Commission and from technicians of the Webster County Soil Conservation District.

TABLE 2.—*Predicted average yields per acre of principal crops under a high level of management*

[Dashes indicate that the crop is not suited to the soil or is not generally grown on it. Corn yields are omitted for soils where the predicted yields are less than 40 bushels]

Soil	Corn	Soybeans	Oats	Hay	Alfalfa-grass pasture
	Bu.	*Bu.*	*Bu.*	*Tons*	*Animal-unit-days* [1]
Alluvial land, 2 to 5 percent slopes					50
Ankeny fine sandy loam, 0 to 3 percent slopes	80	30	64	2.9	145
Billett fine sandy loam, 1 to 5 percent slopes	75	29	60	2.7	135
Billett fine sandy loam, 5 to 10 percent slopes	70	27	56	2.5	125
Biscay clay loam, deep	100	38	80	4.0	200
Boone loamy fine sand, 25 to 45 percent slopes					[2] 30
Buckney fine sandy loam, 0 to 2 percent slopes	80	30	64	2.9	145
Buckney fine sandy loam, 2 to 6 percent slopes	78	30	62	2.8	140
Calamine silty clay loam, 2 to 5 percent slopes	75	29	60	3.0	150
Calamine silty clay loam, 5 to 14 percent slopes	60	23	48	2.4	120
Calco silty clay loam	99	38	80	4.0	200
Canisteo silty clay loam	105	40	84	4.2	210
Clarion loam, 0 to 2 percent slopes	112	43	90	4.7	235
Clarion loam, 2 to 5 percent slopes	110	42	88	4.6	230
Clarion loam, 5 to 9 percent slopes	105	40	84	4.4	220
Clarion loam, 5 to 9 percent slopes, moderately eroded	102	39	82	4.3	215
Clarion loam, 9 to 14 percent slopes, moderately eroded	93	35	74	3.9	195
Clarion loam, 14 to 18 percent slopes, moderately eroded	78	30	60	3.3	160
Colo silty clay loam	104	40	83	4.2	210
Colo-Spillville complex, 2 to 5 percent slopes	108	41	86	4.3	215
Cordova silty clay loam	104	40	78	4.2	210
Cylinder loam, deep	103	39	82	4.3	215
Cylinder loam, moderately deep	88	33	70	3.7	185
Dorchester silt loam	106	40	85	4.4	220
Dorchester silt loam, frequently flooded	86	33	69	3.6	180
Dundas silt loam	98	37	78	3.8	190
Estherville sandy loam, 0 to 2 percent slopes	44	17	35	1.7	85
Estherville sandy loam, 2 to 5 percent slopes	42	16	34	1.7	85
Estherville sandy loam, 5 to 9 percent slopes			25	1.2	60
Estherville sandy loam, 9 to 14 percent slopes				1.0	50
Gosport silt loam, 25 to 45 percent slopes					[2] 25
Guckeen clay loam, 1 to 3 percent slopes	104	40	83	4.4	220
Hanlon fine sandy loam, 0 to 3 percent slopes	80	30	64	2.9	145
Harps clay loam	95	36	76	4.0	200
Hayden loam, 2 to 5 percent slopes	98	37	78	4.1	205
Hayden loam, 5 to 9 percent slopes	92	35	74	3.7	185
Jacwin loam, 1 to 3 percent slopes	103	39	82	4.3	215
Kamrar clay loam, 2 to 5 percent slopes	96	36	77	4.0	200
Lanyon silty clay	80	30	64	3.2	160
Lester loam, 2 to 5 percent slopes	104	40	83	4.4	220
Lester loam, 5 to 9 percent slopes	95	36	76	4.0	200
Lester loam, 9 to 14 percent slopes	86	33	69	3.6	180
Lester loam, 14 to 18 percent slopes	71	27	57	2.9	145
Lester loam, 18 to 35 percent slopes					[2] 50
Le Sueur loam, 1 to 3 percent slopes	112	45	90	4.7	235
Luther loam, 1 to 3 percent slopes	106	40	85	4.5	225
Marna silty clay loam	96	36	77	4.0	200
Minnetonka silty clay loam	90	35	75	3.8	190
Muck, shallow	104	40	83	3.9	190
Muck, shallow, 5 to 14 percent slopes					[2] 30
Nicollet loam, 1 to 3 percent slopes	118	45	94	5.0	250
Nicollet loam, benches, 3 to 6 percent slopes	116	44	93	4.9	245
Okoboji mucky silt loam	86	33	69	3.4	170
Okoboji silty clay loam	84	32	67	3.4	170
Rockton loam, 2 to 5 percent slopes	78	30	62	3.2	155
Rock land and Steep sandy land, 20 to 40 percent slopes					[2] 35
Rolfe silt loam	86	33	69	3.0	150
Sandy alluvial land					[2] 30
Spillville loam, 0 to 2 percent slopes	116	44	93	4.9	245
Spillville loam, 2 to 5 percent slopes	114	43	91	4.8	240
Storden loam, 5 to 9 percent slopes, moderately eroded	92	35	74	3.9	195
Storden loam, 9 to 14 percent slopes, moderately eroded	83	32	66	3.5	175
Storden loam, 14 to 18 percent slopes, moderately eroded	68	26	54	2.9	145
Storden loam, 18 to 25 percent slopes, moderately eroded					[2] 50
Storden loam, 25 to 45 percent slopes, moderately eroded					[2] 40
Storden-Hayden loams, 25 to 70 percent slopes					[2] 40

See footnotes at end of table.

TABLE 2.—*Predicted average yields per acre of principal crops under a high level of management*—Continued

Soil	Corn	Soybeans	Oats	Hay	Alfalfa-grass pasture
	Bu.	*Bu.*	*Bu.*	*Tons*	*Animal-unit-days* [1]
Talcot clay loam, deep	95	36	76	3. 8	190
Talcot clay loam, moderately deep	85	32	68	3. 4	190
Terril loam, 5 to 9 percent slopes	107	41	86	4. 5	225
Terril loam, 9 to 14 percent slopes	98	37	79	4. 1	205
Terril loam, sandy substratum, 2 to 5 percent slopes	90	34	72	3. 6	180
Terril loam, thin surface variant, 5 to 9 percent slopes	107	41	86	4. 5	225
Terril loam, thin surface variant, 9 to 14 percent slopes	98	37	79	4. 1	205
Terril loam, thin surface variant, 14 to 18 percent slopes	73	28	58	3. 1	155
Turlin loam, 2 to 5 percent slopes	116	43	90	4. 7	235
Wacousta silt loam	100	38	80	4. 0	200
Wadena loam, deep, 0 to 2 percent slopes	92	35	74	3. 7	185
Wadena loam, deep, 2 to 5 percent slopes	90	34	72	3. 6	180
Wadena loam, moderately deep, 0 to 2 percent slopes	72	27	61	2. 9	145
Wadena loam, moderately deep, 2 to 5 percent slopes	70	27	60	2. 8	140
Wadena loam, moderately deep, 5 to 9 percent slopes	65	25	55	2. 6	130
Wadena loam, thin surface variant, deep, 2 to 5 percent slopes	84	32	67	3. 4	170
Wadena loam, thin surface variant, moderately deep, 2 to 5 percent slopes	64	24	51	2. 6	130
Webster silty clay loam	110	42	88	4. 4	220
Webster silty clay loam, benches, 0 to 3 percent slopes	100	38	80	4. 0	200

[1] A term used to express the carrying capacity of pasture. It is the number of animal units carried per acre multiplied by the number of days the pasture is grazed during a single grazing season without injury to the sod. Animal-unit-days are based on the a sumption that one mature animal will consume 40 pounds of dry matter per acre per year.

[2] Yield is based on permanent bluegrass pasture.

Woodland suitability groups

The soils in Webster County have been placed in woodland suitability groups to assist owners in properly managing their woodland and in selecting trees and shrubs suited to various kinds of plantings. Each suitability group is made up of soils that have about the same available water capacity and other characteristics that influence the growth of trees. Soils in a woodland suitability group also have similar limitations and are subject to the same hazards when used for trees. All of the soils in a group, therefore, support similar kinds of trees, have about the same potential productivity, and require similar kinds of management.

For most of the woodland suitability groups, the site index is provided for trees that grow in Webster County. Site index is the height, in feet, of dominant and codominant trees in the stand at 50 years of age. It is a rating of potential soil productivity for trees. United States Department of Agriculture Technical Bulletin No. 560 (*12*) was used to classify trees into site index classes and to convert site index classes into board foot production.

Of the species listed as suitable for windbreak plantings, the conifers are especially well suited to farmstead windbreaks and the hardwoods are especially well suited to field windbreaks.

The mention of soil series in the description of a woodland suitability group does not mean all the soils in that series are in the group. To determine the soils in a woodland suitability group, refer to the "Guide to Mapping Units" at the back of this survey.

Woodland suitability groups are identified according to a nationwide system of connotative symbols, made up of three parts or elements. The first part, or element, of the symbol is an Arabic numeral that represents the relative productive potential of soils for growing wood crops. The numeral 1 indicates very high productivity potential. The numerals 2, 3, 4, and 5 represent classes of decreasing productivity potential.

The second part of the symbol is a small letter indicating the soil or physiographic characteristic that is the primary cause of moderate to severe hazards to woodland management. Letters have the following meanings: *w*, excess wetness; *t*, toxic substances such as excess alkalinity in the soil; *c*, clayey material in the soil; *s*, sandy soil; *r*, relief or slope; *o*, no significant soil-related hazards or limitations; and *m*, moisture deficiency in the soil.

The third part of the symbol is also an Arabic numeral, and it indicates the degree of hazards or limitations, and the general suitability of the soils for stated types of trees.

Each woodland suitability group in the county is rated for various management hazards or limitations. Ratings are slight, moderate, or severe, and they are defined in the following paragraphs:

Seedling mortality refers to the expected loss of seedlings as a result of unfavorable soil characteristics or topographic features when plant competition is assumed not to be a factor. *Slight* means a loss of less than 25 percent; *moderate* means a loss of 25 to 50 percent; and *severe* means a loss of more than 50 percent of the seedlings normally planted for adequate stocking.

Plant competition is the degree to which undesirable plants invade when openings are made in the canopy. Competition is *slight* if it does not prevent adequate natural regeneration and early growth or interfere with the normal development of planted seedlings; it is *moderate* if it delays, but does not prevent, the growth and

development of fully stocked, normal stands; it is *severe* if it prevents adequate natural or artificial restocking, without intensive preparation of the site and the use of special maintenance practices.

Equipment limitations are soil characteristics that restrict the use of conventional machinery for planting and harvesting, for building roads, for controlling brush, and for controlling fires. The limitation is *slight* if there is minimal restriction of the type of equipment or the time of year that it can be used; it is *moderate* if the use of equipment is restricted by one or more unfavorable soil characteristics, such as slope, stones, wetness, or instability; it is *severe* if special equipment is needed or if use of equipment is restricted for long periods.

Erosion hazard refers to the expected erosion that results from the cutting and removal of trees. It is *slight* if potential erosion is unimportant; it is *moderate* if some practices, such as those for diverting water, are needed to prevent accelerated erosion; it is *severe* if intensive treatment is needed to control soil loss.

WOODLAND SUITABILITY GROUP 2o1

This group consists of well-drained to somewhat poorly drained, medium-textured and moderately fine textured soils that are nearly level to moderately steep. Permeability is moderate to moderately slow. Available water capacity is high. In this group are soils of the Clarion, Hayden, Kamrar, Lester, Spillville, Terril, and Turlin series, and a thin surface variant of the Terril series.

Suitability of the soils for upland oaks and conifers is high and for cottonwoods, very high. The site index for upland oaks ranges from 66 to 75. Estimated annual growth of existing trees on soils of this group ranges from 200 to 249 board feet per acre per year.

Trees to favor in existing woodlands are red oak, cottonwood, white oak, green ash, black walnut, basswood, hackberry, and hard maple.

Trees most suitable for open-area plantings are eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, European larch, Douglas-fir, black walnut, green ash, and hackberry.

Trees suitable for interplanting in existing stands are the conifers and hardwoods mentioned in the foregoing paragraph and also red oak, white oak, and basswood.

Seedling mortality is slight. Plant competition from grass is slight or moderate. Equipment limitations are slight. The hazard of erosion is slight to moderate.

Trees most suitable for farmstead windbreaks are the *conifers*, eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, and Douglas-fir and the *hardwoods*, Norway poplar, Siouxland poplar, Robusta poplar, green ash, and hackberry.

Species suitable for wildlife plantings are honeysuckle, viburnum, ninebark, lilac, dogwood, and cardinal autumn-olive.

WOODLAND SUITABILITY GROUP 2s1

This group consists of nearly level and gently sloping soils that are medium textured in the upper part of the profile and that have sand and gravel at a depth of about 32 to 40 inches. Permeability is moderate in the upper part and rapid or very rapid in the underlying sand and gravel. Available water capacity is moderate to high. In this group are soils of the Wadena series and its thin surface variant and Terril loam, sandy substratum, 2 to 5 percent slopes.

Suitability of these soils for upland oaks, conifers, and cottonwoods is high. The site index for upland oaks ranges from 66 to 75. Estimated annual growth of existing trees on soils of this group ranges from 200 to 249 board feet or more per acre per year.

Trees to favor in existing woodlands are red oak, white oak, green ash, black walnut, basswood, hackberry, and hard maple.

Trees most suitable for openland plantings are eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, European larch, Douglas-fir, walnut, green ash, and hackberry.

Trees suitable for interplanting in existing stands are the conifers and hardwoods mentioned in the foregoing paragraph and also red oak, white oak, and basswood.

Seedling mortality is slight. Plant competition from grass is slight to moderate. Equipment limitations are slight. The hazard of erosion ranges from slight to severe, depending on slope.

Trees most suitable for farmstead windbreaks are the *conifers*, eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, and Douglas-fir and the *hardwoods*, Norway poplar, Siouxland poplar, Robusta poplar, green ash, and hackberry. Shrubs include honeysuckle.

Species suitable for wildlife plantings are honeysuckle, viburnum, ninebark, lilac, dogwood, and cardinal autumn-olive.

WOODLAND SUITABILITY GROUP 3r1

The only soil in this group is Lester loam, 18 to 35 percent slopes. It is well drained, medium textured and moderately fine textured, and steep. Permeability is moderate. Available water capacity is high.

Suitability of this soil for upland oaks is moderately high on north- and east-facing slopes, and moderate on south- and west-facing slopes; for conifers, moderately high; and for cottonwoods, moderately high or high. The site index for upland oaks ranges from 56 to 65 on north- and east-facing slopes and from 46 to 55 on south- and west-facing slopes. Estimated annual growth of existing trees ranges from 150 to 199 board feet per acre per year on north- and east-facing slopes and from 100 to 149 on south- and west-facing slopes.

Trees to favor in existing woodlands on north- and east-facing slopes are red oak, white oak, green ash, black walnut, basswood, hackberry, and hard maple. Black walnut, basswood, and hard maple are not so well adapted for south- and west-facing slopes.

Trees most suitable for openland plantings are eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, European larch, Douglas-fir, black walnut, green ash, and hackberry.

Trees suitable for interplanting in existing stands are the conifers and hardwoods mentioned in the foregoing paragraph and also red oak, white oak, and basswood.

Seedling mortality is slight. Plant competition from grass is moderate. Equipment limitations are moderate. The hazard of erosion is severe.

Trees most suitable for farmstead windbreaks are the *conifers*, eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, and Douglas-fir and the *hard-*

woods, Norway poplar, Siouxland poplar, Robusta poplar, green ash, and hackberry.

Species suitable for wildlife plantings are honeysuckle, viburnum, ninebark, lilac, dogwood, and cardinal autumn-olive.

WOODLAND SUITABILITY GROUP 3s1

This group consists of nearly level to strongly sloping soils that are moderately coarse textured throughout the profile and soils that are medium textured or moderately fine textured in the upper part of the profile and that have sand and gravel or bedrock at a depth of 24 to 32 inches. Permeability is moderate to rapid. Available water capacity is low to moderate. In this group are soils of the Billett, Buckney, Rockton, Wadena, and Wadena, thin surface variant, series.

Suitability of these soils for upland oaks, conifers, and cottonwoods is moderately high. The site index for upland oaks ranges from 56 to 65. Estimated annual growth of existing trees on soils of this group ranges from 150 to 199 board feet or more per acre per year.

Trees to favor in existing woodlands are red oak, white oak, green ash, black walnut, basswood, hackberry, and hard maple.

Trees most suitable for openland plantings are eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, European larch, Douglas-fir, walnut, green ash, and hackberry.

Trees suitable for interplanting in existing stands are the conifers and hardwoods mentioned in the foregoing paragraph and also red oak, white oak, and basswood.

Seedling mortality is slight. Plant competition from grass is slight or moderate. Equipment limitations are slight. The hazard of erosion ranges from slight to severe, depending on slope.

Trees most suitable for farmstead windbreaks are the *conifers*, eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, and Douglas-fir and the *hardwoods*, Norway poplar, Siouxland poplar, Robusta poplar, green ash, and hackberry. Shrubs include honeysuckle.

Species suitable for wildlife plantings are honeysuckle, viburnum, ninebark, lilac, dogwood, and cardinal autumn-olive.

WOODLAND SUITABILITY GROUP 3w1

This group consists of nearly level to gently sloping soils that are moderately poorly drained and medium textured and moderately fine textured. Permeability is moderate to moderately slow, except in the Guckeen soil that is slowly permeable in some layers. In this group are soils of the Cylinder, Guckeen, Le Sueur, Luther, and Nicollet series. Available water capacity is high, except in the Cylinder soils that have a low to moderate available water capacity.

Suitability of these soils for upland oaks and conifers is moderately high and for cottonwoods, high. The site index for the hardwood trees ranges from 56 to 65. Estimated annual growth of existing trees on soils of this group ranges from 150 to 199 board feet per acre per year.

Trees to favor in existing woodlands are green ash, hackberry, white oak, red oak, and cottonwood.

Trees most suitable for openland plantings are eastern white pine, Scotch pine, red pine, Norway spruce, eastern redcedar, European larch, green ash, walnut, and hackberry.

Trees suitable for interplanting in existing stands are the conifers and hardwoods mentioned in the foregoing paragraph and also red oak, white oak, and basswood.

Seedling mortality is slight. Plant competition from undesirable species is moderate. Equipment limitations are slight. The hazard of erosion ranges from slight to none.

Trees most suitable for farmstead windbreaks are the *conifers*, eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, and Douglas-fir and the *hardwoods*, Norway poplar, Siouxland poplar, Robusta poplar, green ash, and hackberry. Shrubs most suitable are honeysuckle and red-osier dogwood.

WOODLAND SUITABILITY GROUP 4s1

This group consists of nearly level to strongly sloping soils that are excessively drained, moderately coarse textured, and that have sand and gravel at a depth of 15 to 30 inches. Permeability is rapid to very rapid. Available water capacity is low. In this group are soils of the Estherville series.

Suitability of these soils for upland oaks is moderate and for conifers and cottonwoods is moderately high. The site index for upland oaks ranges from 46 to 55. Estimated annual growth of existing trees on soils of this group ranges from 100 to 149 board feet per acre per year.

Trees to favor in existing woodlands are red oak, white oak, green ash, hackberry, and cottonwood.

Trees most suitable for openland plantings are eastern white pine, red pine, Scotch pine, European larch, and eastern redcedar.

Trees suitable for interplanting in existing stands are the conifers and hardwoods mentioned in the foregoing paragraph and also red oak, white oak, and basswood.

Seedling mortality is severe in some dry years. Plant competition from grass is slight to moderate. Equipment limitations are slight. The hazard of erosion ranges from slight to severe, depending on slope.

Trees most suitable for farmstead windbreaks are the *conifers*, eastern white pine, red pine, Scotch pine, eastern redcedar, Norway spruce, and Douglas-fir and the *hardwoods*, Norway poplar, Siouxland poplar, Robusta poplar, green ash, and hackberry. Suitable shrubs for planting include honeysuckle.

Species suitable for wildlife plantings are honeysuckle, viburnum, ninebark, lilac, dogwood, and cardinal autumn-olive.

WOODLAND SUITABILITY GROUP 5s1

This group consists of excessively drained and well-drained, coarse-textured and medium-textured soils that are shallow to sand and bedrock. Permeability is mostly very rapid. In this group are Boone loamy fine sand, 25 to 45 percent slopes, and Rock land and Steep sandy land. Available water capacity is very low for the Boone soil and variable but mainly very low for the Rock land and Steep sandy land.

