United States
Department of
Agriculture

Soil
Conservation
Service

In cooperation with
Iowa Agriculture and
Home Economics
Experiment Station;
Cooperative Extension
Service, Iowa State
University;
and Department of
Soil Conservation,
State of Iowa

Soil Survey of Pocahontas County Iowa

HOW TO USE

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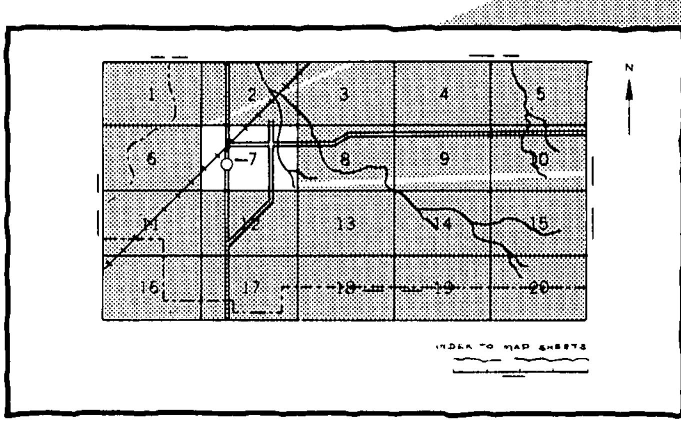

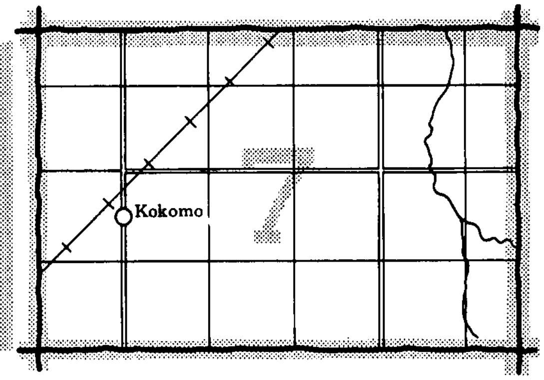

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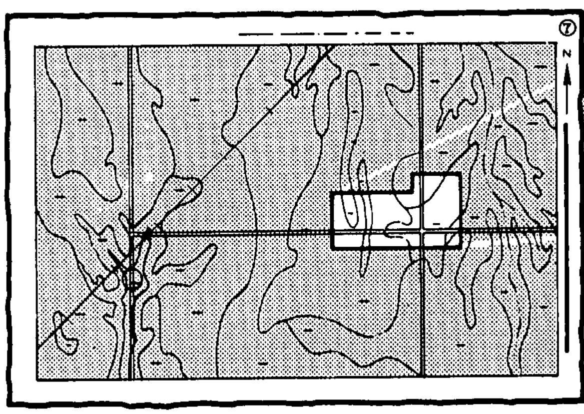