Suitability of these soils for upland oaks, conifers, and cottonwoods is low. The site index for upland oaks is less than 45. Estimated annual growth of existing trees on

soils of this group is less than 100 board feet per acre per year.

Trees to favor in existing hardwood woodlands are green ash, hackberry, red oak, and white oak.

Trees suitable for openland noncommercial plantings are eastern white pine, Scotch pine, red pine, European larch, eastern redcedar, and cottonwood.

Trees suitable for interplanting in existing stands are the conifers and hardwoods mentioned in the foregoing paragraph and also red oak, white oak, and basswood.

Seedling mortality is slight to severe on these soils, depending on the amount of competition from grass and variation in moisture supply. Equipment limitation is slight on slopes of 0 to 18 percent and moderate or severe on slopes of more than 18 percent. The hazard of erosion ranges from slight to severe, depending on slope.

Trees most suitable for farmstead windbreaks are the *conifers*, eastern white pine, Scotch pine, red pine, and eastern redcedar.

Species most suitable for wildlife plantings are honeysuckle and ninebark.

WOODLAND SUITABILITY GROUP 5t1

This group consists of moderately sloping to very steep soils that are well drained and medium textured. Available water capacity is high. In this group are soils of the Storden series and a Hayden soil that is mapped in a complex with the Storden soils. Storden soils are calcareous at or near the surface.

Suitability of these soils for upland oaks and conifers is low and for cottonwoods, moderate. The site index for upland oaks is less than 45. Estimated annual growth of existing trees on soils of this group is less than 100 board feet per acre per year.

Trees most suitable for noncommercial plantings are ponderosa pine, Austrian pine, Scotch pine, hackberry, cottonwood, and green ash.

Seedling mortality is moderate to severe. Plant competition from grass is severe. Equipment limitations are moderate to severe. The hazards of erosion and climate are severe. Alkalinity is severe.

Trees most suitable for farmstead windbreaks are the *conifers*, ponderosa pine, Austrian pine, and Scotch pine and the *hardwoods*, Norway poplar, Siouxland poplar, Robusta poplar, green ash, hackberry, and Russian-olive.

Species suitable for wildlife plantings are wild plum, honeysuckle, aromatic sumac, Russian-olive, and redcedar.

WOODLAND SUITABILITY GROUP 5w1

This group consists of nearly level to steep, moderately well drained to poorly drained soils that have shale in the substratum. Permeability is very slow. Available water capacity is low to high. Runoff is slow to rapid. In this group are soils of the Calamine, Gosport, and Jacwin series.

Suitability of these soils for upland oaks, conifers, and cottonwoods is low. The site index for upland hardwoods is less than 45. Estimated annual growth of existing trees on soils of this group is less than 100 board feet per acre per year.

Trees to favor in existing hardwood woodlands are green ash, hackberry, and cottonwood.

Trees most suitable for openland noncommercial plantings are redcedar, Scotch pine, green ash, hackberry, and cottonwood.

Seedling mortality is slight. Plant competition from undesirable species is slight. Equipment limitations are moderate. The hazard of erosion ranges from slight to moderate.

Trees most suitable for farmstead windbreaks are the *conifers*, redcedar and Scotch pine and the *hardwoods*, green ash, hackberry, and cottonwood. The quality of the windbreak site is good for green ash, hackberry, and cottonwood and poor for redcedar and Scotch pine.

WOODLAND SUITABILITY GROUP 5w2

This group consists of nearly level to gently sloping soils that are well drained to somewhat poorly drained and moderately coarse textured and medium textured. These soils are on bottom lands. Permeability is moderate to rapid. Available water capacity ranges from high to very low. Runoff is slow to medium. Most areas of these soils are subject to flooding. In this group are soils of the Ankeny, Dorchester, Hanlon, and Spillville series and Alluvial land and Sandy alluvial land.

Suitability of these soils for upland oaks and conifers is low; for bottomland hardwoods, moderately high to high.

Trees to favor in existing woodlands are cottonwood, soft maple, and green ash. These soils are not well suited to upland hardwoods or conifers.

Seedling mortality is slight to moderate. Plant competition from undesirable species is moderate to severe. Equipment limitations are slight. The hazard of erosion is slight.

Trees most suitable for windbreaks are cottonwood, soft maple, and green ash. The quality of the windbreak site is high for cottonwood and soft maple.

WOODLAND SUITABILITY GROUP 5w3

This group consists of nearly level to gently sloping soils that are poorly drained and medium textured to fine textured. They are in depressions. Permeability is moderate to very slow. In this group are soils of the Biscay, Calco, Canisteo, Colo, Cordova, Dundas, Harps, Lanyon, Marna, Minnetonka, Okoboji, Rolfe, Spillville, Talcot, Wacousta, and Webster series. Available water capacity is high for most of the soils, but it is moderate for the Biscay soil and low to moderate for the Talcot soil.

Suitability of these soils for upland oaks and conifers is low and for cottonwoods, moderate to high. These soils are not well suited to commercial wood crop production.

Trees most suited to these soils are soft maple, cottonwood, sycamore, willow, green ash, and hackberry.

Trees less suited to these soils are redcedar, eastern white pine, Scotch pine, Norway spruce, and European larch. These conifers are suited mainly to soils on uplands and terraces.

WOODLAND SUITABILITY GROUP 5w4

This group consists of very poorly drained Muck soils. Suitability of these organic soils for cottonwood and willow is moderate to high.

Species suitable for wildlife plantings are red-osier dogwood and buttonball bush.

Use of the Soils for Wildlife and Recreation

Webster County supports a number of types of wildlife that contribute to its economy and recreation. The kinds and amounts of wildlife that can be produced and maintained in the county are largely determined by the kinds and amounts of vegetation the soils can support and by the manner in which this vegetation is distributed. Wildlife is influenced by topography and by such soil characteristics as fertility (fertile soils are capable of supporting more wildlife than infertile soils). Extremely rough, irregular areas are hazardous to livestock and are unsuited to the production of crops. In such areas the undisturbed vegetation is often valuable to wildlife. If not, suitable vegetation can be developed to attract desirable kinds of wildlife in many places.

Wetness and available water capacity of the soils are important in selecting sites for fish ponds and in maintaining aquatic or semi-aquatic habitat suitable for waterfowl and for some species of furbearing animals.

The wildlife resources of Webster County are important mainly for the opportunities they provide for recreation. Many species of wildlife, however, are also beneficial in the control of undesirable insects and rodents. Many species of birds are highly beneficial because they eat harmful insects. Hawks, owls, and other avian predators help to keep undesirable rodents within tolerable numbers, as do shrews, skunks, foxes, and snakes.

Pheasant, cottontail rabbit, jackrabbit, squirrel, and deer provide much of the recreational hunting in Webster County. Pheasant and rabbit have a fairly uniform distribution throughout the county. However, soils in soil associations 1, 4, and 5 are often used so intensively for row crops that the cover needed for wildlife shelter and nesting is limited. This is also true to a lesser extent in nearly level areas of soil association 2. Squirrel and deer are most numerous in soil association 3 because trees, the food supply, and the cover favor these species. Opossum, raccoon, weasel, badger, muskrat, mink, fox, and skunk are present in varying numbers throughout the county. Beaver live along some streams (fig. 18).

Sloughs and depressions are abundant in Webster County, but nearly all of them have been drained and provide very little benefit to migrating waterfowl. Most of the waterfowl land near a river, stream, or ditch and feed in nearby cornfields.

The Des Moines River, Lizard Creek, and Badger Lake provide some fishing. A few farm ponds in the county have been stocked with fish, and these provide excellent fishing if properly managed. The Storden soils and soils of the Storden-Hayden complex are well suited to farm ponds so far as site and soil material are concerned. Most of the better sites are in soil association 3.

The combination of soils, topography, and vegetation in Webster County favors the development of facilities for outdoor recreation. Many areas that are of no great value for farming are suitable for such developments.

Dolliver State Park near Lehigh, Deception Hollow State Park southeast of Lehigh, Woodman Hollow State Park near Coalville, and Kennedy County Park north of Fort Dodge are examples of recreational developments. In these places the Boone, Gosport, and Storden soils and soils of the Storden-Hayden complex provide sites for recreation for many people in the form of hiking, picnicking, and nature study. The adjacent Nicollet and Clarion soils on uplands, Terril and Spillville soils on foot slopes, and Hanlon soils on bottom lands provide sites for picnic areas.

Many areas that cannot be used economically to produce crops are well suited to wildlife. On most farms there are areas that are better suited to the development of wildlife habitat than to other uses. Most of the soils in the county are suited to wildlife habitat and recreation, but Estherville, Storden, and Wadena soils, Rock land and Steep sandy land, or bottomland areas of Alluvial land, Sandy alluvial land, or Buckney soils are better suited than other areas. Such small areas as gravel spots, sand spots, old quarries, borrow pits, or gravel pits are also suitable.

Engineering Uses of the Soils [2]

This section is useful to those who need information about soils used as structural material or as foundations upon which structures are built. Among those who can benefit from this section are planning commissions, town and city managers, land developers, engineers, contractors, and farmers.

Among properties of soils highly important in engineering are permeability, strength, compaction characteristics, soil drainage condition, shrink-swell potential, grain size, plasticity, and soil reaction. Also important are depth to the water table, depth to bedrock, and slope. These properties, in various degrees and combinations, affect construction and maintenance of roads, airports, pipelines, foundations for small buildings, irrigation systems, ponds and small dams, and systems for disposal of sewage and refuse.

Information in this section of the soil survey can be helpful to—

1. Select potential residential, industrial, commercial, and recreational areas.
2. Evaluate alternate routes for roads, highways, pipelines, and underground cables.
3. Seek sources of gravel, sand, or clay.
4. Plan farm drainage systems, irrigation systems, ponds, terraces, and other structures for controlling water and conserving soil.
5. Correlate performance of structures already built with properties of the kinds of soil on which they are built, for the purpose of predicting performance of structures on the same or similar kinds of soil in other locations.
6. Predict the trafficability of soils for cross-country movement of vehicles and construction equipment.
7. Develop preliminary estimates pertinent to construction in a particular area.

[2] Tables 3 and 4 were prepared with the help of D. A. ANDERSON, soils engineer, Iowa State Highway Commission.

Figure 18.—**Dam built by beaver in Lizard Creek.**

Most of the information in this section is presented in tables 3, 4, and 5.

This information, along with the soil map and other parts of this publication, can be used to make interpretations in addition to those given in tables 3 and 4, and it also can be used to make other useful maps.

Engineering classification systems

The two systems most commonly used in classifying samples of soils for engineering are the Unified system (*19*) used by the SCS engineers, Department of Defense, and others, and the AASHO system (*1*) adopted by the American Association of State Highway Officials.

In the Unified system soils are classified according to particle-size distribution, plasticity, liquid limit, and organic matter. Soils are grouped in 15 classes. These are eight classes of coarse-grained soils, identified as GW, GP, GM, GC, SW, SP, SM, and SC; six classes of fine-grained soils, identified as ML, CL, OL, MH, CH, and OH; and one class of highly organic soils, identified as Pt. Soils on the borderline between two classes are designated by symbols for both classes; for example, ML–CL.

This information, however, does not eliminate the need for further investigations at sites selected for engineering works, especially works that involve heavy loads or that require excavations to depths greater than those shown in the tables, generally depths greater than 6 feet. Also, inspection of sites, especially small ones, is needed because many delineated areas of a given soil mapping unit may contain small areas of other kinds of soil that have strongly contrasting properties and different suitabilities or limitations for engineering.

Some of the terms used in this soil survey have special meaning to soil scientists that is not known to all engineers. The Glossary defines many of these terms.

TABLE 3.—*Estimated soil properties*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil, which may of this table. The symbol > means

Soil series and map symbol	Depth to seasonal high water table	Depth from surface	Classification		
			Dominant USDA texture	Unified	AASHO
	Feet	*Inches*			
Alluvial land: 315B. Soil properties too variable for valid estimates.					
Ankeny: 136A	>5	0–28	Fine sandy loam	SM or SC	A–4 (0–3)
		28–52	Fine sandy loam	SM or SC	A–2–4 (0) or A–4 (0–3)
		52–62	Sand	SM or SP–SM	A–2–4 (0) or A–3 (0)
Billett: 775B, 775C	>5	0–22	Fine sandy loam	SM or SC	A–2–4 (0) or A–4 (1–3)
		22–46	Fine sandy loam and fine sandy clay loam.	SM or SC	A–2–4 (0) or A–4 (1–4)
		46–60	Sand	SM or SP–SM	A–2–4 (0) or A–3 (0)
Biscay: 259	1–3	0–19	Clay loam	OL or CL	A–7–5 or A–7–6 (10–14)
		19–39	Clay loam and sandy clay loam.	CL	A–6 (4) to A–7–6 (14)
		39–60	Sand and gravel	SP–SM or SM	A–1–b or A–2–4 (0)
Boone: 210G	>5	0–16	Loamy fine sand and loamy sand.	SM	A–2–4 (0)
		16–25	Sand	SP–SM or SM	A–2–4 (0) or A–3 (0)
		25–31	Sandstone		
Buckney: 636A, 636B	[1] 3–5	0–12	Fine sandy loam	SM	A–2–4 (0) to A–4 (4)
		12–54	Fine sandy loam and loamy fine sand.	SM	A–2 or A–4 (0)
Calamine: 551B, 551D	0–3	0–20	Silty clay loam	CH	A–7–5 or A–7–6 (10–14)
		20–32	Silty clay loam	CL or CH	A–7–6 (10–16)
		32–68	Silty clay loam shale	CH	A–7–6 (14–20)
Calco: 733	[1] 1–3	0–20	Silty clay loam	OH or CH or CL	A–7–5 or A–7–6 (14–18)
		20–37	Silty clay loam	CH or CL	A–7–6 (14–18)
		37–60	Clay loam, loam, and sandy loam.	CL or SM	A–4 (6) to A–2–4 (0)
Canisteo: 507	1–3	0–17	Silty clay loam and clay loam.	OL or CL, OH or CH	A–7–5 or A–7–6 (14–19)
		17–38	Clay loam	CL	A–6 (10) to A–7–6 (14)
		38–60	Loam	CL	A–6 (6) to A–7–6 (14)
Clarion: 138A, 138B, 138C, 138C2, 138D2, 138E2.	>5	0–11	Loam	CL	A–4 (4) to A–6 (9)
		11–55	Loam	CL	A–4 (4) to A–6 (9)
*Colo: 133, 585B For properties of Spillville part of 585B, see the Spillville series.	[1] 1–3	0–39	Silty clay loam	OH or CH or CL	A–7–5 or A–7–6 (14–19)
		39–51	Silty clay loam	CH or CL	A–7–6 (14–19)
		51–56	Silty clay loam	CL	A–7–6 (12–18)
Cordova: 386	1–3	0–15	Silty clay loam	OL or CL	A–7–5 or A–7–6 (14–19)
		15–37	Clay loam	CL or CH	A–7–6 (14–18)
		37–58	Loam	CL	A–6 (4) to A–7–6 (14)

See footnotes at end of table.

significant in engineering

have different properties. For this reason the reader should follow carefully the instructions for referring to another series in the first column greater than; the symbol < means less than]

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)	*Inches per hour*	*Inches per inch of soil*	*pH value*	
100	95–100	35–45	2. 0–6. 3	0. 15	6. 6–7. 3	Low.
100	95–100	25–45	2. 0–6. 3	0. 12	7. 4–7. 8	Low.
100	95–100	5–25	6. 3–20. 0	0. 04	7. 4–7. 8	Low.
100	90–100	30–50	2. 0–6. 3	0. 12	6. 1–7. 3	Low.
100	90–100	30–45	2. 0–6. 3	0. 13	5. 6–6. 5	Low.
100	100	5–30	6. 3–20. 0	0. 04	6. 6–7. 3	Low.
100	95–100	70–85	0. 63–2. 0	0. 21	6. 6–7. 3	Moderate or high.
100	95–100	50–75	0. 2–2. 0	0. 17	6. 6–7. 8	Moderate.
75–95	60–80	5–25	6. 3–20. 0+	0. 03	7. 4–8. 4	Very low or none.
100	100	15–30	6. 3–20. 0	0. 08	6. 1–6. 5	Low.
100	100	5–15	6. 3–20. 0	0. 04	5. 6–6. 0	Low.
					5. 6–6. 0	None.
100	100	30–50	2. 0–6. 3	0. 14	7. 4–7. 8	Low.
100	100	15–50	6. 3–20. 0	0. 04–0. 12	7. 4–7. 8	Low.
100	95–100	85–100	0. 2–0. 63	0. 20	6. 6–7. 3	Moderate or high.
95–100	90–100	65–85	0. 2–0. 63	0. 15	6. 6–7. 8	High.
100	95–100	90–100	<0. 06	0. 10	7. 9–8. 4	High.
100	100	80–95	0. 2–0. 63	0. 21	7. 4–7. 8	High.
100	100	75–90	0. 2–0. 63	0. 18	7. 4–8. 4	High.
100	95–100	30–80	0. 63–2. 0	0. 12–0. 16	7. 9–8. 4	Moderate.
100	95–100	70–90	0. 63–2. 0	0. 21	7. 9–8. 4	Moderate or high.
95–100	90–100	60–80	0. 2–0. 63	0. 17	7. 9–8. 4	Moderate or high.
95–100	90–100	50–75	0. 63–2. 0	0. 17	7. 9–8. 4	Moderate.
95–100	95–100	50–75	0. 63–2. 0	0. 18	6. 6–7. 3	Moderate.
90–100	85–100	50–75	0. 63–2. 0	0. 16	6. 6–8. 4	Moderate.
100	100	80–95	0. 2–0. 63	0. 21	6. 6–7. 3	High.
100	100	75–90	0. 2–0. 63	0. 18	6. 6–7. 3	High.
100	100	70–90	0. 63–2. 0	0. 18	7. 4–7. 8	Moderate or high.
100	95–100	70–90	0. 2–0. 63	0. 21	6. 1–7. 3	Moderate or high.
95–100	95–100	60–80	0. 2–0. 63	0. 17	7. 3–7. 8	Moderate or high.
95–100	90–100	50–80	0. 63–2. 0	0. 17	7. 9–8. 4	Moderate.