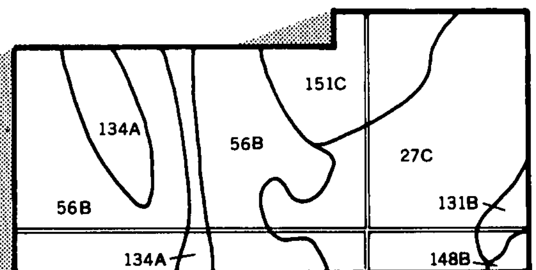

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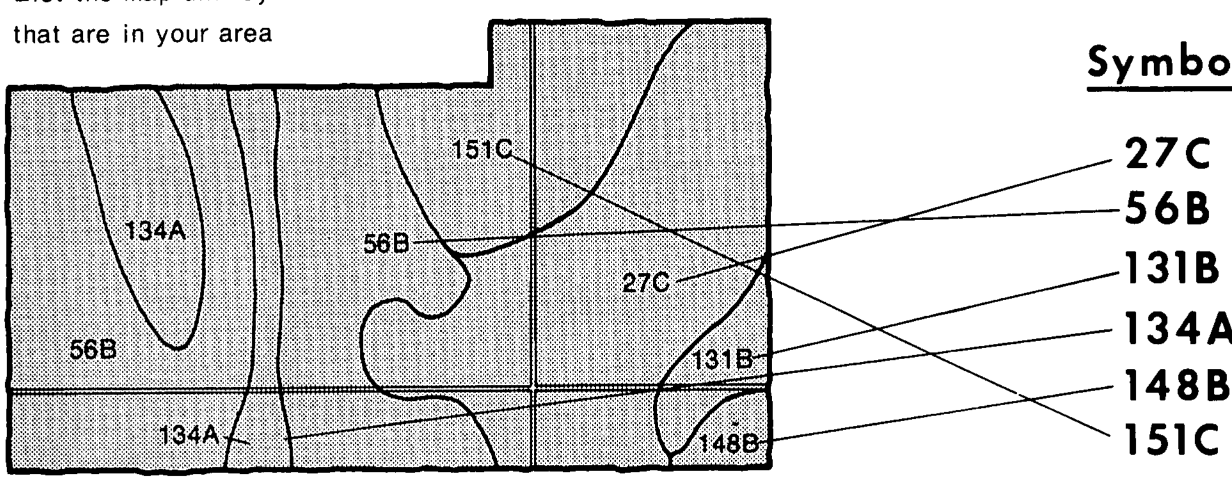
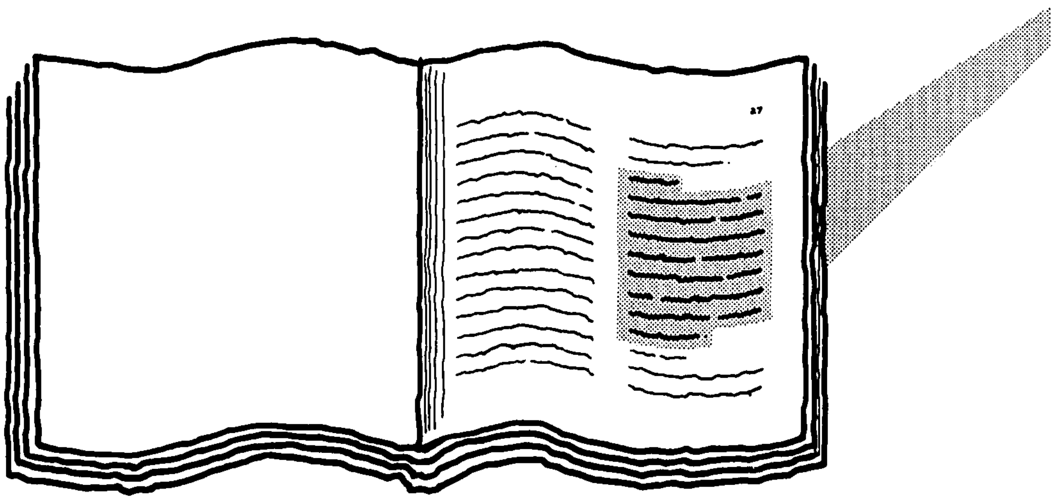
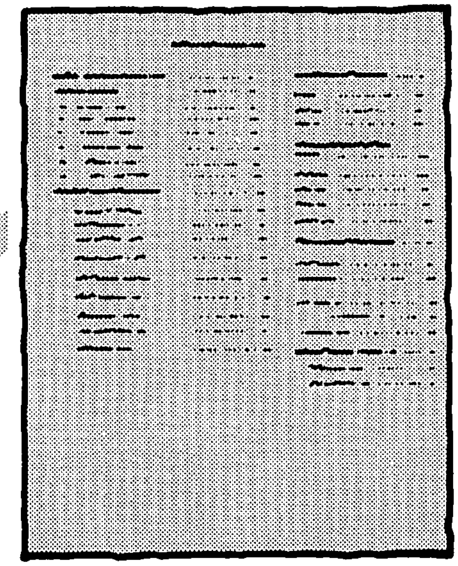


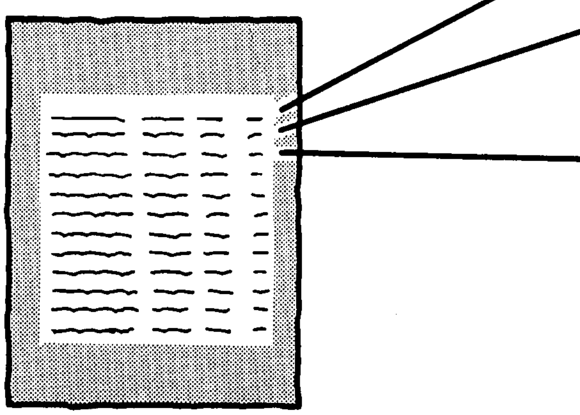
THIS SOIL SURVEY

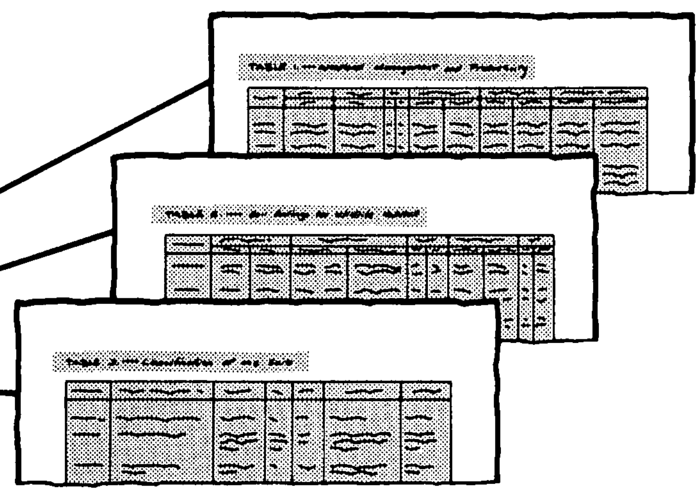
5. Turn to "Index to Soil Map Units" which lists the name of each map unit and the page where that map unit is described.





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





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

This soil survey is a publication of the National Cooperative Soil Survey, a joint effort of the United States Department of Agriculture and other federal agencies, state agencies including the Agricultural Experiment Stations, and local agencies. The Soil Conservation Service has leadership for the federal part of the National Cooperative Soil Survey. In line with Department of Agriculture policies, benefits of this program are available to all, regardless of race, color, national origin, sex, religion, marital status, or age.

Major fieldwork for this soil survey was completed in the period 1977-1981. Soil names and descriptions were approved in 1982. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1982. This survey was made cooperatively by the Soil Conservation Service; the Iowa Agriculture and Home Economics Experiment Station; the Cooperative Extension Service, Iowa State University; and the Department of Soil Conservation, State of Iowa. It is part of the technical assistance furnished to the Pocahontas County Soil Conservation District. Funds appropriated by Pocahontas County were used to defray part of the cost of this survey.

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

Cover: An area of Clarion and Nicollet soils used for corn, one of the principal crops grown in Pocahontas County.

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Preface

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

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

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

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

Soil Survey of
Pocahontas County, Iowa

By Richard D. Finley and John A. Lucassen, Soil Conservation Service

Fieldwork by Richard D. Finley, James A. Martzke, and John A. Lucassen,
Soil Conservation Service

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

POCAHONTAS COUNTY is in the northwestern part of Iowa (fig. 1). It has a total area of 372,480 acres, or 582 square miles. Pocahontas, the county seat, is in the center of the county. It is about 116 miles northwest of Des Moines and 103 miles northeast of Sioux City.

Farming is the main enterprise in the county. The principal crops are corn and soybeans. Along with beef cattle, hogs, and dairy products, they are the chief sources of local income. Industry is becoming increasingly important in the vicinity of Pocahontas.

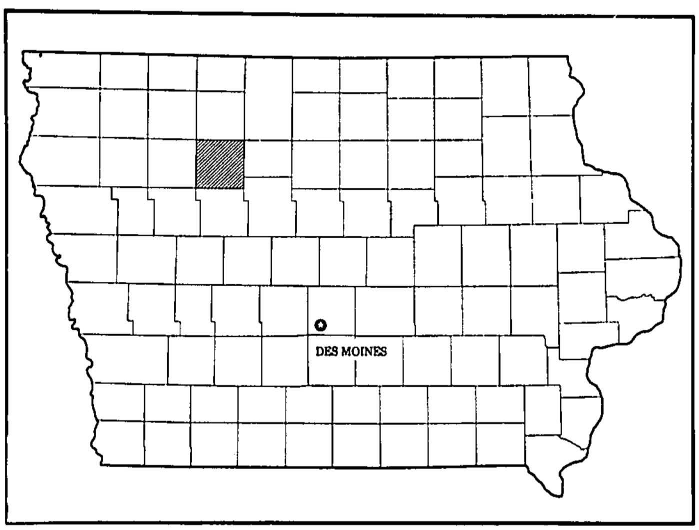

Figure 1.—Location of Pocahontas County in Iowa.

This survey updates the survey of Pocahontas County published in 1928 (*6*). It provides additional information and larger maps, which show the soils in more detail.

General Nature of the County

The following paragraphs provide general information about Pocahontas County. They describe the climate, physiography and drainage, history, farming, and transportation facilities.

Climate

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

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

Table 1 gives data on temperature and precipitation for the survey area as recorded at Pocahontas, Iowa, in the period 1951 to 1979. Table 2 shows probable dates of the first freeze in fall and the last freeze in spring. Table 3 provides data on length of the growing season.

In winter the average temperature is 19 degrees F, and the average daily minimum temperature is 10 degrees. The lowest temperature on record, which occurred at Pocahontas on January 21, 1970, is -26 degrees. In summer the average temperature is 72 degrees, and the average daily maximum temperature is 83 degrees. The highest recorded temperature, which occurred at Pocahontas on July 31, 1955, is 108 degrees.

Growing degree days are shown in table 1. They are equivalent to "heat units." During the month, growing degree days accumulate by the amount that the average temperature each day exceeds a base temperature (50 degrees F). The normal monthly accumulation is used to schedule single or successive plantings of a crop between the last freeze in spring and the first freeze in fall.

The total annual precipitation is 29.46 inches. Of this, 22 inches, or 75 percent, usually falls in April through September. The growing season for most crops falls within this period. In 2 years out of 10, the rainfall in April through September is less than 17 inches. The heaviest 1-day rainfall during the period of record was 6.3 inches at Pocahontas on August 31, 1962. Thunderstorms occur on about 45 days each year, and most occur in summer.

The average seasonal snowfall is 31 inches. The greatest snow depth at any one time during the period of record was 23 inches. On an average of 25 days, at least 1 inch of snow is on the ground. The number of such days varies greatly from year to year.

The average relative humidity in midafternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 70 percent of the time possible in summer and 55 percent in winter. The prevailing wind is from the west. Average windspeed is highest, 13 miles per hour, in spring.

Tornadoes and severe thunderstorms strike occasionally. These storms are local in extent and of short duration and result in sparse damage in narrow belts. Hailstorms occur at times during the warmer part of the year in scattered small areas.