TABLE 3.—*Estimated soil properties*

Soil series and map symbol	Depth to seasonal high water table	Depth from surface	Classification		
			Dominant USDA texture	Unified	AASHO
	Feet	*Inches*			
Cylinder:					
203	2–4	0–14	Loam	CL	A–6 (8) to A–7–6 (12)
		14–38	Loam	CL or SC	A–4 (3) to A–6 (8)
		38–50	Sand and gravel	SP–SM or SM	A–1–b (0) or A–2–4 (0)
202	2–4	0–14	Loam	CL	A–6 (8) to A–7–6 (12)
		14–29	Loam and sandy clay loam.	CL or SC	A–4 (1) to A–6 (8)
		29–48	Sand and gravel	SP–SM or SM	A–1–b (0) or A–2–4 (0)
Dorchester: 158, 815	[1] 0–4	0–31	Silt loam	ML or CL	A–4 (6) to A–6 (10)
		31–59	Silt loam	ML or CL	A–4 (6) to A–6 (10)
		59–76	Very fine sandy loam to loamy fine sand.	SM or ML	A–4 (1–4) or A–2–4 (0)
Dundas: 307	[2] 0–3	0–12	Silt loam	CL	A–6 (6) to A–7–6 (12)
		12–40	Clay loam	CH	A–7–6 (15–20)
		40–58	Clay loam	CL	A–6 (8) to A–7–6 (14)
Estherville: 34A, 34B, 34C, 34D	>5	0–14	Sandy loam	SM	A–2–4 (0)
		14–35	Sandy loam	SM	A–2–4 (0)
		35–48	Sand and gravel	SP–SM or SM	A–1–b (0) or A–2–4 (0)
Gosport: 313G	>5	0–7	Silt loam	ML or CL	A–6 (8–12)
		7–28	Silty clay	CH	A–7–6 (20)
		28–60	Shale	CH	A–7–6 (20)
Guckeen: 385A	2–4	0–16	Clay loam	CL or CH	A–6 (10) to A–7–6 (16)
		16–36	Light clay	CH	A–7–6 (16–20)
		36–72	Clay loam	CL	A–6 (8) to A–7–6 (13)
Hanlon: 536A	[1] 2–5	0–27	Fine sandy loam	SM	A–4 (0–4)
		27–46	Fine sandy loam	SM	A–4 (0–4)
		46–60	Medium and coarse sand.	SM–SP or SM	A–1–b (0) or A–2–4 (0)
Harps: 95	1–3	0–16	Clay loam	OL or CL	A–6 (8) to A–7–5 (13)
		16–42	Loam	CL	A–6 (8) to A–7–6 (13)
		42–60	Loam	CL	A–6 (8–12)
Hayden: 168B, 168C	>5	0–15	Loam	ML–CL or CL	A–4 (4–8)
		15–42	Clay loam	CL	A–6 (5–10)
		42–60	Loam	CL	A–4 (4) to A–6 (9)
Jacwin: 444A	2–4	0–12	Loam	CL	A–6 (6–12)
		12–24	Clay loam	CL	A–6 (8–12)
		24–36	Cobbly loam	SM or SC	A–4 (0–4)
		36–54	Shale with fragments of limestone and sandstone.	CH	A–6 (6) to A–7–6 (16)
Kamrar: 387B	>5	0–12	Clay loam	CL	A–6 (8) to A–7–6 (14)
		12–26	Clay loam	CL or CH	A–6 (12) to A–7–6 (16)
		26–56	Clay loam and loam	CL	A–6 (6) to A–7–6 (12)

See footnotes at end of table.

significant in engineering—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
			Inches per hour	*Inches per inch of soil*	*pH value*	
100	90–100	50–75	0. 63–2. 0	0. 18	6. 6–7. 3	Moderate.
95–100	80–100	40–60	0. 63–2. 0	0. 15	6. 1–7. 3	Moderate.
75–95	60–80	5–25	6. 3–20. 0+	0. 03	7. 4–8. 4	Very low or none.
100	90–100	50–75	0. 63–2. 0	0. 18	6. 6–7. 3	Moderate.
95–100	80–100	35–60	0. 63–2. 0	0. 15	6. 1–7. 3	Moderate.
75–95	60–80	5–25	6. 3–20. 0+	0. 03	6. 6–7. 8	Very low or none.
100	95–100	80–95	0. 63–2. 0	0. 18	7. 8–8. 4	Low or moderate.
100	95–100	70–90	0. 63–2. 0	0. 18	7. 8–8. 4	Low or moderate.
100	90–100	30–60	2. 0–6. 3	0. 10	7. 8–8. 4	Low.
100	95–100	70–90	0. 63–2. 0	0. 20	5. 6–6. 5	Moderate.
95–100	95–100	70–90	0. 06–0. 63	0. 17	5. 1–7. 8	High.
95–100	90–100	50–80	0. 20–2. 0	0. 17	7. 9–8. 4	Moderate.
100	80–95	20–35	2. 0–6. 3	0. 10	6. 1–7. 3	Low.
90–100	75–95	15–35	2. 0–6. 3	0. 08	6. 6–7. 3	Low.
70–90	60–80	5–30	6. 3–20. 0+	0. 03	7. 4–7. 8	Very low or none.
100	100	85–100	0. 63–2. 0	0. 18	5. 1–7. 3	Moderate.
100	100	90–100	<0. 06	0. 12	4. 5–5. 0	High.
100	95–100	90–100	<0. 06	0. 08	----------	High.
100	95–100	70–90	0. 2–0. 63	0. 18	5. 6–6. 5	Moderate or high.
100	95–100	75–90	0. 06–0. 63	0. 16	6. 1–7. 8	High.
95–100	90–100	50–75	0. 20–2. 0	0. 17	7. 9–8. 4	Moderate.
100	95–100	40–50	2. 0–6. 3	0. 12	6. 6–7. 8	Low.
100	95–100	35–50	2. 0–6. 3	0. 10	7. 4–7. 8	Low.
100	90–100	5–25	6. 3–20. 0	0. 03	7. 9–8. 4	Low to none.
100	95–100	65–80	0. 63–2. 0	0. 18	7. 9–8. 4	Moderate or high.
95–100	95–100	65–80	0. 63–2. 0	0. 17	7. 9–8. 4	Moderate.
95–100	90–100	50–75	0. 63–2. 0	0. 16	7. 9–8. 4	Moderate.
100	95–100	50–75	0. 63–2. 0	0. 17	5. 6–6. 5	Moderate.
95–100	90–100	50–75	0. 63–2. 0	0. 17	6. 1–7. 3	Moderate.
90–100	85–100	50–75	0. 62–2. 0	0. 16	7. 9–8. 4	Moderate.
100	80–100	55–75	0. 63–2. 0	0. 18	6. 1–6. 5	Moderate.
100	80–100	55–75	0. 63–2. 0	0. 17	6. 6–7. 8	Moderate.
50–75	45–70	35–50	2. 0–6. 3	0. 12	7. 4–7. 8	Low or moderate.
25–50	25–50	50–70	<0. 06	0. 10	7. 9–8. 4	High.
95–100	95–100	60–85	0. 63–2. 0	0. 19	5. 6–6. 5	Moderate.
95–100	90–100	60–85	0. 2–0. 63	0. 17	6. 1–7. 3	Moderate or high.
90–100	85–95	50–75	0. 63–2. 0	0. 16	7. 4–8. 4	Moderate.

TABLE 3.—*Estimated soil properties*

Soil series and map symbol	Depth to seasonal high water table	Depth from surface	Classification		
			Dominant USDA texture	Unified	AASHO
	Feet	*Inches*			
Lanyon: 606	[2] 0–3	0–13	Silty clay	CH or OH	A–7–5 or A–7–6 (16–20)
		13–52	Silty clay	CH	A–7–6 (16–20)
		52–70	Clay loam	CL	A–6 (8) to A–7–6 (14)
Lester: 236B, 236C, 236D, 236E, 236F	>5	0–12	Loam	ML–CL or CL	A–4 (6) to A–6 (8)
		12–48	Clay loam	CL	A–6 (5–10) or A–7–6 (10–14)
		48–72	Loam	CL	A–4 (4) to A–6 (12)
Le Sueur: 325A	2–4	0–12	Loam	ML–CL or CL	A–4 (4) to A–6 (8)
		12–38	Clay loam	CL	A–6 (8) to A–7–6 (4)
		38–52	Loam and clay loam	CL	A–4 (4) to A–6 (12)
Luther: 355A	2–4	0–10	Loam	ML–CL or CL	A–4 (4) to A–6 (8)
		10–42	Clay loam	CL	A–6 (8) to A–7–6 (14)
		42–72	Loam	CL	A–4 (4) to A–6 (12)
Marna: 383	1–3	0–14	Silty clay loam to silty clay.	OH or CH	A–7–5 or A–7–6 (14–20)
		14–40	Silty clay to silty clay loam.	CH	A–7–6 (15–20)
		40–67	Light clay loam and loam.	CL	A–6 (6) to A–7–6 (14)
Minnetonka: 583	1–3	0–14	Silty clay loam	OH or CH or CL	A–7–5 or A–7–6 (12–17)
		14–33	Silty clay	CH	A–7–6 (17–20)
		33–52	Loam	CL	A–6 (6–12)
Muck: 21, 21D	0–2	0–15	Muck	Pt	Muck
		15–48	Silt loam, silty clay loam, clay loam, and loam.	OL to CL or CH	A–7–5 or A–7–6 (10–18)
		48–72	Clay loam	CL	A–6 (8) to A–7–6 (14)
Nicollet: 55A, 55B	2–4	0–11	Loam or light clay loam.	CL or ML–CL	A–6 (8) to A–7–6 (14)
		11–32	Clay loam	CL	A–6 (8) to A–7–6 (14)
		32–60	Loam	CL	A–4 (4) to A–6 (12)
Okoboji:					
6	[2] 0–3	0–32	Silty clay loam	OH or CH	A–7–5 or A–7–6 (14–20)
		32–60	Silty clay loam	CH or CL	A–7–6 (14–20)
90	[2] 0–3	0–8	Mucky silt loam	Pt	Muck
		8–32	Silty clay loam	OH or CH	A–7–5 or A–7–6 (14–20)
		32–60	Silty clay loam	CH or CL	A–7–6 (14–20)
Rock land and Steep sandy land: 478G. Soil properties too variable for valid estimates.					
Rockton: 214B	>5	0–13	Loam	CL	A–4 (4) to A–6 (8)
		13–24	Loam	CL	A–4 (4) to A–6 (8)
		24–40	Fragmented limestone with shale and loamy material.	----------	----------

See footnotes at end of table.

significant in engineering—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)	*Inches per hour*	*Inches per inch of soil*	*pH value*	
100	100	90–100	0. 06–0. 63	0. 18	6. 6–7. 8	High.
100	95–100	80–95	0. 06–0. 63	0. 16	7. 9–8. 4	High.
95–100	90–100	60–80	0. 63–2. 0	0. 16	7. 9–8. 4	Moderate.
95–100	95–100	60–80	0. 63–2. 0	0. 19	6. 1–7. 3	Moderate.
95–100	90–100	50–75	0. 63–2. 0	0. 17	5. 6–7. 3	Moderate.
90–100	85–100	50–75	0. 63–2. 0	0. 16	7. 9–8. 4	Moderate.
95–100	95–100	60–80	0. 63–2. 0	0. 20	5. 6–6. 5	Moderate.
95–100	90–100	60–80	0. 63–2. 0	0. 17	5. 6–6. 5	Moderate.
90–100	85–100	50–75	0. 63–2. 0	0. 16	7. 4–8. 4	Moderate.
95–100	95–100	60–80	0. 63–2. 0	0. 19	6. 1–7. 3	Moderate.
95–100	90–100	60–80	0. 20–0. 63	0. 17	5. 6–7. 3	Moderate.
90–100	85–100	50–75	0. 63–2. 0	0. 16	7. 4–8. 4	Moderate.
100	100	75–90	0. 06–0. 20	0. 19	6. 1–6. 5	High.
100	95–100	70–90	0. 06–0. 20	0. 16	6. 6–7. 8	High.
90–100	90–100	50–75	0. 63–2. 0	0. 17	7. 8–8. 4	Moderate.
100	95–100	80–95	0. 20–0. 63	0. 21	5. 6–6. 5	Moderate or high.
100	95–100	80–95	0. 06–0. 20	0. 17	5. 1–6. 5	High.
95–100	90–100	50–75	0. 20–0. 63	0. 17	6. 6–8. 4	Moderate.
100	100	100	2. 0–6. 3+	0. 25	7. 9–8. 4	Moderate.
100	95–100	70–90	0. 20–2. 0	0. 20	7. 9–8. 4	Moderate or high.
95–100	90–100	50–75	0. 20–2. 0	0. 17	7. 9–8. 4	Moderate.
95–100	95–100	60–80	0. 63–2. 0	0. 19	6. 1–6. 5	Moderate.
95–100	90–100	60–80	0. 63–2. 0	0. 17	6. 6–7. 8	Moderate.
90–100	85–100	50–80	0. 63–2. 0	0. 16	7. 9–8. 4	Moderate.
100	100	80–95	0. 06–0. 20	0. 21	7. 4–7. 8	High.
100	95–100	80–95	0. 06–0. 20	0. 19	7. 4–8. 4	High.
100	100	95–100	2. 0–6. 3	0. 23	7. 4–7. 8	Moderate.
100	100	80–95	0. 06–0. 20	0. 21	7. 4–7. 8	High.
100	95–100	80–95	0. 06–0. 20	0. 19	7. 4–7. 8	High.
95–100	80–100	50–75	0. 63–2. 0	0. 17	5. 6–6. 1	Moderate.
95–100	80–100	55–75	0. 63–2. 0	0. 16	5. 6–6. 5	Moderate.
10–30	5–20	5–20	(3)	(3)	6. 1–6. 5	Low to none.

TABLE 3.—*Estimated soil properties*

Soil series and map symbol	Depth to seasonal high water table	Depth from surface	Classification		
			Dominant USDA texture	Unified	AASHO
	Feet	*Inches*			
Rolfe: 274	[2] 0–3	0–14	Silt loam	OL or CL	A–6 (6–12)
		14–30	Silty clay loam	CL or CH	A–7–6 (14–18)
		30–60	Clay loam	CL	A–6 (8) to A–7–6 (14)
Sandy alluvial land: 715	[1] 2–5	0–48	Sandy or gravelly [3]	SP–SM or SM	A–2–4 (0) or A–3 (0)
Spillville: 485A, 485B	[1] 2–5	0–40	Loam	OL or CL	A–4 (8) to A–7–5 (12)
		40–60	Sandy loam	SM or SC	A–2–4 (0) or A–4 (2–6)
*Storden: 356G, 62C2, 62D2, 62E2, 62F2, 62G2. For properties of Hayden part of 356G, see the Hayden series.	>5	0–58	Loam	CL	A–4 (4) to A–6 (9)
Talcot:					
559	1–3	0–15	Clay loam	OL or CL	A–7–5 (10) to A–7–6 (14)
		15–37	Clay loam and sandy clay loam.	CL	A–6 (4) to A–7–6 (14)
		37–52	Sand and gravel	SP–SM or SM	A–1–b (0) or A–2–4 (0)
558	1–3	0–15	Clay loam	OL or CL	A–7–5 (10) to A–7–6 (14)
		15–28	Clay loam and sandy clay loam.	CL	A–6 (4) to A–7–6 (14)
		28–48	Sand and gravel	SP–SM or SM	A–1–b (0) or A–2–4 (0)
Terril:					
27C, 27D	>5	0–31	Loam	OL or CL	A–6 (5) to A–7–5 (10)
		31–48	Loam	CL	A–6 (6–12)
		48–72	Clay loam	CL	A–6 (6–12)
323B	>5	0–36	Loam	CL	A–4 (4) to A–6 (12)
		36–42	Sandy loam	SM	A–2–4 (0) or A–4 (2–4)
		42–50	Loamy fine sand	SM or SC	A–2–4 (0)
Terril, thin surface variant: 566C, 566D, 566E.	>5	0–15	Loam	CL	A–4 (4) to A–6 (12)
		15–58	Loam	CL	A–4 (4) to A–6 (12)
Turlin: 96B	[1] 3–5+	0–34	Loam	OL or CL	A–6(5) to A–7–5(10)
		34–66	Loam	CL	A–4(4) to A–6(8)
Wacousta: 506	[2] 0–3	0–8	Silt loam	OL or ML	A–6 (8) to A–7–6(14)
		8–28	Silty clay loam	CL or CH	A–6(9) to A–7–6(15)
		28–56	Loam	CL	A–6 (6–12)
Wadena:					
308A, 308B	>5	0–15	Loam	ML–CL or CL	A–4 (4) to A–6 (8)
		15–38	Loam	SC or CL	A–4 (4) to A–6 (8)
		38–50	Sand and gravel	SP–SM or SM	A–1–b (0) or A–2–4 (0)
108A, 108B, 108C	>5	0–16	Loam	ML–CL or CL	A–4 (4) to A–6 (8)
		16–30	Loam, sandy clay loam, and sandy loam.	SC or CL	A–4 (2) to A–6 (8)
		30–52	Sand and gravel	SP–SM or SM	A–1–b (0) or A–2–4 (0)

See footnotes at end of table.

significant in engineering—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
			Inches per hour	*Inches per inch of soil*	*pH value*	
100	95–100	80–95	0. 63–2. 0	0. 21	6. 1–6. 5	Moderate.
100	95–100	75–95	0. 06–0. 20	0. 18	6. 1–7. 3	High.
95–100	90–100	55–75	0. 20–0. 63	0. 17	6. 6–8. 4	Moderate or high.
95–100	95–100	5–25	6. 3–20. 0+	0. 08–0. 03	7. 4–8. 4	Low.
100	95–100	65–80	0. 63–2. 0	0. 20	6. 6–7. 3	Moderate.
100	90–100	25–50	2. 0–6. 3	0. 10	6. 6–7. 3	Moderate.
90–100	85–100	50–75	0. 63–2. 0	0. 16	7. 9–8. 4	Moderate.
100	95–100	70–85	0. 63–2. 0	0. 21	7. 9–8. 4	Moderate or high.
95–100	90–100	50–75	0. 20–2. 0	0. 17	7. 9–8. 4	Moderate.
75–95	60–80	5–25	6. 3–20. 0+	0. 03	7. 9–8. 4	Very low or none.
100	95–100	70–85	0. 63–2. 0	0. 21	7. 4–8. 4	Moderate or high.
95–100	90–100	50–75	0. 20–2. 0	0. 17	7. 9–8. 4	Moderate.
75–95	60–80	5–25	6. 3–20. 0+	0. 03	7. 9–8. 4	Very low or none.
100	95–100	60–80	0. 63–2. 0	0. 19	6. 1–7. 3	Moderate.
95–100	95–100	60–80	0. 63–2. 0	0. 17	6. 1–6. 5	Moderate.
90–100	90–100	60–80	0. 63–2. 0	0. 17	6. 6–7. 3	Moderate.
100	100	60–75	0. 63–2. 0	0. 19	6. 1–6. 5	Moderate.
100	95–100	30–40	2. 0–6. 3	0. 12	6. 1–6. 5	Low.
95–100	95–100	15–30	6. 3–20. 0	0. 07	6. 6–7. 3	Low.
95–100	90–100	60–80	0. 63–2. 0	0. 19	5. 6–6. 0	Moderate.
95–100	90–100	60–80	0. 63–2. 0	0. 16	6. 1–7. 3	Moderate.
100	95–100	60–80	0. 63–2. 0	0. 19	6. 6–7. 3	Moderate.
100	95–100	55–75	0. 63–2. 0	0. 17	6. 6–7. 3	Moderate.
100	100	80–95	0. 63–2. 0	0. 23	6. 6–7. 8	Moderate or high.
100	95–100	75–95	0. 20–2. 0	0. 19	7. 4–8. 4	Moderate or high.
95–100	90–100	60–80	0. 63–2. 0	0. 17	7. 9–8. 4	Moderate.
100	90–100	50–75	0. 63–2. 0	0. 18	6. 1–7. 3	Moderate.
95–100	80–100	45–60	0. 63–2. 0	0. 17	6. 6–7. 8	Moderate.
75–95	60–80	5–25	6. 3–20. 0+	0. 03	7. 4–8. 4	Very low or none.
100	90–100	50–75	0. 63–2. 0	0. 18	6. 6–7. 3	Moderate.
95–100	80–100	45–60	0. 63–2. 0	0. 15	6. 6–7. 8	Moderate.
75–95	60–80	5–25	6. 3–20. 0+	0. 03	7. 4–8. 4	Very low or none.

TABLE 3.—*Estimated soil properties*

Soil series and map symbol	Depth to seasonal high water table	Depth from surface	Classification		
			Dominant USDA texture	Unified	AASHO
Wadena, thin surface variant, deep:	*Feet*	*Inches*			
778B	>5	0–11	Loam	ML–CL or CL	A–4 (4) to A–6 (8)
		11–39	Clay loam and sandy clay loam.	SC or CL	A–4 (2) to A–6 (8)
		39–48	Sand and gravel	SP–SM or SM	A–1–b (0) or A–2–4 (0)
777B	>5	0–10	Loam	ML–CL or CL	A–4 (4) to A–6 (8)
		10–28	Clay loam and sandy clay loam.	SC or CL	A–4 (3) to A–6 (8)
		28–60	Gravelly sand	SP–SM	A–1–b (0) to A–2–4 (0)
Webster: 107, 107B	1–3	0–24	Silty clay loam	OL, CL, OH or CH	A–7–5 or A–7–6 (14–19)
		24–36	Clay loam	CL	A–6 (10) to A–7–6 (17)
		36–65	Loam	CL	A–6 (6) to A–7–6 (14)

[1] Subject to flooding.
[2] Subject to ponding of surface water.
[3] Variable.

TABLE 4.—*Interpretations of*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil, which may first column

Soil series and map symbol	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Alluvial land: 315B	Suitability is variable.	Poor: many areas not suitable; generally sand is variable and stratified with fines.	Not suitable	Variable: subject to flooding; material wet and hard to excavate in places.	Subject to flooding; seasonal high water table; variable soil materials for foundation for embankment at bridge sites.	Subject to flooding; seasonal high water table; variable soil material, but generally fair to good bearing capacity and shear strength.
Ankeny: 136A	Good: moderately coarse textured; moderate content of organic matter.	Poor: underlying sand variable; considerable fines in many places.	Not suitable	Good: fair bearing capacity; slight compressibility; good workability; good compaction.	Erodible where exposed on embankments; deep cuts can seep and slide.	Low shrink-swell potential: fair bearing capacity; subject to rapid and possibily uneven consolidation.