Physiography and Drainage

The topography in Pocahontas County is geologically immature, as is evidenced by the large number of potholes and other depressions and by the limited number of minor upland streams. Two distinct types of morainal topography are evident in the county. One is a complex of short, uneven slopes that have many, small, indistinct drainage patterns. This kind of topography is prevalent in the western part of the county. The other type is a series of flat-topped, smooth-sided hills. Areas adjacent to the major streams are dissected but show little evidence of headward extension.

Two major Iowa drainage systems, the Big Cedar Creek and the Des Moines River, receive runoff from Pocahontas County. The eastern two-thirds of the county is drained by the Des Moines River and its tributaries, and the western third is drained by Big Cedar Creek and its tributaries. Lizard, Beaver, Pilot, and Crooked Creeks flow into the Des Moines River from the west. Little Cedar Creek flows into Big Cedar Creek in the western part of the county.

History

The first settlers in the area now known as Pocahontas County arrived in 1855. They settled in sections 12 and 13 of Lizard Township. This was the site of the first permanent settlement. The second settlement was in section 26 of Des Moines Township (*3*). The county was organized in 1859. The Pocahontas County Board of Supervisors was organized in 1861. The county was named after Pocahontas, the Indian Princess and wife of John Rolfe. The county seat was first located in Old Rolfe in 1859. In the fall of 1876, it was moved to Pocahontas.

The first road in the county was completed in 1860, in Des Moines Township. The second road, completed in 1861, linked Des Moines Township and Lizard Township. In 1860, the first bridge over the Des Moines River was built. In 1870, the first railroad in the county reached Cedar Creek, the present site of Fonda. Soon afterwards, railroads reached other parts of the county, providing better service and outlets for farm products. The development of telegraph communications closely paralleled the development of railroads. The first telephone line was established in 1886.

The population of the county was 103 in 1860. It increased most rapidly during the period 1860 to 1900. By 1900, it was about 15,000, and by 1940, it reached 16,266, the maximum population. The population has gradually declined since 1940. In 1980, it was 11,369 (*17*).

The Pocahontas County Soil Conservation District was formed in 1946. Harry L. Lund was elected the first chairman.

Farming

Farming is a vital part of the economy of Pocahontas County. It provides a livelihood not only for farmers but also for related businesses and professions. In 1980, about 41 percent of the population in the county lived on farms (*17*).

In recent years, the number of farms in the county has been decreasing and the average size of the farms has been increasing. According to a report published in 1981, the number of farms is 1,150 and the average size is 312 acres (*4*).

Corn and soybeans are the main row crops. Some areas are used for oats or hay and pasture. Livestock production is becoming more specialized. More farmers are raising only one class of livestock. In recent years, the number of total confinement livestock systems has increased. Most of the farmers using these systems raise swine.

In the past few years, the total cash receipts for the farms in the county have been considerably above the average for Iowa. Production has increased as the farms have decreased in number and increased in size. The increased productivity is partly the result of more efficient farming methods.

The annual expenses for crop and livestock production may be nearly half of the total cash receipts in the county. These expenses can vary greatly from year to year. They include outlays for feed, seed, fertilizer, chemicals, fuel, oil, machinery, and other products, most of which are purchased locally.

Transportation Facilities

Two major highways divide Pocahontas County. State Highway 3 traverses the county from east to west and State Highway 4 from north to south. The two highways intersect in Pocahontas. Hard-surface state or county roads connect these highways to all of the other communities in the county. All farms are along hard-surface farm-to-market roads or gravel roads. The major county roads are well distributed throughout the county.

Four railroads provide rail service to the towns throughout the county. Limited bus transportation is available in Pocahontas, Laurens, Fonda, Rolfe, and Gilmore City. Airstrips are located at Pocahontas and Laurens. Motor freight lines serve every trading center in the county.

How This Survey Was Made

This survey was made to provide information about the soils in the survey area. The information includes a description of the soils and their location and a discussion of the suitability, limitations, and management of the soils for specified uses. Soil scientists observed the steepness, length, and shape of slopes; the general pattern of drainage; the kinds of crops and native plants growing on the soils; and the kinds of bedrock. They dug many holes to study the soil profile, which is the sequence of natural layers, or horizons, in a soil. The profile extends from the surface down into the unconsolidated material in which the soil formed. The unconsolidated material is devoid of roots and other living organisms and has not been changed by other biologic activity.

The soils in the survey area occur in an orderly pattern that is related to the geology, the landforms, relief, climate, and the natural vegetation of the area. Each kind of soil is associated with a particular kind of landscape or with a segment of the landscape. By observing the soils in the survey area and relating their position to specific segments of the landscape, a soil scientist develops a concept, or model, of how the soils were formed. Thus, during mapping, this model enables the soil scientist to predict with considerable accuracy the kind of soil at a specific location on the landscape.

Commonly, individual soils on the landscape merge into one another as their characteristics gradually change. To construct an accurate soil map, however, soil scientists must determine the boundaries between the soils. They can observe only a limited number of soil profiles. Nevertheless, these observations, supplemented by an understanding of the soil-landscape relationship, are sufficient to verify predictions of the kinds of soil in an area and to determine the boundaries.

Soil scientists recorded the characteristics of the soil profiles that they studied. They noted soil color, texture, size and shape of soil aggregates, kind and amount of rock fragments, distribution of plant roots, acidity, and other features that enable them to identify soils. After describing the soils in the survey area and determining their properties, the soil scientists assigned the soils to taxonomic classes (units). Taxonomic classes are concepts. Each taxonomic class has a set of soil characteristics with precisely defined limits. The classes are used as a basis for comparison to classify soils systematically. The system of taxonomic classification used in the United States is based mainly on the kind and character of soil properties and the arrangement of horizons within the profile. After the soil scientists classified and named the soils in the survey area, they compared the individual soils with similar soils in the same taxonomic class in other areas so that they could confirm data and assemble additional data based on experience and research.

While a soil survey is in progress, samples of some of the soils in the area generally are collected for laboratory analyses and for engineering tests. Soil scientists interpreted the data from these analyses and tests as well as the field-observed characteristics and the soil properties in terms of expected behavior of the soils under different uses. Interpretations for all of the soils were field tested through observation of the soils in different uses under different levels of management. Some interpretations are modified to fit local conditions, and new interpretations sometimes are developed to meet local needs. Data were assembled from other sources, such as research information, production records, and field experience of specialists. For example, data on crop yields under defined levels of management were assembled from farm records and from field or plot experiments on the same kinds of soil.

Predictions about soil behavior are based not only on soil properties but also on such variables as climate and biological activity. Soil conditions are predictable over long periods of time, but they are not predictable from year to year. For example, soil scientists can state with a fairly high degree of probability that a given soil will have a high water table within certain depths in most years, but they cannot assure that a high water table will always be at a specific level in the soil on a specific date.

After soil scientists located and identified the significant natural bodies of soil in the survey area, they drew the boundaries of these bodies on aerial photographs and identified each as a specific map unit. Aerial photographs show trees, buildings, fields, roads, and rivers, all of which help in locating boundaries accurately.

Map Unit Composition

A map unit delineation on a soil map represents an area dominated by one major kind of soil or an area dominated by several kinds of soil. A map unit is identified and named according to the taxonomic classification of the dominant soil or soils. Within a taxonomic class there are precisely defined limits for the properties of the soils. On the landscape, however, the soils are natural objects. In common with other natural objects, they have a characteristic variability in their properties. Thus, the range of some observed properties may extend beyond the limits defined for a taxonomic class. Areas of soils of a single taxonomic class rarely, if ever, can be mapped without including areas of soils of other taxonomic classes. Consequently, every map unit is made up of the soil or soils for which it is named and some soils that belong to other taxonomic classes. These latter soils are called inclusions or included soils.

Most inclusions have properties and behavioral patterns similar to those of the dominant soil or soils in the map unit, and thus they do not affect use and management. These are called noncontrasting (similar) inclusions. They may or may not be mentioned in the map unit descriptions. Other inclusions, however, have properties and behavior divergent enough to affect use or require different management. These are contrasting (dissimilar) inclusions. They generally occupy small areas and cannot be shown separately on the soil maps because of the scale used in mapping. The inclusions of contrasting soils are mentioned in the map unit descriptions. A few inclusions may not have been observed and consequently are not mentioned in the descriptions, especially where the soil pattern was so complex that it was impractical to make enough observations to identify all of the kinds of soil on the landscape.

The presence of inclusions in a map unit in no way diminishes the usefulness or accuracy of the soil data. The objective of soil mapping is not to delineate pure taxonomic classes of soils but rather to separate the landscape into segments that have similar use and management requirements. The delineation of such landscape segments on the map provides sufficient information for the development of resource plans, but onsite investigation is needed to plan for intensive uses in small areas.

General Soil Map Units

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

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

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

Soil Descriptions

1. Clarion-Webster-Canisteo association

Nearly level to strongly sloping, well drained and poorly drained, loamy soils that formed in local alluvium and glacial till on uplands

This association is on till plains. It consists of nearly level soils on flats and in swales and gently sloping to strongly sloping soils on knolls and ridges and along upland drainageways. Slope generally ranges from 0 to 14 percent.

This association makes up about 75 percent of the county. It is about 23 percent Clarion soils, 20 percent Webster soils, 19 percent Canisteo soils, and 38 percent soils of minor extent (fig. 2).

The well drained Clarion soils are on knolls, ridges, and the sides of upland drainageways. They are dominantly gently sloping, but in some areas they are steeper. The poorly drained, nearly level Webster soils are in swales and slightly concave draws and in some areas on flats. The poorly drained, nearly level Canisteo soils are on broad upland flats.

Typically, the surface layer of the Clarion soils is black loam about 8 inches thick. The subsurface layer also is loam about 8 inches thick. It is black in the upper part and very dark grayish brown in the lower part. The subsoil is friable loam about 25 inches thick. It is brown in the upper part and dark yellowish brown in the lower part. The substratum to a depth of about 60 inches is yellowish brown, mottled, calcareous loam.