See footnote at end of table.

significant in engineering—Continued

Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 200 (0.074 mm.)				
			Inches per hour	*Inches per inch of soil*	*pH value*	
100	90–100	50–75	0. 63–2. 0	0. 18	6. 1–6. 5	Moderate.
95–100	90–100	40–60	0. 63–2. 0	0. 15	6. 1–7. 3	Moderate.
75–95	50–80	5–25	6. 3–20. 0+	0. 03	7. 4–8. 4	Very low or none.
95–100	95–100	50–75	0. 63–2. 0	0. 17	6. 6–7. 3	Moderate.
95–100	90–100	40–60	0. 63–2. 0	0. 16	6. 6–7. 3	Moderate.
75–95	50–80	5–25	6. 3–20. 0+	0. 03	7. 9–8. 4	Very low or none.
100	95–100	70–90	0. 63–2. 0	0. 21	6. 6–7. 3	Moderate or high.
95–100	95–100	60–80	0. 20–2. 0	0. 17	6. 6–7. 3	Moderate or high.
95–100	90–100	50–75	0. 63–2. 0	0. 16	7. 9–8. 4	Moderate.

engineering properties

have different interpretations. For this reason the reader should follow carefully the instructions for referring to another series in the of this table]

Soil features affecting—Continued						Soil limitations for use as—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Septic tank absorption field	Sewage lagoon
Reservoir area	Embankment						
Variable material in substratum, but moderately rapid or rapid permeability in many places.	Wet and hard to excavate in places; variable soil material.	Subject to flooding; variable natural drainage; outlets generally difficult to obtain.	Variable but generally rapid intake rate; subject to flooding; seldom used for crops.	Nearly level bottom land.	Nearly level bottom land; variable soil material; subject to flooding.	Severe: subject to flooding and high water table; hazard of contamination to streams or water supplies.	Severe: permeability variable but generally moderately rapid; subject to flooding.
Rapid permeability in substratum.	Fair stability; good workability; good compaction; erodible on slopes; poor resistance to piping.	Well drained; drainage not needed.	Low or moderate available water capacity; rapid intake rate.	Nearly level to gently sloping; soil features favorable for construction; erodible on back slopes and in channels.	Erodible; droughtiness hinders establishing vegetation in places.	Slight: hazard of contamination to streams or water supplies.	Severe: moderately rapid or rapid permeability.

TABLE 4.—*Interpretations of*

Soil series and map symbol	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Billett: 775B, 775C	Fair: moderately coarse textured; low content of organic matter.	Poor: underlying sand variable; considerable fines in many places.	Not suitable	Good: fair bearing capacity; slight compressibility; low shrink-swell potential.	Erodible where exposed on embankments; good workability.	Slight compressibility; fair shear strength; fair bearing capacity; can liquefy and flow where saturated.
Biscay: 259	Fair: moderately fine textured; high content of organic matter; seasonal high water table.	Good, but generally mixed with gravel: high water table can hinder excavation.	Fair, but mixed with sand; high water table can hinder excavation.	Very poor to depth of about 2 feet; very good in underlying sand and gravel: high water table can hinder excavation.	Seasonal high water table; high content of organic matter to depth of about 1½ to 2 feet; substratum a good source of borrow material.	Seasonal high water table; high content of organic matter; good bearing capacity and slight compressibility in substratum.
Boone: 210G	Unsuitable: steep slopes; available material in a thin layer; low in fertility; low in available water capacity.	Not suitable	Not suitable	Poor: mostly in-place rock and little available soil material; steeply sloping and rough topography.	Sandstone bedrock at depth of 20 to 30 inches; steeply sloping and rough topography.	Sandstone bedrock at depth of 20 to 30 inches; good bearing capacity; slight compressibility; steep slopes
Buckney: 636A, 636B.	Fair or good: moderately coarse textured; moderate content of organic matter.	Not suitable	Not suitable	Good: fair or good bearing capacity; slight compressibility; good workability; good compaction; erodible where exposed on embankments.	Gently sloping; subject to flooding; good source of borrow material.	Low compressibility; low shrink-swell potential; fair shear strength; subject to flooding.
Calamine: 551B, 551D.	Poor: moderately fine textured; seepy and wet in many places.	Not suitable	Not suitable	Very poor: very elastic; subject to large volume change; poor bearing capacity.	High slide potential in slopes of embankments and in back slopes of cuts; seepy and wet in places.	Seepy and wet; high shrink-swell potential; high compressibility; poor bearing capacity; poor shear strength.

See footnote at end of table.

engineering properties—Continued

Soil features affecting—Continued						Soil limitations for use as—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Septic tank absorption field	Sewage lagoon
Reservoir area	Embankment						
Rapid permeability in substratum.	Fair stability; pervious where compacted; low shrink-swell potential; poor resistance to piping.	Well drained; drainage not needed.	Low or moderate available water capacity; rapid intake rate; erodible.	Soil features favorable for construction; erodible on back slopes and in channels.	Low fertility and droughtiness hinder establishing vegetation in places; erodible.	Slight: hazard of contamination to streams or water supplies.	Severe: moderately rapid or rapid permeability.
Coarse-textured, porous substratum; nearly level.	High content of organic matter to depth of about 1½ to 2 feet; seasonal high water table; sand and gravel substratum stable but pervious in embankments.	Sand and gravel in substratum hinders installation of drain tile in places; moderate or moderately slow permeability above sand and gravel.	Moderate available water capacity; medium intake rate; poorly drained; rapid or very rapid permeability in substratum.	Nearly level.	Nearly level; seasonal high water table.	Severe: shallow to seasonal high water table; poorly drained; hazard of contamination to water supplies.	Severe: rapid or very rapid permeability in underlying sand and gravel.
Sandstone bedrock at depth of 20 to 30 inches; steep slopes.	Sandstone bedrock at depth of 20 to 30 inches; steeply sloping.	Excessively drained; drainage not needed.	Steeply sloping; shallow to bedrock; not used for crops.	Steeply sloping; shallow to sandstone bedrock.	Steeply sloping; shallow to sandstone bedrock.	Severe: steeply sloping; shallow to sandstone bedrock.	Severe: steeply sloping; shallow to sandstone bedrock.
Rapid permeability in substratum; subject to flooding.	Fair stability; good workability; erodible on slopes; poor resistance to piping.	Well drained; drainage not needed.	Moderate or low available water capacity; moderately rapid intake rate.	Gently sloping bottom land.	Soil features favorable for construction; erodible; vegetation difficult to establish.	Moderate or severe: rapid permeability; hazard of contamination of streams or water supplies; subject to flooding.	Severe: rapid permeability.
Very slow permeability; gently or strongly sloping.	Very slow permeability; high shrink-swell potential; tendency to creep in embankments.	Very slow permeability in underlying shale; wetness due to seeps and to high water table.	Slow intake rate; poorly drained; wet and seepy.	Wet and seepy in many places; high slide potential in embankments.	Wet and seepy; vegetation difficult to establish.	Severe: seasonal high water table; very slow permeability in substratum.	Moderate where slope is less than 9 percent; severe where slope is more than 9 percent; surface layer high in content of organic matter; very slow permeability.

TABLE 4.—*Interpretations of*

Soil series and map symbol	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Calco: 733	Fair: thick surface layer; high content of organic matter; calcareous; moderately fine textured.	Not suitable	Not suitable	Very poor: poor bearing capacity; poor shear strength; seasonal high water table; high content of organic matter to depth of about 3 feet.	Seasonal high water table; subject to flooding; poor foundation for high fills; stability and settlement characteristics require investigation.	Seasonal high water table; subject to some flooding; high compressibility with uneven consolidation.
Canisteo: 507	Fair: moderately fine textured; calcareous; high content of organic matter.	Not suitable	Not suitable	Very poor: seasonal high water table; high content of organic matter to depth of 1½ to 2 feet.	Seasonal high water table; high content of organic matter to depth of 1½ to 2 feet.	Fair bearing capacity; seasonal high water table; medium to high compressibility.
Clarion: 138A, 138B, 138C, 138C2, 138D2, 138E2.	Good: medium textured; moderate or moderately low content of organic matter.	Not suitable	Not suitable	Good: good shear strength; good bearing capacity; good workability; good compaction.	Nearly level to moderately steep, undulating topography; good source of borrow material.	Good shear strength; moderate shrink-swell potential; deep to seasonal high water table.
*Colo: 133, 585B For Spillville part of 585B, see the Spillville series.	Fair or good: moderately fine textured; high content of organic matter.	Not suitable	Not suitable	Very poor: poor bearing capacity; poor shear strength; seasonal high water table; highly compressible; high content of organic matter to depth of about 3 feet or more.	Seasonal high water table; generally subject to flooding; poor foundation for high fills.	Seasonal high water table; generally subject to flooding; high compressibility where consolidation is uneven.
Cordova: 386	Fair: moderately fine textured; high content of organic matter in surface layer.	Not suitable	Not suitable	Very poor: seasonal high water table; high content of organic matter to depth of 1½ to 2 feet.	Seasonal high water table; high content of organic matter to depth of 1½ to 2 feet.	Fair bearing capacity; seasonal high water table; medium to high compressibility.

See footnote at end of table.

engineering properties—Continued

Soil features affecting—Continued						Soil limitations for use as—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Septic tank absorption field	Sewage lagoon
Reservoir area	Embankment						
Nearly level topography; high in content of organic matter to depth of about 3 feet or more.	High content of organic matter to depth of about 3 feet; fair or poor stability; generally poor compaction.	Poorly drained; moderately slow permeability; good outlets not available for tile in places.	Medium intake rate; high available water capacity; subject to flooding.	Nearly level bottom land.	Seasonal high water table and wetness; soil features favorable; waterways not needed in most areas.	Severe: seasonal high water table; subject to flooding; moderately slow permeability.	Moderate: high content of organic matter to a depth of about 3 feet; subject to flooding.
Nearly level topography; moderate or moderately slow permeability.	Fair stability and fair compaction below the surface layer; slow permeability if compacted.	Seasonal high water table; moderate to moderately slow permeability.	High available water capacity; medium intake rate; drainage needed.	Nearly level; seasonal high water table.	Sometimes too wet for construction in places; soil features are favorable.	Severe: seasonal high water table; moderate to moderately slow permeability.	Moderate: moderately slow to moderate permeability; high content of organic matter to depth of about 1½ to 2 feet.
Moderate permeability; pockets of sand and gravel in places.	Good stability; slow permeability if compacted; stones and boulders in places; moderate shrink-swell potential.	Not needed	Nearly level to moderately steep; undulating topography; high available water capacity; medium intake rate.	Nearly level to moderately steep; undulating topography soil features favorable except for stones and boulders in places.	Soil features favorable for vegetation and construction; stones and boulders in places.	Slight where slope is less than 5 percent; moderate where slope is 5 to 9 percent; severe where slope is more than 9 percent; moderate permeability; deep to the water table.	Moderate where slope is less than 9 percent; severe where slope is more than 9 percent; moderate permeability.
Nearly level topography; high content of organic matter to depth of about 3 feet or more.	High content of organic matter in the top 3 feet or more; high shrink-swell potential; difficult to compact.	Moderately slow permeability; poorly drained; unsubmerged outlets not available in some places; generally subject to flooding.	Medium intake rate; high available water capacity; seasonal high water table; generally subject to flooding.	Nearly level bottom land.	Soil features favorable for construction and vegetation; seasonal high water table.	Severe: seasonal high water table; generally subject to flooding; moderately slow permeability.	Moderate: high content of organic matter to depth of about 3 feet; generally subject to flooding.
Level topography not suited to conventional pond sites; moderately slow permeability.	Not ordinarily used because of position; fair stability and fair compaction below surface layer; seasonal high water table.	Moderately slow permeability.	Medium intake rate; high available water capacity; drainage needed.	Nearly level	Seasonal high water table.	Severe: seasonal high water table; moderately slow permeability.	Slight or moderate: high content of organic matter to depth of about 1½ to 2 feet; moderately slow permeability.

TABLE 4.—*Interpretations of*

Soil series and map symbol	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Cylinder: 202, 203	Good: medium textured; moderate or high content of organic matter.	Good below depth of about 24 to 40 inches: variable amounts of fines and gravels; seasonal high water table.	Fair below depth of about 24 to 40 inches: variable amounts of gravel.	Good: fair or good bearing capacity in upper part; good bearing capacity, good shear strength, and low shrink-swell potential in underlying sand and gravel.	Nearly level topography; good source of borrow material; seasonal high water table.	Good bearing capacity and shear strength in substratum; low shrink-swell potential; low compressibility; seasonal high water table.
Dorchester: 158, 815	Good: medium textured; calcareous.	Not suitable	Not suitable	Poor: subject to flooding; some areas subject to ponding; poor bearing capacity.	Subject to flooding; some areas subject to ponding; seasonal high water table; poor source of borrow material.	Subject to flooding; highly compressible; can liquefy where saturated; some areas subject to ponding; seasonal high water table.
Dundas: 307	Good in surface layer: medium textured; moderate content of organic matter.	Not suitable	Not suitable	Very poor: seasonal high water table; high shrink-swell potential; fair bearing capacity.	Level topography; seasonal high water table.	Fair bearing capacity; high shrink-swell potential; seasonal high water table; poorly drained.
Estherville: 34A, 34B, 34C, 34D.	Fair: thin layer of material; high content of organic matter.	Good below depth of about 2 feet: mixed sand and gravel.	Good below depth of about 2 feet: mixed sand and gravel.	Good: good bearing capacity; good shear strength; slight compressibility; low or very low shrink-swell potential.	Nearly level to strongly sloping; good source of borrow material.	Good bearing capacity; slight compressibility; deep to water table.

See footnote at end of table.

engineering properties—Continued

Soil features affecting—Continued						Soil limitations for use as—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Septic tank absorption field	Sewage lagoon
Reservoir area	Embankment						
Underlying sand and gravel is too porous to hold water.	Good stability; low shrink-swell potential; pervious; poor resistance to piping.	Somewhat poorly drained; underlain by sand and gravel at depth of 24 to 40 inches.	Medium intake rate; low or moderate available water capacity.	Nearly level	Nearly level; sand and gravel at depth of 24 to 40 inches; cuts lower the available water capacity.	Moderate: seasonal high water table; hazard of contamination to streams and water supplies.	Severe: rapid or very rapid permeability in substratum.
Moderate permeability; seasonal high water table.	Seasonal high water table can hinder excavation; low or moderate shrink-swell potential; subject to liquefaction and piping; poor stability when wet.	Moderately well drained or somewhat poorly drained; subject to flooding; some areas subject to ponding.	High available water capacity; medium intake rate; subject to flooding and to ponding of surface water in frequently flooded areas.	Nearly level bottom land.	Soil features favorable for construction and vegetation.	Severe: subject to flooding; seasonal high water table; hazard of contamination to streams and water supplies.	Severe: moderate permeability in upper layers; generally moderately rapid permeability in sandy substratum below depth of 40 to 50 inches; subject to flooding.
Moderately slow or slow permeability; nearly level.	Poor workability; poor compaction; seasonal high water table; fair to poor stability.	Moderately slow or slow permeability; seasonal high water table.	High available water capacity; slow intake rate; seasonal high water table; drainage needed.	Nearly level; seasonal high water table.	Seasonal high water table; poorly drained; nearly level.	Severe: moderately slow or slow permeability in subsoil; seasonal high water table.	Slight: moderately slow or slow permeability; high shrink-swell potential.
Very porous sand and gravel substratum.	Good stability; pervious; poor resistance to piping.	Somewhat excessively drained; underlain by sand and gravel; drainage not needed.	Low or very low available water capacity; rapid intake rate.	Shallow to sand and gravel; droughty and difficult to vegetate.	Shallow to sand and gravel; droughty and difficult to vegetate.	Slight where slope is less than 5 percent; moderate where slope is 5 to 9 percent; severe where slope is more than 9 percent: severe hazard of contamination to ground water.	Severe: rapid or very rapid permeability in sand and gravel substratum.

TABLE 4.—*Interpretations of*

Soil series and map symbol	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Gosport: 313G	Poor: very thin layer of suitable material; steeply sloping.	Not suitable	Not suitable	Very poor: poor bearing capacity; poor shear strength; high shrink-swell potential; high compressibility.	Very poor for borrow material; soil above shale subject to sliding on the sloping shale surface; steeply sloping.	Very poor shear strength; very poor bearing capacity; high compressibility; high shrink-swell potential.
Guckeen: 385A	Fair: moderately fine textured surface layer.	Not suitable	Not suitable	Poor: fair to poor bearing capacity; fair to poor shear strength; high shrink-swell potential to depth of about 3 feet.	Seasonal high water table; nearly level to gently sloping; poor source of borrow material.	Seasonal high water table; substratum has good bearing capacity, moderate shrink-swell potential, and slight compressibility.
Hanlon: 536A	Fair or good: moderately coarse textured; moderate content of organic matter.	Poor: sand in substratum is variable; stratified with fines.	Not suitable	Good: fair or good bearing capacity; low shrink-swell potential; good workability; good compaction.	Good foundation for embankments; seasonal high water table; subject to flooding.	Seasonal high water table; subject to flooding; low shrink-swell potential; slight compressibility.
Harps: 95	Poor: very high in calcium carbonate; low in fertility.	Not suitable	Not suitable	Very poor: seasonal high water table; high content of organic matter to depth of about 1½ feet; fair bearing capacity and fair shear strength below depth of 1½ feet.	Nearly level; seasonal high water table; wet in many places; adjacent to depressional highly organic soils.	Fair shear strength; fair bearing capacity; seasonal high water table; moderate or high shrink-swell potential.

See footnote at end of table.

engineering properties—Continued

Soil features affecting—Continued						Soil limitations for use as—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Septic tank absorption field	Sewage lagoon
Reservoir area	Embankment						
Very slow permeability; steeply sloping.	Clayey subsoil and shaly substratum have high shrink-swell potential; can creep in embankments; very slow permeability.	Moderately well drained; very steeply sloping; very slow permeability.	Steeply sloping; low potential for crops.	Steeply sloping and rough topography; low potential for crops; clayey infertile subsoil.	Steeply sloping and rough topography; vegetation difficult to establish on clayey infertile subsoil.	Severe: very slow permeability in subsoil and substratum; steeply sloping.	Severe: steeply sloping.
Nearly level to gently sloping; moderate uncompacted permeability in underlying material.	Clayey material in upper part of profile has fair stability and high shrink-swell potential; underlying glacial till material has good stability and moderate shrink-swell potential.	Somewhat poorly drained; slow permeability in clayey subsoil; moderate or moderately slow permeability in substratum.	High available water capacity; slow intake rate.	Clayey subsoil causes difficulty in establishing vegetation in terrace channels.	Seldom needed; clayey subsoil causes difficulty in establishing vegetation in waterway channels.	Moderate: slow permeability in clayey subsoil; moderate or moderately slow permeability in substratum; seasonal high water table.	Slight to moderate: nearly level to gently sloping; slow permeability; moderate or high content of organic matter.
Subject to flooding; rapid permeability in substratum.	Fair stability; erodible on slopes; poor resistance to piping.	Somewhat poorly drained; moderately rapid permeability.	Rapid intake rate; low to moderate available water capacity; subject to flooding; seasonal high water table.	Nearly level to gently sloping; soil properties favorable for construction and vegetation.	Soil properties favorable for construction and vegetation.	Severe: subject to flooding; seasonal high water table; hazard of contamination to streams and water supplies.	Severe: moderately rapid or rapid permeability.
Nearly level topography; seasonal high water table.	Seasonal high water table; wet in many places; high content of organic matter to depth of about 1½ feet.	Moderate permeability.	High available water capacity; medium intake rate; seasonal high water table.	Nearly level soil adjacent to upland depressions.	Nearly level; seasonal high water table.	Severe: moderate permeability seasonal high water table; generally adjacent to very wet, depressional soils.	Moderate: moderate permeability; high content of organic matter in surface layer.