Typically, the surface layer of the Webster soils is black clay loam about 9 inches thick. The subsurface layer is clay loam about 11 inches thick. It is black in the upper part and very dark gray in the lower part. The subsoil is olive gray, mottled, friable clay loam about 16 inches thick. The substratum to a depth of about 60 inches is olive gray, mottled, calcareous clay loam.

Typically, the surface layer of the Canisteo soils is black, calcareous clay loam about 10 inches thick. The subsurface layer also is calcareous clay loam about 10 inches thick. It is black in the upper part and very dark gray and mottled in the lower part. The subsoil is dark gray and grayish brown, mottled, friable, calcareous clay loam about 15 inches thick. The substratum to a depth of about 60 inches is olive gray, mottled, calcareous clay loam.

Minor in this association are the very poorly drained Okoboji and Knoke soils, the highly calcareous Harps and calcareous Storden soils, and the somewhat poorly drained Nicollet soils. Okoboji and Knoke soils are in closed depressions. Harps soils are mainly on the narrow rims around depressions. Nicollet soils are on knolls and swells. Storden soils are moderately sloping to steep.

Most of the acreage in this association is used for row crops. Some areas are used for permanent pasture. Corn and soybeans are the main crops on the nearly level to moderately sloping soils. Oats and hay are grown on the poorly drained soils in some of the low lying areas on livestock farms. The hay is generally alfalfa, a mixture of alfalfa and grass, or clover.

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

Erosion is a hazard on the more sloping soils in this association. Even though slopes are short and irregularly shaped, contour farming and terraces help to control erosion. A drainage system is needed in the poorly drained and very poorly drained soils. Tile lines and drainage ditches reduce the wetness. Soil blowing is a hazard if the soils are plowed in the fall. It can be