TABLE 4.—*Interpretations of*

Soil series and map symbol	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Hayden: 168B, 168C	Fair: thin surface layer; low content of organic matter.	Not suitable	Not suitable	Good: good bearing capacity; good workability; good compaction; stones and boulders in places.	Stones and boulders in places; gently or moderately sloping or very steep.	Good bearing capacity and shear strength; moderate shrink-swell potential; slight compressibility.
Jacwin: 444A	Good: medium textured; high content of organic matter.	Not suitable	Not suitable	Very poor: high content of organic matter; underlain by shale that contains variable amounts of limestone and sandstone; high water table in places.	Seasonal high water table; nearly level topography; underlain by fragmented shale that contains variable amounts of limestone and sandstone.	Seasonal high water table; underlain by fragmented shale that contains variable amounts of limestone and sandstone.
Kamrar: 387B	Fair: moderately fine textured; moderate content of organic matter.	Not suitable	Not suitable	Poor in upper 2 to 3 feet: moderate or high shrink-swell potential; good in underlying material: good bearing capacity and good compaction.	Gently sloping; plastic in upper 2 to 3 feet; good source of borrow material below.	Substratum has good bearing capacity and good shear strength; moderate shrink-swell potential and slight compressibility.

See footnote at end of table.

engineering properties—Continued

Soil features affecting—Continued						Soil limitations for use as—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Septic tank absorption field	Sewage lagoon
Reservoir area	Embankment						
Moderate permeability; gently or moderately sloping or very steep.	Good stability; good compaction; good resistance to piping.	Well drained; drainage not needed.	High available water capacity; medium intake rate; subject to runoff and erosion.	Soil features favorable for construction and vegetation; stones or boulders in places.	Soil features favorable for construction and vegetation; stones or boulders in places.	Slight where slope is less than 5 percent; moderate where slope is 5 to 9 percent; severe where slope is more than 9 percent: moderate permeability; deep to seasonal high water table.	Moderate where slope is less than 9 percent; severe where slope is more than 9 percent: moderate permeability.
Permeability of the underlying bedrock is generally very slow but variable; nearly level to gently sloping.	The underlying shale has poor stability but is impermeable in embankments; variable amounts of limestone and sandstone in bedrock.	Generally not needed; underlain by fragmented shale that contains variable amounts of limestone and sandstone.	Medium intake rate; moderate or high available water capacity; underlying shale has slow permeability.	Nearly level to gently sloping; underlain by shale that contains variable amounts of limestone and sandstone.	Soil features are favorable for construction; seasonal high water table; cuts reduce available water capacity.	Severe: seasonal high water table; generally very slow permeability, but variable permeability in bedrock; effluent can travel horizontally above bedrock and cause hazard of contamination to streams or water supplies.	Moderate: generally very slow permeability in bedrock; effluent can travel horizontally above bedrock and cause hazard of contamination to streams or water supplies; high in content of organic matter.
Moderately slow permeability; stones and boulders in places in substratum.	Fair to good stability; good resistance to piping; stones and boulders in places in substratum; good compaction.	Drainage not needed.	High available water capacity; medium intake rate; subject to runoff; erodible.	Soil features for construction generally favorable; the heavy clay loam subsoil causes difficulty in establishing vegetation in places, especially if compacted.	Soil features for construction generally favorable; heavy clay loam subsoil causes difficulty in establishing vegetation in places, especially if compacted.	Slight: moderately slow permeability in subsoil, but moderate permeability in substratum.	Slight: moderately slow permeability; good compaction.

TABLE 4.—*Interpretations of*

Soil series and map symbol	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Lanyon: 606	Poor: fine textured surface layer and subsoil.	Not suitable	Not suitable	Very poor: poor bearing capacity; poor shear strength; high shrink-swell potential; high content of organic matter; seasonal high water table; wet in many places.	Very poorly drained; wet in many places; subject to ponding; very plastic; uneven consolidation likely.	Poor bearing capacity; poor shear strength; wet in many places due to high water table; subject to ponding; high shrink-swell potential.
Lester: 236B, 236C, 236D, 236E, 236F.	Good: medium-textured surface layer; moderately low content of organic matter.	Not suitable	Not suitable	Good: good bearing capacity; good shear strength; good workability; good compaction; moderate shrink-swell potential.	Gently sloping to steep topography; good source of borrow material.	Good bearing capacity; good shear strength; slight compressibility; moderate shrink-swell potential.
Le Sueur: 325A	Good: medium-textured surface layer; moderately low content of organic matter.	Not suitable	Not suitable	Good: fair or good bearing capacity; fair or good shear strength; good compaction; moderate shrink-swell potential.	High water table in places; good source of borrow material; nearly level to gently sloping.	Fair or good bearing capacity; fair or good shear strength; slight compressibility; high water table in places.
Luther: 355A	Fair: medium-textured surface layer; low content of organic matter.	Not suitable	Not suitable	Fair or good: fair or good bearing capacity; fair or good shear strength; good compaction; moderate shrink-swell potential.	High water table in places; fair source of borrow material.	Fair or good bearing capacity; fair or good shear strength; slight compressibility; high water table in places.
Marna: 383	Fair or poor: moderately fine textured surface layer; seasonal high water table; high content of organic matter.	Not suitable	Not suitable	Very poor: seasonal high water table; high shrink-swell potential; very plastic; high content of organic matter to depth of 1½ to 2 feet.	Seasonal high water table; very plastic; very poor for borrow material; high content of organic matter to depth of 1½ to 2 feet.	Fair or poor shear strength; fair or poor bearing capacity; seasonal high water table; high shrink-swell potential in surface layer and subsoil, moderate in substratum.

See footnote at end of table.

engineering properties—Continued

Soil features affecting—Continued						Soil limitations for use as—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Septic tank absorption field	Sewage lagoon
Reservoir area	Embankment						
High water table most of the time; depressional soil.	Poor compaction; poor workability; high shrink-swell potential.	Moderately slow or slow permeability; subject to ponding.	Very poorly drained; wetness and ponding are hazards.	Occurs in upland depressions.	Occurs in upland depressions.	Severe: moderately slow or slow permeability; subject to ponding.	Slight or moderate: moderately slow or slow permeability; high content of organic matter.
Moderate permeability; pockets of sand or gravel in places.	Good stability; stones or boulders in places; good resistance to piping.	Well drained; moderate permeability.	High available water capacity; medium intake rate; subject to runoff; erodible.	Soil features are favorable, except for stones and boulders in places.	Soil features are favorable, except for stones and boulders in places.	Slight where slope is less than 5 percent; moderate where slope is 5 to 9 percent; severe where slope is more than 9 percent; moderate permeability; deep to seasonal high water table.	Moderate where slope is less than 9 percent; severe where slope is more than 9 percent; moderate permeability.
Nearly level to gently sloping; moderate permeability.	Fair to good stability; good compaction; stones or boulders in places; good resistance to piping.	Moderate permeability.	High available water capacity; medium intake rate; nearly level to gently sloping.	Nearly level to gently sloping; high water table in places; stones or boulders in places.	High water table in places; stones or boulders in places.	Moderate: moderate permeability; high water table in places.	Moderate: moderate permeability.
Nearly level to gently sloping; moderately slow permeability.	Fair to good stability; good compaction; stones or boulders in places; good resistance to piping.	Moderately slow permeability; high water table in places.	High available water capacity; medium intake rate; nearly level to gently sloping.	Nearly level to gently sloping; high water table in places; stones and boulders in places.	High water table in places; stones and boulders in places.	Moderate to severe: moderately slow permeability; high water table in places.	Slight: moderately slow permeability; low content of organic matter.
Nearly level; slow permeability.	Fair stability; seasonal high water table; high shrink-swell potential; high content of organic matter to depth of about 1½ to 2 feet.	Slow permeability; seasonal high water table.	Slow intake rate; needs drainage; high available water capacity.	Nearly level	Nearly level; seasonal high water table; subsoil clayey; vegetation difficult to establish.	Severe: seasonal high water table; slow permeability.	Slight or moderate: high content of organic matter in the upper 1½ to 2 feet; slow permeability; poor workability; poor compaction.

TABLE 4.—*Interpretations of*

Soil series and map symbol	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Minnetonka: 583	Fair: moderately fine textured; high content of organic matter.	Not suitable	Not suitable	Very poor: poor bearing capacity; poor shear strength; seasonal high water table; high compressibility; high content of organic matter to depth of about 1½ feet or more.	Seasonal high water table; high content of organic matter to depth of about 1½ feet or more; nearly level to slightly depressional.	Seasonal high water table; high compressibility; high shrink-swell potential; poor shear strength.
Muck: 21, 21D	Good if mixed with mineral soil.	Not suitable	Not suitable	Very poor: very high content of organic matter; high water table most of the time; subject to ponding and wetness in depressions and to seepiness on slopes.	High water table most of the time; subject to ponding in depressions; seepy and wet on slopes; high compressibility.	High water table most of the time; subject to ponding in depressions; seepy and wet on slopes.
Nicollet: 55A	Good: medium textured surface layer; high content of organic matter.	Not suitable	Not suitable	Good: high content of organic matter to depth of about 1½ feet; material below has good bearing capacity and good compaction.	High water table in places; high content of organic matter to depth of about 1½ feet; nearly level to gently sloping.	Good bearing capacity; fair shear strength; slight compressibility; high water table in places.
55B	Good: medium textured surface layer; high content of organic matter.	Not suitable	Not suitable	Good: high content of organic matter to depth of about 1½ feet; material below has good bearing capacity and good compaction.	High water table in wet periods; high content of organic matter to depth of about 1½ feet.	Good bearing capacity; fair shear strength; slight compressibility; high water table in places.

See footnote at end of table.

engineering properties—Continued

Soil features affecting—Continued						Soil limitations for use as—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Septic tank absorption field	Sewage lagoon
Reservoir area	Embankment						
Nearly level; slow permeability.	High content of organic matter to depth of 1½ feet or more; high shrink-swell potential; slow permeability; poor workability; poor compaction.	Seasonal high water table; slow permeability.	Poorly drained; seasonal high water table; slow permeability in subsoil; drainage needed.	Nearly level; seasonal high water table.	Nearly level; seasonal high water table.	Severe: seasonal high water table; slow permeability.	Moderate: slow permeability; high content of organic matter to depth of about 1½ feet or more.
High water table most of the time; subject to ponding in depressions; seepy and wet on slopes.	High water table most of the time; subject to ponding in depressions; seepy and wet on slopes; very high content of organic matter; high compressibility.	Variable, but generally moderate or moderately slow permeability; wetness of sloping areas due to seepiness.	Very poorly drained; very high or high available water capacity; medium intake rate; high water table most of the time; subject to ponding or seepiness.	Topography is depressional or consists of strongly sloping, very wet and seepy side slopes.	Topography is depressional or strongly sloping; very wet and seepy on slopes.	Severe: high water table most of the time; subject to ponding in depressions; seepy and wet on slopes.	Severe: very high content of organic matter; high water table most of the time or seepiness and wetness; permeability variable, but generally moderate or moderately slow.
Moderate permeability; nearly level to gently sloping.	Fair to good stability; high content of organic matter to depth of about 1½ feet; material below has good compaction.	Moderate permeability; high water table in places.	High available water capacity; medium intake rate; nearly level to gently sloping.	Nearly level to gently sloping; high water table in places; stones or boulders in places.	High water table in places; stones or boulders in places.	Moderate: moderate permeability; high water table in places.	Moderate: high content of organic matter in upper 1½ feet; moderate permeability.
Moderate permeability; gently sloping.	Fair to good stability; high content of organic matter to depth of about 1½ feet; material below has good compaction.	Somewhat poorly drained; moderate permeability.	High available water capacity; medium intake rate; subject to runoff; erodible.	Soil features are favorable; high water table in places.	Soil features are favorable; high water table in places.	Moderate: moderate permeability; high water table in places; slow permeability in layer at depth of about 5 to 6 feet in places.	Moderate: gently sloping; moderate permeability, but slow permeability in layer at depth of 5 to 6 feet in places.

TABLE 4.—*Interpretations of*

Soil series and map symbol	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Okoboji: 90, 6	Fair: thick layer; high content of organic matter; wet in many places.	Not suitable	Not suitable	Very poor: high content of organic matter to depth of about 3 feet; poor bearing capacity; high compressibility that contains uneven consolidation; wet in many places; subject to ponding.	High water table most of the time; subject to ponding; very poor for borrow material; uneven consolidation likely.	Poor bearing capacity; high compressibility that contains uneven consolidation; high water table most of the time; subject to ponding.
Rockton: 214B	Good in surface layer and upper part of subsoil; medium textured.	Not suitable	Not suitable	Fair to good to depth of about 2 to 3 feet; poor below; fragmented limestone bedrock that contains silty clay shale and other textures below depth of about 2 feet.	Gently sloping topography; underlain by limestone bedrock that is generally fragmented.	Good bearing capacity; slight compressibility; generally low shrink-swell potential in substratum.
Rock land and Steep sandy land: 478G.	Poor: very thin or sandy surface layer; low in fertility; steeply sloping.	Not suitable	Not suitable	Variable suitability: material contains sand and lime rock.	Steeply sloping; variable material contains sand and lime rock.	Steeply sloping; lime rock at shallow depths in places.
Rolfe: 274	Good: high water table most of the time; wet in many places.	Not suitable	Not suitable	Very poor: high water table most of the time; subject to ponding; high shrink-swell potential; high compressibility.	High water table most of the time; subject to ponding; very poorly drained.	High water table most of the time; subject to ponding; high shrink-swell potential.
Sandy alluvial land: 715.	Poor: generally coarse textured; low content of organic matter.	Poor: variable; considerable content of fines; subject to flooding; high water table.	Not suitable	Fair or poor: subject to flooding; high water table; very erodible; good bearing capacity.	Subject to flooding most of the time; very erodible; good bearing capacity.	Subject to flooding most of the time; high water table.

See footnote at end of table.

engineering properties—Continued

Soil features affecting—Continued						Soil limitations for use as—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Septic tank absorption field	Sewage lagoon
Reservoir area	Embankment						
High water table most of the time; depressional topography; slow permeability.	Material high in content of organic matter to depth of about 3 feet; poor workability; high compressibility.	Very poorly drained; slow permeability; subject to ponding.	A very poorly drained soil in which wetness and ponding are serious hazards.	Located in upland depressions.	Located in upland depressions; high water table most of the time.	Severe: high water table most of the time; subject to ponding.	Moderate or severe: high content of organic matter to depth of about 3 feet; high water table most of the time; slow permeability.
The underlying lime rock is generally too fractured and porous to hold water.	Underlain by fragmented lime rock at depth of about 2 to 3 feet.	Well drained; underlain by limestone bedrock; drainage not needed.	Low or moderate available water capacity; medium intake rate; rapid permeability in underlying bedrock.	Underlain by limestone bedrock at depth of about 2 to 3 feet; cuts lower the available water capacity.	Limestone bedrock at depth of about 2 or 3 feet; low available water capacity where cuts are deep.	Severe: underlain by fractured limestone bedrock; hazard of contamination to streams and water supplies.	Severe: fractured limestone bedrock at depth of about 2 to 3 feet.
Steeply sloping; variable material contains sand and lime rock.	Variable material contains sand and lime rock.	Well drained to excessively drained; drainage not needed.	Steeply sloping; shallow to bedrock in places.	Steeply sloping; shallow to bedrock in places.	Steeply sloping; shallow to bedrock in places.	Severe: steeply sloping; shallow to bedrock in places.	Severe: steeply sloping; shallow to bedrock in places.
Slow permeability in subsoil; moderately slow permeability in substratum; located in depressions on uplands.	High water table most of the time; subject to ponding; fair or poor workability; fair or poor compaction; high shrink-swell potential.	Slow permeability; subject to ponding.	Very poorly drained; subject to ponding; slow permeability.	Located in depressions on uplands.	Located in depressions on uplands; high water table most of the time; subject to ponding.	Severe: high water table most of the time; subject to ponding; slow permeability.	Moderate: slow permeability; high content of organic matter; subject to ponding; high water table most of the time.
Sandy, porous material; generally along larger streams.	Subject to flooding most of the time; high water table.	Not used for crops; subject to flooding most of the time.	Low available water capacity; rapid intake rate; not used for crops; subject to flooding most of the time.	Nearly level bottom land.	Nearly level bottom land; variable but generally sandy material.	Severe: rapid permeability; subject to flooding most of the time; high water table; hazard of contamination to streams and water supplies.	Severe: too porous to prevent seepage; subject to flooding most of the time.

TABLE 4.—*Interpretations of*

Soil series and map symbol	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Spillville: 485A, 485B	Good: thick layer of medium-textured material; high content of organic matter.	Not suitable	Not suitable	Fair or poor: high content of organic matter; fair bearing capacity; fair or good workability.	Subject to flooding; nearly level or gently sloping; fair or poor source of borrow material.	Subject to flooding; fair bearing capacity; fair shear strength; medium or high compressibility.
*Storden: 62C2, 62D2, 62E2, 62F2, 62G2, 356G. For Hayden part of 356G, see Hayden series.	Fair: low content of organic matter; low in fertility.	Not suitable	Not suitable	Good: good bearing capacity; easily compacted.	Moderately sloping to very steep; rolling topography; good source of borrow material.	Good bearing capacity; good shear strength; slight compressibility; deep to seasonal high water table.
Talcot: 558, 559	Fair: moderately fine textured; seasonal high water table; high content of organic matter.	Good below depth of 24 to 40 inches: mixed with gravel; high water table can hinder excavation.	Fair below depth of 24 to 40 inches: high in sand; high water table can hinder excavation.	Very poor to depth of about 2 feet; very good in underlying sand and gravel; high water table can hinder excavation.	Seasonal high water table; high content of organic matter to depth of about 1½ to 2 feet; substratum is a good source of borrow material.	Seasonal high water table; substratum has good bearing capacity and slight compressibility.
Terril: 27C, 27D	Good: medium textured; high content of organic matter.	Not suitable	Not suitable	Poor: high content of organic matter; fair or poor bearing capacity; medium compressibility.	Moderately to strongly sloping; high content of organic matter; poor source of borrow material.	Fair or poor bearing capacity; fair shear strength; medium compressibility; moderate shrink-swell potential.
323B	Good: medium textured; high content of organic matter.	Poor: considerable fines.	Not suitable	Poor above the substratum; high content of organic matter; fair or poor bearing capacity; good in substratum.	Gently sloping on foot slopes; good foundation for embankments.	Good bearing capacity; good shear strength; deep to seasonal high water table.

See footnote at end of table.

engineering properties—Continued

Soil features affecting—Continued						Soil limitations for use as—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Septic tank absorption field	Sewage lagoon
Reservoir area	Embankment						
Moderate permeability; nearly level or gently sloping	High in content of organic matter; fair or good workability.	Moderately well drained or somewhat poorly drained; subject to flooding; moderate permeability.	High available water capacity; medium intake rate; subject to flooding.	Nearly level or gently sloping; soil features favorable.	Soil features favorable.	Moderate or severe: subject to flooding; high water table in places; moderate permeability.	Severe: high content of organic matter; moderate permeability; subject to flooding; sandy texture in substratum in places.
Pockets of sand and gravel in places; moderate permeability.	Fair to good stability; slow compacted permeability; stones or boulders in places.	Well drained; moderately sloping to very steep; drainage not needed.	Moderately sloping to very steep; short irregular slopes in many places.	Stones and boulders in places; low in fertility; irregular topography.	Moderately sloping to very steep; stones and boulders in places; low fertility.	Moderate limitations where slope is 5 to 9 percent; severe where slope is more than 9 percent: moderate permeability.	Moderate where slope is less than 9 percent; severe where slope is more than 9 percent: moderate permeability.
Coarse textured, porous substratum; nearly level.	High content of organic matter to depth of about 1½ to 2 feet; seasonal high water table; sand and gravel substratum is stable, but pervious in embankments.	Sand and gravel in substratum can hinder the installation of drain tile; seasonal high water table.	Low or moderate available water capacity; medium intake rate; poorly drained; rapid or very rapid permeability in substratum.	Nearly level	Nearly level; seasonal high water table.	Severe: seasonal high water table; poorly drained; hazard of contamination to streams or water supplies.	Severe: rapid or very rapid permeability in the under lying sand- and gravel.
Moderate uncompacted permeability; high content of organic matter; moderately to strongly sloping.	High content of organic matter; fair stability; fair or poor workability; fair or poor compaction; medium compressibility.	Moderately well drained; moderately or strongly sloping; moderate permeability.	High available water capacity; medium intake rate; subject to runoff; erodible; subject to gullying in places.	Soil features favorable.	Soil features favorable.	Moderate where slope is 5 to 9 percent; severe where slope is more than 9 percent: moderate permeability.	Moderate where slope is less than 9 percent; severe where slope is more than 9 percent: moderate permeability; high content of organic matter.
Rapid permeability in substratum.	Fair to good stability; erodible on back slopes; poor resistance to liquefaction and piping.	Well drained; drainage not needed.	Moderate available water capacity; medium intake rate; subject to runoff; erodible.	Soil features favorable for construction but cuts lower the available water capacity.	Low available water capacity where cuts are deep; soil features favorable for construction and vegetation.	Slight: hazard of contamination to streams and water supplies.	Severe: gently sloping; rapid permeability in sandy substratum.