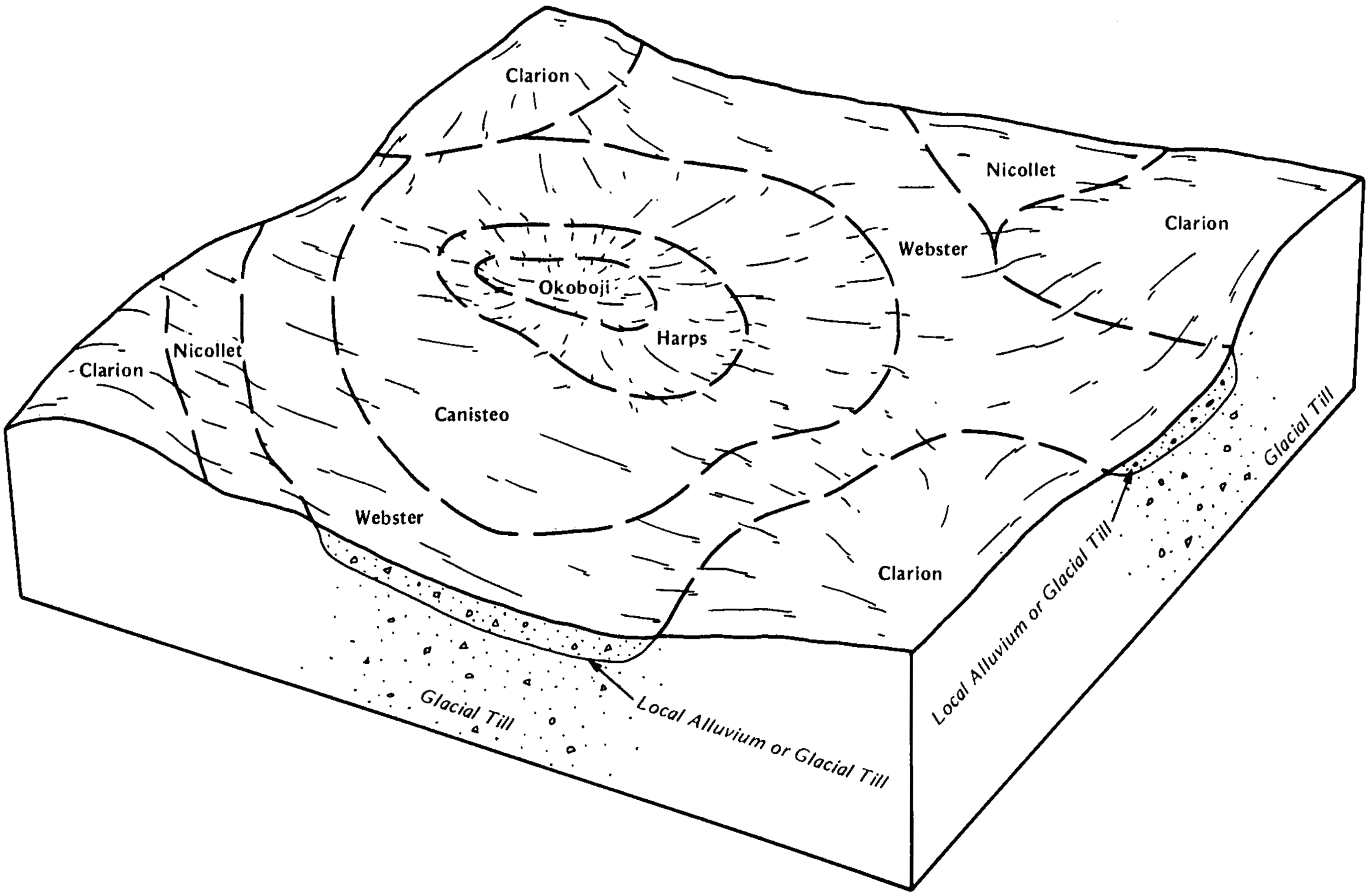

Figure 2.—Typical pattern of soils and parent material in the Clarion-Webster-Canisteo association.

controlled, however, by a conservation tillage system that leaves a protective amount of crop residue on the surface and by field windbreaks.

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

2. Webster-Canisteo-Nicollet association

Nearly level and very gently sloping, poorly drained and somewhat poorly drained, loamy soils that formed in local alluvium and glacial till on uplands

This association consists of nearly level soils on flats and in swales and very gently sloping soils on slight rises. Slope generally ranges from 0 to 3 percent.

This association makes up about 23 percent of the county. It is about 35 percent Webster soils, 23 percent Canisteo soils, 17 percent Nicollet soils, and 25 percent soils of minor extent (fig. 3).

The poorly drained, nearly level Webster soils are in swales and slightly concave draws and on flats. The poorly drained, nearly level Canisteo soils are on broad upland flats. The somewhat poorly drained, very gently sloping Nicollet soils are on slight rises.

Typically, the surface layer of the Webster soils is black clay loam about 9 inches thick. The subsurface layer is clay loam about 11 inches thick. It is black in the upper part and very dark gray in the lower part. The subsoil is olive gray, mottled, friable clay loam about 16 inches thick. The substratum to a depth of about 60 inches is olive gray, mottled, calcareous clay loam.

Typically, the surface layer of the Canisteo soils is black, calcareous clay loam about 10 inches thick. The subsurface layer also is calcareous clay loam about 10 inches thick. It is black in the upper part and very dark gray and mottled in the lower part. The subsoil is dark gray and grayish brown, mottled, friable, calcareous clay loam about 15 inches thick. The substratum to a depth