TABLE 4.—*Interpretations of*

Soil series and map symbol	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Terril, thin surface variant: 566C, 566D, 566E.	Good: medium textured; moderate in content of organic matter.	Not suitable	Not suitable	Good: good workability; good compaction; fair bearing capacity.	Moderately sloping to moderately steep; good source of borrow material; good foundation for embankments.	Good shear strength; moderate shrink-swell potential; deep to seasonal high water table.
Turlin: 96B	Good: medium textured; high in content of organic mater.	Not suitable	Not suitable	Fair or poor: high content of organic matter; fair or poor bearing capacity; medium or high compressibility.	Gently sloping; high content of organic matter; subject to flooding in places.	Fair or poor bearing capacity; fair shear strength; medium or high compressibility; moderate shrink-swell potential; subject to flooding in places.
Wacousta: 506	Fair to good, but wet in many places.	Not suitable	Not suitable	Very poor: high water table most of the time; subject to ponding; high content of organic matter in surface layer.	High water table most of the time; subject to ponding; erratic consolidation can be expected.	High water table most of the time; subject to ponding; fair bearing capacity.
Wadena: 308A, 308B, 108A, 108B, 108C.	Good: medium textured.	Good below depth of 24 to 40 inches: variable in content of gravel and fines.	Fair below depth of 24 to 40 inches: variable in content of gravel.	Good: material below depth of 24 to 40 inches has good bearing capacity, good shear strength, and low shrink-swell potential; surface material to depth of 24 to 40 inches has fair or good bearing capacity and moderate shrink-swell potential.	Good source of borrow material; nearly level to moderately sloping.	Good bearing capacity; slight compressibility; deep to water table.

See footnote at end of table.

engineering properties—Continued

Soil features affecting—Continued						Soil limitations for use as—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Septic tank absorption field	Sewage lagoon
Reservoir area	Embankment						
Moderate permeability; moderately sloping to moderately steep.	Good stability; good workability; good compaction; moderate shrink-swell potential.	Not needed	Moderately sloping to moderately steep; high available water capacity; medium intake rate.	Soil features favorable.	Soil features favorable.	Moderate where slope is 5 to 9 percent; severe where slope is more than 9 percent: moderate permeability; deep to water table.	Moderate limitations where slope is less than 9 percent; severe where slope is more than 9 percent: moderate permeability.
Moderate permeability; high in content of organic matter; coarse strata below depth of 4 feet in places; gently sloping.	High content of organic matter; fair stability; fair or poor workability; fair or poor compaction; medium or high compressibility.	Somewhat poorly drained; moderate permeability.	High available water capacity; medium intake rate; subject to flooding in places.	Soil features favorable.	Soil features favorable.	Moderate or severe: moderate permeability; high water table in places; subject to flooding in places.	Moderate or severe: subject to flooding in places; moderate permeability; coarse strata below depth of 4 feet in places.
Moderately slow or moderate permeability; high water table most of the time; located in depressions on uplands.	Fair or poor workability; fair or poor compaction; high water table most of the time; subject to wetness.	Moderate or moderately slow permeability; subject to ponding; outlets require deep cuts in places.	Very poorly drained; subject to ponding; medium intake rate; high available water capacity.	Located in depressions on uplands.	Located in depressions on uplands; high water table most of the time; wet in many places.	Severe: high water table most of the time; subject to ponding.	Moderate: high in content of organic matter in upper 10 to 20 inches; subject to high water table and ponding most of the time; moderate or moderately slow permeability.
The underlying sand and gravel are too porous to hold water; nearly level to moderately sloping.	Good stability; underlying sand and gravel are pervious and have poor resistance to piping.	Well drained; underlain by sand and gravel at depth of 24 to 40 inches; drainage not needed.	Low or moderate available water capacity; medium intake rate; rapid or very rapid permeability in underlying sand and gravel.	Sand and gravel at depth of 24 to 40 inches; cuts lower the available water capacity.	Sand and gravel at depth of 24 to 40 inches; very low available water capacity where cuts are deep.	Slight where slope is less than 5 percent; moderate where slope is 5 to 9 percent: porous substratum; hazard of contamination of streams and water supplies.	Severe: rapid or very rapid permeability in underlying sand and gravel.

TABLE 4.—*Interpretations of*

Soil series and map symbol	Suitability as a source of—				Soil features affecting—	
	Topsoil	Sand	Gravel	Road fill	Highway location	Foundations for low buildings [1]
Wadena, thin surface variant: 777B, 778B.	Fair to good: medium textured; low content of organic matter.	Good below depth of 24 to 40 inches: variable content of fines and gravel.	Fair below depth of 24 to 40 inches: variable content of gravel mixed with sand.	Good: material below depth of 24 to 40 inches has good bearing capacity and good shear strength; slight compressibility; low shrink-swell potential.	Good borrow material; gently sloping.	Good shear strength; good bearing capacity; slight compressibility; deep to water table.
Webster: 107	Fair: moderately fine textured; high content of organic matter; seasonal high water table.	Not suitable	Not suitable	Very poor: high content of organic matter in upper 1½ to 2 feet; wet in many places; seasonal high water table.	Nearly level; seasonal high water table; high content of organic matter in upper 1½ to 2 feet.	Fair or poor bearing capacity; seasonal high water table; medium to high compressibility.
107B	Fair: moderately fine textured; many stones and boulders in places.	Not suitable	Not suitable	Very poor: seasonal high water table; wet in many places; many stones and boulders in many places; underlain by fractured limestone that contains some shale at depth of about 2½ to 4 feet in some places.	Seasonal high water table; high content of organic matter to depth of about 1½ to 2 feet; many stones and boulders in many places.	Fair bearing capacity; seasonal high water table; wetness; many stones and boulders in many places; underlain by fractured limestone that contains some shale at depth of about 2½ to 4 feet in some places.

[1] Engineers and others should not apply specific values to the estimates given for bearing capacity of soils.

engineering properties—Continued

Soil features affecting—Continued						Soil limitations for use as—	
Farm ponds		Agricultural drainage	Irrigation	Terraces and diversions	Grassed waterways	Septic tank absorption field	Sewage lagoon
Reservoir area	Embankment						
The underlying sand and gravel are too porous to hold water.	Good stability; substratum is pervious and has poor resistance to piping.	Well drained; underlain by sand and gravel at depth of 24 to 40 inches; drainage not needed.	Low or moderate available water capacity; medium intake rate.	Sand and gravel at depth of 24 to 40 inches; cuts lower the available water capacity.	Sand and gravel at depth of 24 to 40 inches; very low available water capacity where cuts are deep.	Slight where slope is less than 5 percent; moderate where slope is 5 to 9 percent: rapid or very rapid permeability in substratum; hazard of contamination of streams and water supplies.	Severe: rapid or very rapid permeability in underlying sand and gravel.
Nearly level topography; moderate or moderately slow permeability; seasonal high water table.	Fair stability and fair compaction below surface layer; slow permeability if compacted; high content of organic matter in upper 1½ to 2 feet.	Moderate or moderately slow permeability; seasonal high water table.	Poorly drained; high available water capacity; medium intake rate.	Nearly level; seasonal high water table.	Nearly level; seasonal high water table.	Severe: seasonal high water table; moderate or moderately slow permeability.	Moderate or severe: high content of organic matter in upper 1½ to 2 feet; seasonal high water table; moderate or moderately slow permeability.
Nearly level topography; moderate or moderately slow permeability; seasonal high water table.	Seasonal high water table; wetness; many stones and boulders in many places; underlain by fractured limestone that contains some shale at depth of about 2½ to 4 feet in some places.	Moderate or moderately slow permeability; many stones and boulders in many places; underlain by fractured limestone that contains some shale at depth of about 2½ to 4 feet in some places.	Poorly drained; high available water capacity; medium intake rate; many stones and boulders in many places.	Nearly level; seasonal high water table.	Many stones and boulders in many places; seasonal high water table.	Severe: seasonal high water table; moderate or moderately slow permeability; many stones and boulders in many places; underlain by fractured limestone that contains shale at depth of about 2½ to 4 feet in some places.	Moderate or severe: high content of organic matter; many stones and boulders in many places; fractured limestone that contains shale at depth of about 2½ to 4 feet in some places.

TABLE 5.—*Engineering*

[Tests were performed by the Iowa State Highway Commission in accordance with

Soil name and location	Parent material	Iowa report No. AAD6	Depth	Moisture density [1]	
				Maximum dry density	Optimum moisture
			Inches	*Lb. per cu. ft.*	*Percent*
Clarion loam:					
40 feet east and 50 feet north of southwest corner of SE¼ sec. 19, T. 90 N., R. 29 W.	Glacial till.	10373	0–9	102	18
		10374	17–22	104	19
		10375	40–55	115	14
Guckeen clay loam:					
857 feet north and 1,120 feet east of northwest corner of sec. 26, T. 86 N., R. 28 W.	About 3 feet of moderately fine textured lacustrine sediment over glacial till.	10385	0–9	92	21
		10386	21–28	92	23
		10387	60–72	102	21
Hayden loam:					
300 feet west and 650 feet south of northeast corner of NW¼NE¼ sec. 15, T. 88 N., R. 28 W.	Glacial till.	10366	0–3	98	18
		10367	3–10	109	16
		10368	15–21	108	16
		10369	52–60	107	17
Marna silty clay loam:					
1,041 feet south and 750 feet east of northwest corner of sec. 25, T. 86 N., R. 28 W.	About 40 inches of fine-textured lacustrine sediment over glacial till.	10382	0–6	90	23
		10383	20–26	96	16
		10384	61–67	105	18
Nicollet loam:					
200 feet west and 230 feet south of the northeast corner of sec. 4, T. 89 N., R. 28 W.	Glacial till.	10376	6–11	91	24
		10377	20–26	99	20
		10378	42–60	104	21
Okoboji silty clay loam:					
One-fourth mile south of northwest corner of sec. 26, T. 88 N., R. 29 W.	Alluvial sediment of glacial origin.	10370	7–15	82	25
		10371	15–30	85	27
		10372	30–42	84	25
Webster silty clay loam:					
500 feet west from east fence and 160 feet south from north fence in northeast corner of sec. 4, T. 87 N., R. 28 W.	Glacial till.	10379	7–13	95	21
		10380	24–30	107	17
		10381	50–65	111	17

[1] Based on AASHO Designation: T 99–57, Method A (*1*).

[2] Mechanical analysis according to AASHO Designation T 88–57. Results by this procedure frequently may differ from the results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure the fine material is analyzed by the pipette method and the

The AASHO system is used to classify soils according to those properties that affect use in highway construction and maintenance. In this system, a soil is placed in one of seven basic groups ranging from A–1 through A–7 on the basis of grain-size distribution, liquid limit, and plasticity index. In group A–1 are gravelly soils of high bearing strength, or the best soils for subgrade (foundation). At the other extreme, in group A–7, are clay soils that have low strength when wet and that are the poorest soils for subgrade. Where laboratory data are available to justify a further breakdown, the A–1, A–2, and A–7 groups are divided as follows: A–1–a, A–1–b, A–2–4, A–2–5, A–2–6, A–2–7, A–7–5, and A–7–6. As additional refinement, the engineering value of a soil material can be indicated by a group index number. Group indexes range from 0 for the best material to 20 or more for the poorest. The AASHO classification for tested soils, with group index numbers in parentheses, is shown in table 5; the estimated classification, without group index numbers, is given in table 3 for all soils mapped in the survey area.

Soil properties significant in engineering

Several estimated soil properties significant in engineering are given in table 3. These estimates are made for typical soil profiles, by layers sufficiently different to have different significance for soil engineering. The estimates are based on field observations made in the course of mapping, on test data for these and similar soils, and on experience with the same kinds of soil in other counties.

Most soils in Webster County are deep enough over bedrock that bedrock generally does not affect their use.

test data

standard procedures of the American Association of State Highway Officials (AASHO)]

Mechanical analysis [2]										Liquid limit	Plasticity index	AASHO [3] classification
Percentage passing sieve—						Percentage smaller than—						
¾-in.	⅜-in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.			
			100	90	57	51	38	26	19	36	15	A–6(6)
	100	99	98	87	56	50	40	30	24	36	17	A–6(7)
100	98	96	92	77	49	41	31	19	13	27	11	A–6(3)
			100	95	82	73	61	44	34	48	21	A–7–6(14)
		100	99	92	79	75	65	51	43	58	33	A–7–6(20)
100	98	96	92	82	66	62	52	37	27	45	24	A–7–6(13)
			100	92	63	59	41	20	12	33	9	A–4(6)
		100	99	88	59	54	38	18	10	23	6	A–4(5)
100	98	97	94	79	58	49	41	31	26	40	21	A–6(8)
100	99	98	95	85	59	54	42	28	21	37	19	A–6(8)
			100	95	82	77	64	46	36	49	23	A–7–6(15)
	100	99	96	90	74	73	61	47	39	59	35	A–7–6(20)
[4] 97	95	94	91	84	63	60	49	35	25	40	21	A–6(10)
			100	96	77	73	55	36	26	46	20	A–7–6(13)
		100	99	95	77	71	56	37	29	43	23	A–7–6(14)
		100	98	92	76	72	56	31	21	35	16	A–6(10)
				100	96	91	77	54	42	63	33	A–7–5(20)
					97	95	82	58	46	65	37	A–7–6(20)
					98	96	83	61	47	66	39	A–7–6(20)
			100	95	78	74	58	41	33	56	30	A–7–6(19)
	100	99	97	89	67	63	50	35	29	45	28	A–7–6(14)
[5] 99	97	95	92	78	54	47	35	23	19	34	19	A–6(7)

material coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soil.

[3] Based on AASHO Designation: M 145–49.

[4] 98 percent passed the 1-inch sieve, and 100 percent passed the 1½-inch sieve.

[5] 100 percent passed the 1-inch sieve.

However, Boone soils have sandstone at a depth of about 2 feet; Calamine soils have shale at a depth of about 2 to 3 feet; Jacwin and Gosport soils have shale at a depth of about 2 feet; and Rockton soils have limestone at a depth of about 2 feet. The Rock land in the Rock land and Steep sandy land mapping unit has limestone at a depth of less than 20 inches. Following are explanations of some of the columns in table 3.

The depth to seasonal high water table is the distance from the surface of the soil to the highest level that ground water reaches in the soil in most years.

Soil texture is described in table 3 in the standard terms used by the Department of Agriculture. These terms take into account relative percentages of sand, silt, and clay in soil material that is less than 2 millimeters in diameter. "Loam," for example, is soil material that contains 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the soil contains gravel or other particles coarser than sand, an appropriate modifier is added, as for example, "gravelly loamy sand." "Sand," "silt," "clay," and some of the other terms used in USDA textural classification are defined in the Glossary of this soil survey.

Permeability is that quality of a soil that enables it to transmit water or air. It is estimated on basis of those soil characteristics observed in the field, particularly structure and texture. The estimates in table 3 do not take into account lateral seepage or such transient soil features as a plowpan or a surface crust.

Available water capacity is the ability of soils to hold water for use by most plants. It is commonly defined as the difference between the amount of water in the soil at

field capacity and the amount at the wilting point of most plants.

Reaction is the degree of acidity or alkalinity of a soil, expressed in pH values. The pH value and terms used to describe soil reaction are explained in the Glossary.

Shrink-swell potential is the relative change in volume to be expected of soil material as moisture content changes, that is, the extent to which the soil shrinks as it dries out or swells when it gets wet. Extent of shrinking and swelling is influenced by the amount and kind of clay in the soil. Shrinking and swelling of soils causes much damage to building foundations, roads, and other structures. A high shrink-swell potential indicates a hazard to maintenance of structures built in, on, or with material having this rating.

Engineering interpretations of the soils

The estimated interpretations in table 4 are based on the engineering properties of soils shown in table 3, on test data for soils in Webster County, and others nearby or adjoining, and on the experience of engineers and soil scientists with the soils of the county. In table 4, ratings are used to summarize limitation or suitability of the soils for all listed purposes other than for drainage of cropland and pasture, irrigation, ponds and reservoirs, embankments, and terraces and diversions. For these particular uses, table 4 lists those soil features that should be considered in planning, installation, and maintenance.

Soil limitations are indicated by the ratings slight, moderate, and severe. Slight means that soil properties generally are favorable for the rated use, or in other words, limitations that are minor and easily overcome. Moderate means that some soil properties are unfavorable but can be overcome or modified by special planning and design. Severe means that soil properties are so unfavorable and so difficult to correct or overcome as to require major soil reclamation and special designs. For some uses, the rating of severe is divided to obtain ratings of severe and very severe. Very severe means that one or more soil properties are so unfavorable for a particular use that overcoming the limitations is difficult and costly and commonly not practical.

Soil suitability is rated by the terms good, fair, and poor, which have, respectively, meanings approximately parallel to the terms slight, moderate, and severe. Following are explanations of some of the columns in table 4.

Topsoil is used for topdressing an area where vegetation is to be established and maintained. Suitability is affected mainly by ease of working and spreading the soil material, as in preparing a seedbed; natural fertility of the material, or the response of plants when fertilizer is applied; and absence of substances toxic to plants. Texture of the soil material and the content of stone fragments are characteristics that affect suitability, but also considered in the ratings is damage that results at the area from which topsoil is taken.

Sand and gravel are used in great quantities in many kinds of construction. The ratings in table 4 provide guidance about where to look for probable sources. A soil rated as a good or fair source of sand or gravel generally has a layer at least 3 feet thick, the top of which is within a depth of 6 feet. The ratings do not take into account thickness of overburden, location of the water table, or other factors that affect mining of the materials, and neither do they indicate quality of the deposit.

The suitability of soil material for road fill depends largely on the density that can be obtained by compacting the material. Density affects the rigidity, flexibility, and load-bearing properties of the soil as subgrade fill for paved roads and as surfacing material for unpaved roads. Shrink-swell potential is also a factor in evaluating material for road fill.

Soil features affecting the use of soils for highway location, foundations for low buildings, farm ponds, agricultural drainage, irrigation, terraces and diversions, and waterways are given in table 4. Features that have an adverse effect on these practices generally are listed, but beneficial features are listed for some practices. Special features affecting highway construction are discussed elsewhere in this section.

For foundations of low buildings, the soils are rated for bearing capacity, compressibility, height of the water table, and other important features. These features vary widely, and the engineers and others should not apply specific values to the estimates given for bearing capacity.

Pond reservoir areas hold water behind a dam or embankment. Soils suitable for pond reservoir areas have low seepage, which is related to their permeability and depth to fractured or permeable bedrock or other permeable material.

Embankments, dikes, and levees require soil material resistant to seepage and piping and of favorable stability, shrink-swell potential, shear strength, and compactibility. Presence of stones or organic material in a soil are two unfavorable factors.

Drainage of cropland and pasture is affected by such soil properties as permeability, texture, and structure; depth to claypan, rock, or other layers that influence rate of water movement; depth to the water table; slope; stability in ditchbanks; susceptibility to flooding; salinity or alkalinity; and availability of outlets for drainage.

Irrigation of a soil is affected by such features as slope; susceptibility to flooding, water erosion, or soil blowing; soil texture; content of stones; accumulations of salts and alkali; depth of root zone; rate of water intake at the surface; permeability of soil layers below the surface layer and in the fragipan or other layers that restrict movement of water; amount of water held available to plants; and need for drainage, or depth to water table or bedrock.

Terraces and diversions are embankments, or ridges, constructed across the slope to intercept runoff so that it soaks into the soil or flows slowly to a prepared outlet. Features that affect suitability of a soil for terraces are uniformity and steepness of slope; depth to bedrock or other unfavorable material; presence of stones; permeability; and resistance to water erosion, soil slipping, and soil blowing. A soil that is suitable for these structures provides outlets for runoff and is not difficult to vegetate.

Grassed waterways are natural or constructed waterways, generally broad and shallow, covered by erosion-resistant grasses and used to conduct surface water from cropland. Important features are those that affect the

establishment, growth, and maintenance of vegetation and those that hinder layout and construction.

Septic tank absorption fields are subsurface systems of tile or perforated pipe that distribute effluent from a septic tank into natural soil. The soil material is evaluated from a depth of 18 inches to 6 feet. The soil properties considered are those that affect both absorption of effluent and construction and operation of the system. Properties that effect absorption are permeability, depth to water table or rock, and susceptibility to flooding. Slope is a soil property that affects difficulty of layout and construction and also the risk of soil erosion, lateral seepage, and downslope flow of effluent. Large rocks or boulders increase construction costs.

Sewage lagoons are shallow ponds constructed to hold sewage within a depth of 2 to 5 feet long enough for bacteria to decompose the solids. A lagoon has a nearly level floor and sides, or embankments, of compacted soil material. The assumption is made that the embankment is compacted to medium density and the pond is protected from flooding. Properties are considered that affect the pond floor and the embankment. Those that affect the pond floor are permeability, content of organic material, and slope, and if the floor needs to be leveled, depth to bedrock becomes important. The soil properties that affect the embankment are the engineering properties of the embankment material as interpreted from the Unified Soil Classification and the amounts of stones, if any, that influence the ease of excavation and compaction of the embankment material.

Engineering test data

Table 5 contains engineering test data for some of the major soil series in Webster County. These tests were made to help evaluate the soils for engineering purposes. The engineering classifications given are based on data obtained by mechanical analyses and by tests to determine liquid limits and plastic limits. The mechanical analyses were made by combined sieve and hydrometer methods.

Compaction (or moisture-density) data are important in earthwork. If a soil material is compacted at successively higher moisture content, assuming that the compactive effort remains constant, the density of the compacted material increases until the *optimum moisture content* is reached. After that, density decreases with increase in moisture content. The highest dry density obtained in the compactive test is termed *maximum dry density*. As a rule, maximum strength of earthwork is obtained if the soil is compacted to the maximum dry density.

Liquid limit and plasticity index indicate the effect of water on the strength and consistence of soil material. As the moisture content of a clayey soil is increased from a dry state, the material changes from a semisolid to a plastic state. If the moisture content is further increased, the material changes from a plastic to a liquid state. The plastic limit is the moisture content at which the soil material changes from the semisolid to plastic state, and the liquid limit, from a plastic to a liquid state. The plasticity index is the numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is plastic. Liquid limit and plasticity index in table 5 are based on tests of soil samples.

Soil features affecting road construction [3]

Many of the soils in Webster County formed in glacial till. The till has a relatively high in-place density. It is relatively stable at a normal moisture content and can be compacted readily to high density. The textural composition varies, but when the material is dry there are enough fines and enough coarse material to provide a firm riding surface, with little rebound after loading. The glacial till has good bearing capacity when compacted to maximum practical density, but is reduced in bearing capacity when moisture is absorbed.

Pockets and lenses of sand are in glacial till in places. These are seasonally water-bearing. Frost heave is likely if the road grade is only a few feet above such sand deposits and if the deposits are overlain by loamy till. To prevent frost heave, these deposits can be drained in places, or the soil above them can be replaced with a backfill of coarse granular material or dense glacial till. The Clarion, Nicollet, Lester, Le Sueur, Hayden, and Storden soils are among those that formed in glacial till. This till is dominantly A–4 or A–6 (CL) and can typically be compacted to high density with good bearing characteristics. The B horizon of some of the soils, however, is classified as A–7–6 and has an index number of as much as about 15.

Webster and Canisteo soils formed in glacial sediments and glacial till. These soils have a thick, dark-colored surface layer that is high in organic-matter content to a depth of about 2 feet, and it cannot be compacted to high density. Marna, Guckeen, and Kamrar soils formed in clayey lacustrine sediment and underlying glacial till. The clayey sediment is classified as A–7–6 and has high index numbers. These soils occupy a large area in the southern part of the county.

Soils on bottom lands in the county formed in alluvium. There is considerable variation in texture. Colo and Calco soils are classified as A–7–6 and OL, CL, or CH. These soils have a thick organic surface layer that, in places, consolidates erratically under embankment load. Okoboji and Lanyon soils that formed in silty sediments, and areas of muck in depressions on uplands, also are high in organic-matter content. All of these soils have a low in-place density and a high moisture content. Therefore, if an embankment is to be more than 15 feet high, these soils should be carefully analyzed to be sure that they are strong enough to support it. Excavation of the organic layers and backfilling with more suitable material is desirable in places. Other soils that formed in alluvium on foot slopes and bottom lands include the loamy Terril and Turlin and sandy Buckney, Ankeny, and Hanlon soils.

In places along major streams, underlying strata of glacial till, sandstone, limestone, or shale cause a perched water table or wet, seepy spots. This is mainly along the Des Moines River and Lizard Creek, but it is also true of a few miles along some of the tributary creeks of the

[3] This section was prepared by D. A. ANDERSON, soils engineer, Iowa State Highway Commission.

Des Moines River. An embankment constructed only a few feet above the water table in these places is damaged by frost heave in places. Roadways through bottom lands should be constructed on a continuous embankment that extends above the flood level. Because soils vary greatly in short distances in the larger stream valleys, care should be taken in preliminary investigation.

Water-worn gravel occurs in deposits that underlie such soils as those of the Wadena, Cylinder, and Estherville series. These deposits are a source of high-quality material for construction.

A number of soils in the county formed in or are underlain at relatively shallow depths by residual material. Beds of limestone, sandstone, and shale crop out along the Des Moines River and other streams. Boone soils formed in material weathered from sandstone. They are shallow to sandstone bedrock. Gosport soils formed in material weathered from shale. Unless care is taken, the soil above the shale slides in places if the natural slope is disturbed in construction, or if embankments are constructed on the sloping surface. Calamine and Jacwin soils are underlain by shale, but the material beneath Jacwin soils is variable, and fragments of limestone and sandstone generally occur. Rockton soils are underlain by limestone that contains variable amounts of shale and other material. Calamine, Jacwin, and Rockton soils are on benches near the Des Moines River. The nature of their underlying materials needs to be taken into consideration in planning road construction.

Formation and Classification of the Soils

This section consists of three main parts. In the first part, the factors of soil formation are discussed as they relate to the soils of Webster County. The second part discusses the processes that result in the formation of soil horizons. In the third part, each soil series represented in the county is placed in its respective family, subgroup, and order in the current system for classifying soils. Detailed descriptions of the representative profiles of the soils series are given in the section "Descriptions of the Soils."

Factors of Soil Formation

Soil is produced by the action of soil-forming processes on material deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by (1) the physical and mineralogical composition of the parent material, (2) the climate under which the soil material has accumulated and existed since accumulation, (3) the plant and animal life on and in the soil, (4) the relief, or lay of the land, and (5) the length of time the forces of soil development have acted on the soil material.

Climate and vegetation are active factors of soil genesis. They act on the parent material that has accumulated through the weathering of rocks and slowly change it to a natural body that has genetically related horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of profile that can be formed and, in extreme cases, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil profile. It may be long or short, but some time is always required for horizon differentiation. A long time generally is required for the development of distinct horizons.

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

Parent material

The soils of Webster County formed in several kinds of parent material. Among these are glacial till and sediment from glacial till, alluvium, deposits of organic material, lacustrine sediment, material weathered from sandstone, and material weathered from shale. These different kinds of parent material are discussed briefly in the following paragraphs. Readers interested in more detailed information can refer to some of the publications listed in the Literature Cited. Soil-parent material relationships for soils in some of the soil associations in the county are shown in the section "General Soil Map."

Glacial till is the parent material for many of the soils of Webster County. This county has been subjected to three stages of glaciation—the Nebraskan, the Kansan, and the Wisconsin. The soils formed mainly in glacial till deposited by the most recent of these, the Wisconsin glaciations. Glacial till deposited by the earliest of the other glaciations, the Nebraskan, and by the Kansan, are exposed in many places in the valley of the Des Moines River and in the lower reaches of the valleys of a few of its tributaries. These areas are mainly steep, and they occupy only a small total acreage. Soils formed in this glacial till have been included with those soils formed in the more recently deposited Wisconsin till.

Webster County is near the center of the Des Moines lobe of the Wisconsin glaciation. The glacial till in this lobe was deposited by the Cary substage of this glaciation (*8*, *10*). Radiocarbon dates from the base of the till in the southern part of the lobe indicate that this occurred about 14,000 years ago. One evidence of the Cary substage's geologic youth is its poorly developed surface drainage system and numerous closed depressions.

Among the soils formed in glacial till are those of the Storden, Clarion, Lester, Hayden, and Nicollet series. The Webster, Canisteo, and Harps soils are in lower lying areas on the landscape, and they formed in glacial till and in glacial sediment or reworked glacial till (*20*, *21*), The Okoboji, Wacousta, and Rolfe soils formed in alluvial sediment derived from till that, in many places, washed from nearby slopes.

Alluvium consists of sediment deposited by water along major and minor streams and drainageways. It is also on benches. 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 of the alluvium has been transported only a short distance and is called local alluvium. Such alluvium retains many of the characteristics of the soils from which it has washed. Terril soils, for example, are generally at the base of slopes, below soils that formed in glacial till. They have a texture similar to soils farther up the slopes.

When streams overflow their channels, the coarser textured silty or sandy material is deposited first in areas adjacent to the stream. The flow of water is slowed as the water spreads outward toward the uplands. Generally, the finer particles are deposited farthest from the stream channel, and the finer textured soils are there. This pattern is demonstrated on some stream bottoms of the county. As a rule, Alluvial land and Sandy alluvial land, as well as Carr, Buckney, and Dorchester soils, are nearest the streams. The finer textured soils, such as those of the Spillville, Turlin, Colo, and Calco series, tend to be farther from the channel. This pattern has many exceptions, especially along the smaller streams. In places only one soil, such as the Spillville or Colo soils occurs. Other soils that formed in alluvium are Ankeny and Hanlon soils.

Some soils formed in loamy alluvium that is underlain by sand and gravel. Among these are the Wadena, Cylinder, Biscay, and Talcot soils. The soils are mainly on benches near streams, but some are in low-lying upland areas. The material in which they formed is presumed to have been deposited by melt waters from the receding Cary glacial ice.

Kamrar, Guckeen, Marna, Minnetonka, and Lanyon soils formed in lacustrine sediment and underlying glacial till. The lacustrine sediment is thought to have been deposited by the still water of lakes associated with the margin of the glacial ice, rather than by fast-moving melt water. These sedimentary deposits are mainly 24 to about 48 inches thick over the underlying glacial till. The deposits in which Lanyon soils formed, however, tend to be thicker than those of other soils. In many places the underlying material is stratified sediment of variable texture.

Ankeny and Billett soils formed in alluvium that, in many places, has been modified by local material moved by wind.

Material weathered from sandstone and shale is the oldest parent material in the county. This was deposited during the Pennsylvania and Permian periods (*3*). The bedrock from which soils formed in Webster County consists mainly of sandstone (fig. 19) and shale, but outcroppings of limestone, conglomerate, gypsum, and coal are also present.

The mining and processing of the gypsum (fig. 20) is an important industry near Fort Dodge, and in the past some coal has been mined.

Boone soils formed in material weathered from sandstone. Gorsport soils formed in material weathered from shale. Calamine soils formed in glacial sediment about 2½ feet thick over shale. All of these soils are on the lower parts of the valley sides along the Des Moines River

Figure 19.—**Sandstone bluff in Dolliver State Park. The Boone soils formed in material weathered from sandstone similar to this.**

Figure 20.—**Loading gypsum in a pit near Fort Dodge.**

or on lower reaches of some of its tributary streams. Rockton and Jacwin soils formed in alluvium. This alluvium is underlain by limestone bedrock in the Rockton soils and by shale in the Jacwin soils.

Deposits of organic matter consist of plant material that has accumulated in old lakebeds or swamps that supported a thick growth of waterloving plants. These plants have decomposed to form muck about 10 to 20 inches thick in which Muck soils have formed. The organic material is underlain by glacial sediment and, at a greater depth, by glacial till.

Climate

Webster County soils, according to recent evidence (*20*), formed under variable climatic conditions. In the post-Cary glaciation period from 13,000 to 10,500 years ago the climate was cool and conifers were the dominant vegetation. During the period from 10,500 to about 8,000 years before the present time, there was a warming trend, and the vegetation changed from conifers to a mixed hardwood forest. Beginning about 8,000 years ago, the climate became warmer and drier. Herbaceous prairie vegetation became dominant. Studies of the forest-prairie transition area of central Iowa (*6*) indicate that a late change in postglacial climate from relatively dry prairie to more moist conditions has taken place. This change may have started about 3,000 years ago. The present climate is midcontinental subhumid.

Nearly uniform climate prevails throughout the county. The influence of the general climate is modified by local conditions in or near the developing soil. For example, south-facing slopes have a microclimate that is warmer and less humid than the average climate of nearby areas. North- and east-facing slopes tend to be cooler and more moist than south-facing slopes, and, in a climate like that in Webster County, natural stands of trees are more likely to grow well. Low-lying or depressional, poorly drained or very poorly drained soils are wetter and cooler than those in most areas surrounding them.

The general climate has had an important overall influence on the characteristics of the soils, but it has not caused major differences among them. Local climatic differences influence the characteristics of the soil and account for some of the differences within the same climatic region.

Weathering of the parent material by water and air is activated by changes in temperature. As a result of weathering, changes caused by both physical and chemical actions take place. Rainfall has influenced the formation of the soils through its effect on the amount of leaching in soils and on the kinds of plants that grow.

Some variations in plant and animal life are caused by variations in temperature or by the action of other climatic forces on the soil material. To that extent, climate influences changes in soils that are brought about by differences in plant and animal life.

Plant and animal life

Many kinds of living organisms are important in the formation of soils. The activities of burrowing animals, worms, crayfish, and micro-organisms, for example, are reflected in soil properties. Differences in the kind of vegetation commonly cause the most marked differences in soils (*7*). The dominant kinds of plant life have changed with time. The soils of Webster County appear to have been influenced in recent times by prairie grasses, trees, or both.

In Webster County, tall prairie grasses were the dominant vegetation at the time of settlement. However, trees were near most major streams. Trees occupied about 46,000 acres when Webster County was settled (*2*).

Because grasses have many roots and tops that have decayed in or on the soil, soils that formed under prairie vegetation typically have a thicker, darker colored surface layer than do soils that formed under trees. Under trees the organic matter, derived principally from leaves, was deposited mainly on the surface layer of the soil. Soils that formed under trees generally are more acid and have more downward movement of bases and clay in their profiles.

The Clarion and Nicollet soils are typical of the soils that formed in glacial till under prairie vegetation in Webster County. The Webster and Canisteo soils, which are poorly drained, also formed under prairie, but their native vegetation was grasses and sedges that could tolerate wetness. The very poorly drained Okoboji soils had a native vegetation of sedges, cattails, and other vegetation that was tolerant to wetness.

The Hayden and Luther soils are among those in Webster County that formed under forest vegetation. These soils have a thin, light-colored A1 horizon, a prominent, gravish A2 horizon that is very distinct when dry, and a B horizon that has stronger structure and more evidence of the accumulation of clay than soils formed under prairie.

Lester soils have properties intermediate between those of soils that formed entirely under trees and those that formed under grass. It is believed that these soils formed under prairie and then later trees encroached on the areas. Their morphology reflects the influence of both trees and grass.

Relief

Relief, or topography, refers to the lay of the land. Slopes range from nearly level to very steep in Webster County. Relief is an important factor in soil formation because of its effect on drainage, runoff, the height of the water table, and erosion. A difference in topography is the main reason for the differing properties of some of the soils in the county. The influence of relief can be seen in a number of ways in Webster County.

The thickness and color of the A horizon and the thickness of the solum are related to slope because of its effect on erosion and the amount of water that runs off and percolates through the soil. For example, the thickness and color of the A horizon of Storden, Clarion, and Nicollet soils, which formed in similar parent material, is related to their topography. The thickness of the A horizon increases and the color darkens as the slope decreases. Most areas of Storden soils are strongly sloping to steep; Clarion soils are mainly gently sloping or moderately sloping; and Nicollet soils are mostly nearly level. Likewise, the thickness of the solum increases and depth to carbonates decreases from the Storden to the thicker Clarion and Nicollet soils. In soils that have a wide range of slopes, the depth to carbonates and the thickness of the solum decrease as the percentage of slope increases and as the slopes become more convex. In Webster County this is best exemplified by the gently sloping to steep Lester soils.

Relief affects the color of the B horizon through its effect on drainage and soil aeration. The subsoil of a soil that has good drainage generally is brown because iron compounds are well distributed throughout the horizon and are oxidized. On the other hand, the subsoil of soils that have restricted drainage or poor aeration because of wetness and a high water table is generally grayish and mottled. Webster and Okoboji soils are examples of poorly drained and very poorly drained, nearly level and depressional soils in which the evidence of wetness is expressed in the soil profile. Clarion soils are well drained and have a brownish B horizon. Nicollet soils are somewhat poorly drained and have a grayish-brown B horizon. Their profile characteristics indicate that they are intermediate in drainage.

Time

The passage of time enables the factors of relief, climate, and plant and animal life to bring about changes in parent material. If these factors continue to operate for long periods of time, very similar kinds of soils are formed from widely different kinds of parent material. But soil formation is generally interrupted by geologic events that expose new material. In Webster County new parent material has been added to the upland at least four times (*15*). The bedrock was covered by glacial drift from two glaciers, and then loess was deposited. Another glacier subsequently deposited the present surface material. But geologic erosion has once again exposed shale, sandstone, and other bedrock deposits in the valley of the Des Moines River and other streams. These are the oldest of the parent materials in the county. Gosport and Boone soils formed in these materials.

The radiocarbon technique for determining the age of carbonaceous material found in loess and till has been useful in dating late Pleistocene events. Radiocarbon dates from the base of the Cary glacial drift in the southern part of the Des Moines lobe indicate that the drift was deposited about 14,000 years ago (*8*); thus, all soils formed from it are as young as or younger than 14,000 years old. In much of Iowa, including parts of Webster County, geologic erosion has beveled and, in places, removed material from side slopes and deposited new sediment downslope (*9*). The surfaces of nearly level upland divides are older than the slopes that bevel and ascend to the divides. The side slopes, therefore, are less than 14,000 years old. In Webster County, Clarion, Hayden, and Lester soils are among those soils on side slopes.

The sediment washed from side slopes has accumulated to form local alluvium. By dating the alluvial fill at the bases of slopes, the age of the side slopes is determined. Some alluvium is less than 3,000 years old (*20*). Because the sediment from the side slopes accumulated to form the alluvium, the surfaces of the side slopes in these areas are as young as or younger than 3,000 years. In Webster County, Terril, Spillville, Ankeny, and Colo soils are among those soils that formed in similar alluvium.

Processes of Soil Horizon Differentiation

Horizon differentiation is considered to be the result of additions, removals, transfers, and transformations in the soil system (*13*). Each of these four kinds of changes affects many substances that make up soils. For example, there may be additions, removals, transfers, or transformations of organic matter, soluble salts, carbonates, sesquioxides, or silicate clay minerals.

Generally these processes promote horizon differentiation, but some of the processes offset or retard it. These processes and the resulting changes proceed simultaneously in soils, and the ultimate nature of the profile is governed by the balance of these changes within the profile.

The addition of organic matter is an early step in the process of horizon differentiation in most soils. The amount of organic matter that has accumulated in the A1 horizons of soils in Webster County ranges from high to very low. Hayden and Storden soils, for example, have a thin A1 horizon and are low in content of organic matter. Webster and Colo soils have a thick A1 horizon and are high in content of organic matter. Some soils that formerly had a high content of organic matter now have a low content because of erosion. The accumulation of organic matter has been an important process of soil horizon differentiation in Webster County.

The removal of substances from parts of the soil profile is important in the differentiation of soil horizons in Webster County. The downward movement of calcium carbonates and bases in soils is an example. Most of the soils in the county have been leached free of calcium carbonates in the upper parts of their profiles, and a few have been so strongly leached that they are medium acid or strongly acid in some horizons. The Harps, Canisteo, and Storden soils are among the exceptions, for they are calcareous throughout.

Several kinds of transfers of substances from one horizon to another are evident in the soils of Webster County. For example, phosphorus is removed from the subsoil by plant roots and transferred to those parts of the plant

growing above the surface. It is then added to the surface layer in the plant residue. These processes affect the forms and distribution of phosphorus in the profile.

The translocation of clay is an important process in the differentiation of soil horizons. The clay is made up mainly of silicate clay minerals in this area. It is carried downward, suspended in percolating water, from the A horizon to the B horizon where it accumulates in pores and root channels and in clay films on ped faces. This process has had an influence on the profile of many of the soils in Webster County, examples of which are Hayden and Dundas soils. In other soils, the content of clay in the A and B horizons is not markedly different, and only a minimal movement of clay is indicated.

Another kind of transfer that is minimal in most soils, but which occurs to some extent in very clayey soils, is that brought about by shrinking and swelling. This action causes the formation of cracks that allow some materials from the surface layer to be incorporated into lower parts of the profile. Marna soil is one of the few soils in Webster County with the potential for this kind of physical transfer.

Transformations are physical and chemical. For example, soil particles are weathered to smaller sizes. Another example is the reduction of iron by a process called "greying", which involves the saturation of the soil with water for long periods in the presence of organic matter. This process is characterized by the presence of ferrous iron and gray colors. Reductive, extractable iron, or free iron, is commonly less abundant in poorly drained soils, such as the Webster soil, than in such soils as the Nicollet and Clarion soils (*18*).

Still another kind of transformation is the weathering of the primary apatite mineral in parent material to secondary phosphorous compounds. Studies indicate that the pH value of the soil must decline to about 7 before appreciable amounts of weathering take place (*4*, *11*). This is exemplified in the Storden and Clarion soils of Webster County. For example, Storden soils, which are calcareous, are very low in available phosphorous in the subsoil. Clarion soils, which are leached and about neutral, have a better supply of available phosphorous, although it is also very low.

Classification of the Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationship to one another and to the whole environment, and to deevlop principles that help us to understand their behavior and their response to manipulation. First through classification and then through use of soil maps, we can apply our knowledge of soils to specific fields or other tracts of land.

The narrow categories of classification, such as those used in detailed soil surveys, allow us to organize and supply knowledge about soils in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas, such as countries or continents.

The system of soil classification currently used was adopted by the National Cooperative Soil Survey in 1965. Because the current system is under continual study (*14*, *17*), readers interested in developments of the current system should search the latest literature available.

The current system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar genesis, or mode of origin, are grouped. In table 6 the soil series of Webster County are placed in several categories of the current system. Classes of the current system are briefly defined in the following paragraphs.

ORDER.—Ten soil orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate among soil orders are those that tend to give broad climatic groupings of soils. The two exceptions to this are the Entisols and Histosols, which occur in many different climates.

Table 6 shows the four orders in Webster County—Alfisols, Entisols, Mollisols, and Inceptisols. Alfisols have a clay-enriched B horizon that is high in base saturation. Entisols are recent soils that do not have genetic horizons or have only the beginnings of such horizons. Mollisols have a thick, friable surface layer that has been darkened by organic matter. Inceptisols are soils that contain one or more diagnostic horizons that presumably form rather quickly and that do not represent significant illuviation or eluviation or extreme weathering.

SUBORDER.—Each order is subdivided into suborders that are based primarily on those characteristics that seem to produce classes with the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging, or soil differences resulting from climate or vegetation. The names of suborders have two syllables. The last syllable indicates the order. An example is Aquent (*Aqu* meaning water or wet, and *ent* for Entisol).

GREAT GROUPS.—Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and features. The horizons used to make separations are those in which clay, iron, or humus have accumulated, or those that have a pan that interferes with the growth of roots or movement of water, or both, and a thick, dark-colored surface horizon. The features used are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), dark-red and dark-brown colors associated with basic rocks, and the like. The names of great groups are made by adding a prefix to the name of the suborder. An example is Haplaquents.

SUBGROUPS.—Great groups are divided into subgroups, one representing the central (typic) segment of the group and others, called intergrades, that have properties of one great group and also one or more properties of another great group, suborder, or order. Subgroups may also be

TABLE 6.—*Classification of the soil series by higher categories*

Series	Family	Subgroup	Order
Ankeny	Coarse-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Billett [1]	Coarse-loamy, mixed, mesic	Mollic Hapludalfs	Alfisols.
Biscay	Fine-loamy over sandy or sandy-skeletal, mixed, noncalcareous, mesic.	Typic Haplaquolls	Mollisols.
Boone	Mesic, uncoated	Typic Quartzipsamments	Entisols.
Buckney [1]	Coarse-loamy, mixed, mesic	Entic Hapludolls	Mollisols.
Calamine [1]	Fine, illitic, noncalcareous	Typic Argiaquolls	Mollisols.
Calco [1]	Fine-silty, mixed, calcareous, mesic	Cumulic Haplaquolls	Mollisols.
Canisteo	Fine-loamy, mixed, calcareous, mesic	Typic Haplaquolls	Mollisols.
Clarion	Fine-loamy, mixed, mesic	Typic Hapludolls	Mollisols.
Colo	Fine-silty, mixed, noncalcareous, mesic	Cumulic Haplaquolls	Mollisols.
Cordova	Fine, mixed, noncalcareous, mesic	Typic Argiaquolls	Mollisols.
Cylinder	Fine-loamy over sandy or sandy-skeletal, mixed, mesi	Aquic Hapludolls	Mollisols.
Dorchester [1]	Fine-silty, mixed, calcareous, mesic	Typic Udifluvents	Entisols.
Dundas [1]	Fine-loamy, mixed, mesic	Udollic Ochraqualfs	Alfisols.
Estherville [1]	Coarse-loamy over sandy or sandy-skeletal, mixed, mesic.	Typic Hapludolls	Mollisols.
Gosport [1]	Fine, illitic, mesic	Typic Dystrochrepts	Inceptisols.
Guckeen	Fine, montmorillonitic, mesic	Aquic Hapludolls	Mollisols.
Hanlon [1]	Coarse-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Harps	Fine-loamy, mixed, mesic	Typic Calciaquolls	Mollisols.
Hayden	Fine-loamy, mixed, mesic	Typic Hapludalfs	Alfisols.
Jacwin	Fine-loamy over clayey, mixed, mesic	Aquic Hapludolls	Mollisols.
Kamrar	Fine, montmorillonitic, mesic	Typic Hapludolls	Mollisols.
Lanyon	Fine, montmorillonitic, noncalcareous, mesic	Typic Haplaquolls	Mollisols.
Lester	Fine-loamy, mixed, mesic	Mollic Hapludalfs	Alfisols.
Le Sueur	Fine-loamy, mixed, mesic	Aquic Argiudol s	Mollisols.
Luther	Fine-loamy, mixed, mesic	Aeric Ochraqualfs	Alfisols.
Marna	Fine, montmorillonitic, noncalcareous, mesic	Typic Haplaquolls	Mollisols.
Minnetonka	Fine, montmorillonitic, noncalcareous, mesic	Typic Argiaquolls	Mollisols.
Nicollet	Fine-loamy, mixed, mesic	Aquic Hapludolls	Mollisols.
Okoboji	Fine, montmorillonitic, noncalcareous, mesic	Cumulic Haplaquolls	Mollisols.
Rockton [1]	Fine-loamy, mixed, mesic	Typic Argiudolls	Mollisols.
Rolfe	Fine, montmorillonitic, mesic	Typic Argialbolls	Mollisols.
Spillville	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Storden	Fine-loamy, mixed, mesic	Typic Udorthents	Entisols.
Talcot	Fine-loamy over sandy or sandy-skeletal, mixed, calcareous, mesic.	Typic Haplaquolls	Mollisols.
Terril	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Terril, thin surface variant.	Fine-loamy, mixed, mesic	Typic Hapludolls	Mollisols.
Turlin	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols.
Wacousta	Fine-silty, mixed, noncalcareous, mesic	Typic Haplaquolls	Mollisols.
Wadena	Fine-loamy over sandy or sandy-skeletal, mixed, mesic	Typic Hapludolls	Mollisols.
Wadena, thin surface variant.	Fine-loamy over sandy or sandy-skeletal, mixed, mesic	Mollic Hapludalfs	Alfisols.
Webster	Fine-loamy, mixed, noncalcareous, mesic	Typic Haplaquolls	Mollisols.

[1] These soils are taxadjuncts to the series. Ways in which they differ from the classified series are given in the descriptions of the soil series.

made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group. An example is Typic Haplaquents.

FAMILY.—Soil families are separated within a subgroup primarily on the basis of properties important to the growth of plants or on the behavior of soils used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence. A family name consists of a series of adjectives that precede the subgroup name. The adjectives are the class names for texture, mineralogy, and so on, that are used as family differentiae. An example is fine-loamy, mixed, mesic family of Typic Hapludolls.

General Nature of the County

This section was prepared mainly for those not familiar with the county. It discusses the early history, climate, topography and drainage, transportation, industries, and markets, and farming of the county. Farm statistics used are from the Iowa Annual Farm Census for 1969.

Prior to 1850 only a few widely scattered farms were in the part of Iowa that is now Webster County. In 1850 a military post, Fort Clarke, was established on high ground east of the Des Moines River and south of Soldier Creek to provide protection for the few settlers who lived in the area. The name of the post was changed to Fort Dodge in the following year. It was abandoned in 1853, but it formed the nucleus for the city of Fort Dodge.

By 1853 the population of the area was 243, and the need for local governmental organization was increasing. The General Assembly of Iowa provided for organization of Webster County on January 22, 1853, and the first official action by the county was taken in May of 1853. A dispute arose over the selection of a county seat, but Fort Dodge was selected in 1856.

By 1860 the population of the county had increased to 2,504, and by 1900 it was 31,775. Since that time the growth in population has been slower and has been mainly in the cities and towns, especially the city of Fort Dodge. In 1967 Fort Dodge had a population of 29,654.

Climate [4]

Webster County is in the northwestern part of central Iowa, and the Des Moines River crosses from the north-central to the southeastern part of the county. The climate data in table 7 were recorded at Fort Dodge and are representative of the county as a whole.

Average precipitation is about 30 inches per year, of which about 70 percent falls in the crop season of April through September. A trace or more of rain falls on about 175 days per year. Showers of heavier intensity vary from about 95 days with at least 0.01 inch, through 59 days with 0.10 inch, to 19 days with 0.50 inch or more. About 80 percent of the heavier showers fall during the warm half of the year when the hazard of soil erosion is the greatest. The sloping areas of Webster County are subject to sheet erosion, and the undulating areas, which are characteristic of the remainder of the county, have undrained depressions in places that become wet with standing water in periods of heavy showers.

Snow cover of an inch or more is reported on about 77 days per year and averages about 5 inches in depth. Since 1942 the greatest depth of snow was 22 inches in March 1962. Generally a snowfall of an inch or more is first reported late in November. In an average season about 40 inches of snow falls on Webster County. This is about 13 percent of the total annual precipitation.

Ideally, in the crop season moisture in the subsoil is abundant and moisture in the topsoil is moderate. Variations from optimum soil conditions are normally frequent but generally not extreme. Generally ample rain falls in May and June and is followed by drier weather later in the summer. Well-developed corn needs about an inch of moisture per week for optimum growth. The chances of receiving this amount of rainfall in each week are about 40 percent in June and 25 percent in July and August.

Midday temperatures vary little throughout the county, but nighttime temperatures can vary as much as 10 degrees between cold air sinking into the lowlands and the relatively warmer air above the uplands and urban areas. Optimum corn growth is normally attained when temperatures are warm, but below 90° F. On the average, about 23 days in summer have a temperature of 90° or higher. Operations in winter are hampered by subfreezing temperatures that occur on about 127 days per season. The average date of last occurrence of a 32-degree temperature in spring is about May 5. The average date of first occurrence of a 32-degree temperature in fall is about October 4. The average length of the growing season is 152 days. Subzero days average about 20 or 25 per year.

Topography and Drainage

Most of the soils in Webster County are nearly level to gently sloping or moderately sloping. The greatest differences in relief are in the vicinity of the Des Moines River and near the mouths of tributary streams, where the slopes are steep in places. Generally the elevation of the uplands ranges from 1,100 to 1,200 feet (*3*). The soil sur-

[4] This section was prepared by PAUL J. WAITE, climatologist for Iowa, National Weather Service, U.S. Department of Commerce.

TABLE 7.—*Temperature and precipitation, Webster County, Iowa*

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Average monthly maximum	Average monthly minimum	Average monthly total	One year in 10 will have—		Number of days with snow cover of 1 inch or more	Average depth of snow on days with snow cover
						Less than—	More than—		
	°F.	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*		*Inches*
January	28	10	48	−16	1.1	2.0	0.2	22	5
February	32	13	51	−10	1.0	2.3	.2	20	5
March	43	24	69	2	1.9	4.1	.7	14	7
April	60	37	82	21	2.5	5.4	1.2	1	3
May	72	48	89	32	3.8	7.1	2.0	(1)	(2)
June	81	58	94	43	5.1	10.7	2.8	0	0
July	87	62	97	50	3.5	6.0	1.4	0	0
August	84	61	95	46	3.7	5.6	1.6	0	0
September	77	51	91	32	3.2	5.0	.4	0	0
October	65	41	84	23	1.7	3.5	.2	0	0
November	46	26	68	6	1.8	3.3	.1	5	3
December	33	15	53	−8	1.0	1.8	.3	15	4
Year	59	37	99	−18	30.2	40.0	22.6	77	5

[1] Less than one day.
[2] Less than 1 inch.

face is somewhat higher in the western, northern, and extreme southern parts of the county than in the central and eastern parts. Small morainal hills of low relief extend across the county along the southern boundary and through the northern two-thirds of the county. The nearly level soils of the county, mainly in soil associations 4 and 5, contain depressional areas that were once wet and swampy. Most of these areas have since been artificially drained and are now used as cropland.

The Des Moines River flows from about the center of the northern boundary of the county to the south and southeastward and leaves the county near the eastern end of the southern boundary. In most places the valley of the Des Moines River is less than three-fourths of a mile wide, but it is deep. This river and its tributary streams, most of which are relatively short, provide the stream drainage for much of the county.

Among the streams that flow into the Des Moines River in Webster County are Der, Bass, Badger, Soldier, Brushy, Skillett, Prairie, and Lizard Creeks and the Boone River. Most of these smaller streams are deeply incised near their mouths, but within 5 to 10 miles from the Des Moines River they become sluggish streams that, for the most part, have been straightened and deepened artificially. These streams carry off water from tile drains on the adjacent farms and minimize flood damage. A few creeks in the southwestern part of the county, including the east and west branches of Buttrick Creek and Hardin Creek, drain into the Raccoon River. A small area in the northeastern part of the county drains into the Boone River.

Transportation, Industries, and Markets

U.S. Highway No. 20 serves east-west traffic and U.S. Highway No. 169 serves north-south traffic across the county. These highways intersect at Fort Dodge and are connected with all parts of the county by State Routes 7, 50, and 175 and by county roads. All farms have access to hardsurfaced or graveled roads. Three railroads serve Fort Dodge, and most towns are served by one or more railroads. Scheduled airline transportation is available at Fort Dodge in the north-central part of the county. Bus transportation is available on the main highways. Motor freight lines serve every trading center in the county.

Farming is the main enterprise, but several industries are in the county, mainly at Fort Dodge. Among those at Fort Dodge are meat-packing plants and plants for manufacturing gypsum products, livestock feed, and farm machinery. Clay tile products are manufactured at several plants between Lehigh and Fort Dodge. A large limestone quarry is located at Fort Dodge, and it furnishes limestone that is used as a soil amendment and for other purposes. A large plant for manufacturing nitrogen fertilizer is a few miles east of Fort Dodge. A large laboratory at Fort Dodge produces vaccines and serums for livestock.

Most grain crops are marketed at grain elevators that are in most of the towns. Livestock are marketed at plants in Fort Dodge or at markets in other cities, including Sioux City and Omaha. Also numerous hog-buying stations are in the county. Milk and milk products marketed in the county and elsewhere are processed and packaged at a few dairies and creameries. Poultry and eggs are marketed at numerous places in the county.

Farming

According to the Iowa Annual Farm Census (*5*), Webster County had a total of 430,561 acres in farms in 1969. About 307,464 acres were used for field crops, and about 49,877 acres were in pasture. The rest of the acreage, about 73,220 acres, was used for other farm purposes, including lots, roads, building sites, waste land, and so on.

In recent years there has been a steady decrease in the number of farms and an increase in the size of farms. In 1969 a total of 5,968 people lived on 1,566 farms that had an average size of 275 acres. In that year 33.8 percent of the land was owned by the farm operators and 66.2 percent was rented by the farm operators.

Many farms are of the cash-grain type, and most of the income is derived from the sale of corn and soybeans. Some farms are of the general type, and part of the income is derived from the sale of livestock and part from the sale of crops. A smaller number of farms are specialized, and on these farms dairying or the production or feeding of a specific kind of livestock, such as beef cattle, hogs, or turkeys, is the main source of farm income.

In 1969 the largest acreage of cropland in Webster County, or 147,807 acres, was used for growing soybeans, and the next largest acreage was used for growing corn. Corn was harvested for grain on 136,011 acres and was grown for silage or other purposes on about 2,600 acres. In that year the average yield of soybeans was 29.8 bushels per acre, and the average yield of corn was 96.2 bushels per acre. A total of 10,738 acres was in oats, and 9,963 acres were in hay of all kinds.

Beef cattle and hogs are the kinds of livestock raised most extensively in Webster County. Grain-fed cattle marketed in 1969 totaled 25,827. Sows that were farrowed in the fall of 1969 and in the spring of 1970 totaled 16,033, and hogs that were marketed totaled 108,330. There were 27,100 laying hens and 85,000 turkeys raised. Beef cows totaled 6,223, and milk cows totaled 1,003. Lambs born in 1969 totaled 2,308.

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Glossary

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as crumbs, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Alluvium, local. Soil material that has been moved a short distance and deposited at the base of slopes and along small drainageways. It includes the poorly sorted material near the base of slopes that has been moved by gravity, frost action, soil creep, and local wash.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Bench position. A high, shelflike position.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Contour farming. Plowing, cultivating, planting, and harvesting in rows that are at right angles to the natural direction of the slope or that are parallel to terrace grade.

Drainage class (natural). Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A horizon and upper part of the B horizon and have mottling in the lower part of the B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time, and some soils commonly have mottling at a depth below 6 to 16 inches.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Erosion. The wearing away of the land surface by wind (sandblast), running water, and other geological agents.

Flood plain. Nearly level land, consisting of stream sediments, that borders a stream and is subject to flooding unless protected artificially.

Glacial till (geology). Unassorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Gleyed soil. A soil in which waterlogging and lack of oxygen have caused the material in one or more horizons to be neutral gray in color. The term "gleyed" is applied to soil horizons with yellow and gray mottling caused by intermittent waterlogging.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer.—Consolidated rock beneath the soil. The rock usually underlies a C horizon but may be immediately beneath an A or B horizon.

Leaching. The removal of soluble materials from soils or other material by percolating water.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few*, *common*, and *many;* size—*fine*, *medium*, and *coarse;* and contrast—*faint*, *distinct*, and *prominent*. The size measurements are these: *fine*, less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium*, ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse*, more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Parent material. Disintegrated and partly weathered rock from which soil has formed.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

Percolation. The downward movement of water through the soil.

Permeability. The quality that enables the soil to transmit water or air. Terms used to describe permeability are as follows: *very slow*, *slow*, *moderately slow*, *moderate*, *moderately rapid*, *rapid*, and *very rapid*.

Reaction, soil. The degree of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Mildly alkaline	7.4 to 7.8
Very strongly acid	4.5 to 5.0	Moderately alkaline	7.9 to 8.4
Strongly acid	5.1 to 5.5	Strongly alkaline	8.5 to 9.0
Medium acid	5.6 to 6.0	Very strongly alkaline	9.1 and higher
Slightly acid	6.1 to 6.5		
Neutral	6.6 to 7.3		

Relief. The elevations or inequalities of a land surface, considered collectively.

Sand. Individual rock or mineral fragments in a soil that range in diameter from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that it may soak into the soil or flow slowly to a prepared outlet without harm. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod.

Terrace (geological). An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand*, *loamy sand*, *sandy loam*, *loam*, *silt loam*, *silt*, *sandy clay loam*, *clay loam*, *silty clay loam*, *sandy clay*, *silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Upland (geology). Land consisting of material unworked by water in recent geologic time and lying, in general, at a higher elevation than the alluvial plain or stream terrace. Land above the lowlands along rivers.

Water table. The highest part of the soil underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

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