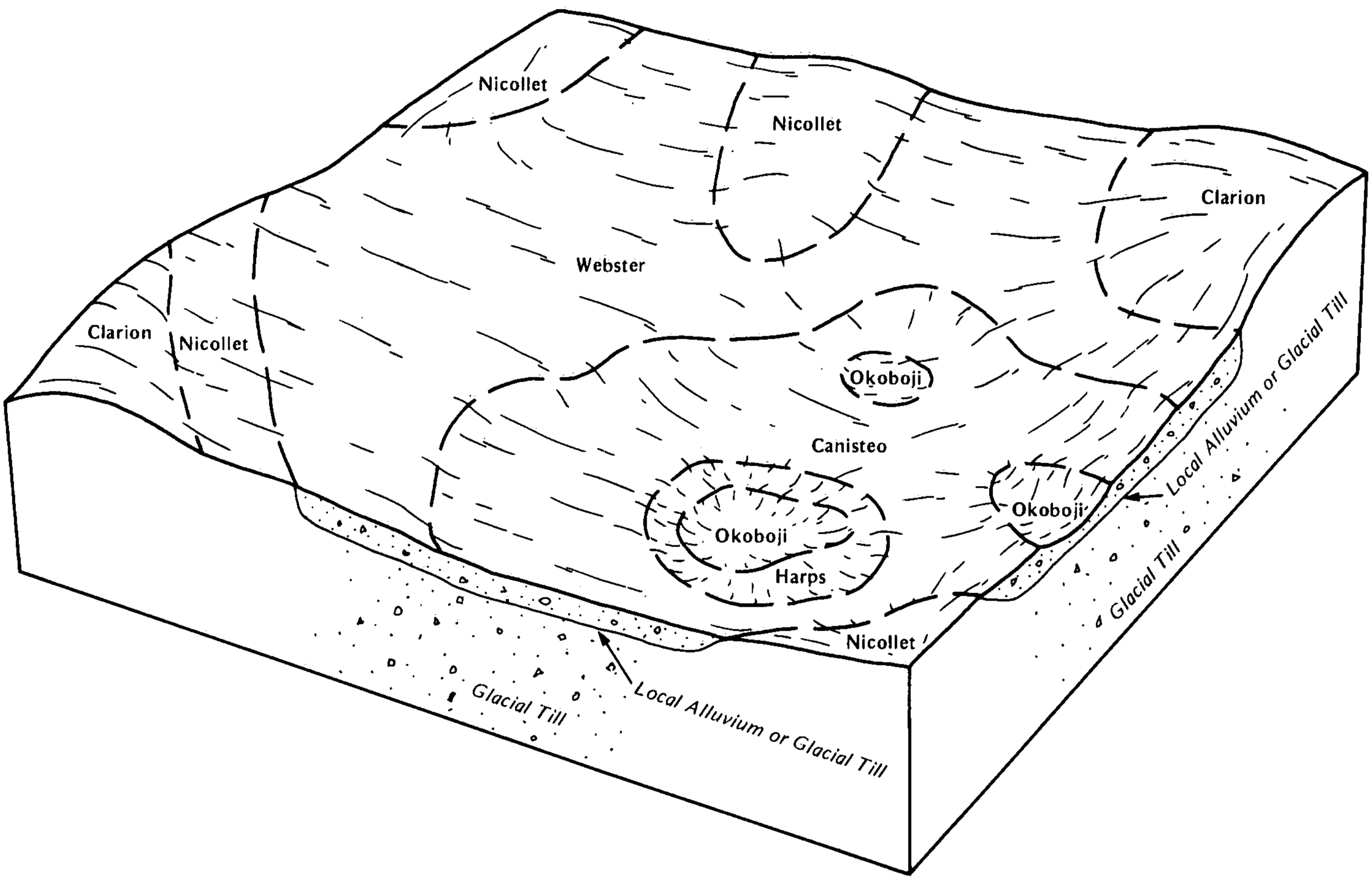

Figure 3.—Typical pattern of soils and parent material in the Webster-Canisteo-Nicollet association.

of about 60 inches is olive gray, mottled, calcareous clay loam.

Typically, the surface layer of the Nicollet soils is black clay loam about 9 inches thick. The subsurface layer is black and very dark gray clay loam about 13 inches thick. The subsoil is dark grayish brown, friable clay loam about 9 inches thick. It is mottled in the lower part. The substratum to a depth of about 60 inches is grayish brown and light yellowish brown, mottled, calcareous loam.

Minor in this association are the very poorly drained Okoboji and Knoke soils, the poorly drained Harps soils, and the well drained Clarion soils. Okoboji and Knoke soils are in the closed depressions. Knoke soils are calcareous. Harps soils are highly calcareous. They are mainly on narrow rims around depressions. Clarion soils are gently sloping and are on knolls.

Almost all of the acreage in this association is used for row crops. Corn and soybeans are the main crops. A large amount of the grain is sold for cash. A few farms are diversified and raise livestock. On these farms part of the corn is fed to beef cattle and swine.

Soil blowing is a hazard if the soils in this association are plowed in the fall. It can be controlled, however, by a conservation tillage system that leaves a protective amount of crop residue on the surface and by field windbreaks.

The trees on this association are grown mainly as farmstead windbreaks and ornamentals around farmsteads.

3. Havelock-Coland-Estherville association

Nearly level to moderately sloping, poorly drained and somewhat excessively drained, loamy soils that formed in alluvium or glacial outwash on bottom land, terraces, and outwash plains

This association consists mainly of nearly level soils on bottom land and nearly level to moderately sloping soils on terraces and outwash plains. Many trees and old meandering stream channels are on the bottom land,

and irrigation systems are on the terraces. Slope ranges from 0 to 9 percent.

This association makes up about 2 percent of the county. It is about 24 percent Havelock soils, 15 percent Coland soils, 14 percent Estherville soils, and 47 percent soils of minor extent (fig. 4).

The poorly drained, nearly level Havelock and Coland soils are on channeled bottom land. The somewhat excessively drained, nearly level to moderately sloping Estherville soils are on terraces and outwash plains.

Typically, the surface layer of the Havelock soils is black, calcareous clay loam about 9 inches thick. The subsurface layer is calcareous clay loam about 31 inches thick. It is black in the upper part and very dark gray in the lower part. The upper part of the substratum is gray, calcareous loam. The lower part to a depth of about 60 inches is gray, mottled, calcareous sandy loam.

Typically, the surface layer of the Coland soils is black clay loam about 7 inches thick. The subsurface layer is about 30 inches thick. It is black clay loam in the upper part and very dark gray loam in the lower part. The substratum to a depth of about 60 inches is very dark gray and black loam. It is calcareous in the lower part.

Typically, the surface layer of the Estherville soils is black sandy loam about 7 inches thick. The subsurface layer also is black sandy loam. It is about 6 inches thick. The subsoil is dark brown, very friable coarse sandy loam about 5 inches thick. The substratum to a depth of about 60 inches is multicolored, calcareous, stratified sand and gravel.

Minor in this association are the poorly drained Talcot, Biscay, and Hanska soils, the somewhat poorly drained Cylinder, Linder, and Watseka soils, and the well drained Wadena soils. Talcot, Biscay, and Hanska soils are on low lying terraces. Talcot soils are calcareous. Cylinder, Linder, and Watseka soils are in swales on the terraces. Wadena soils are in positions on the landscape similar to those of the Estherville soils.

About 50 percent of the acreage in this association is used for crops, including corn, soybeans, oats, and hay. The hay generally is alfalfa or an alfalfa-grass mixture. Pastured areas generally occur as areas of wet or

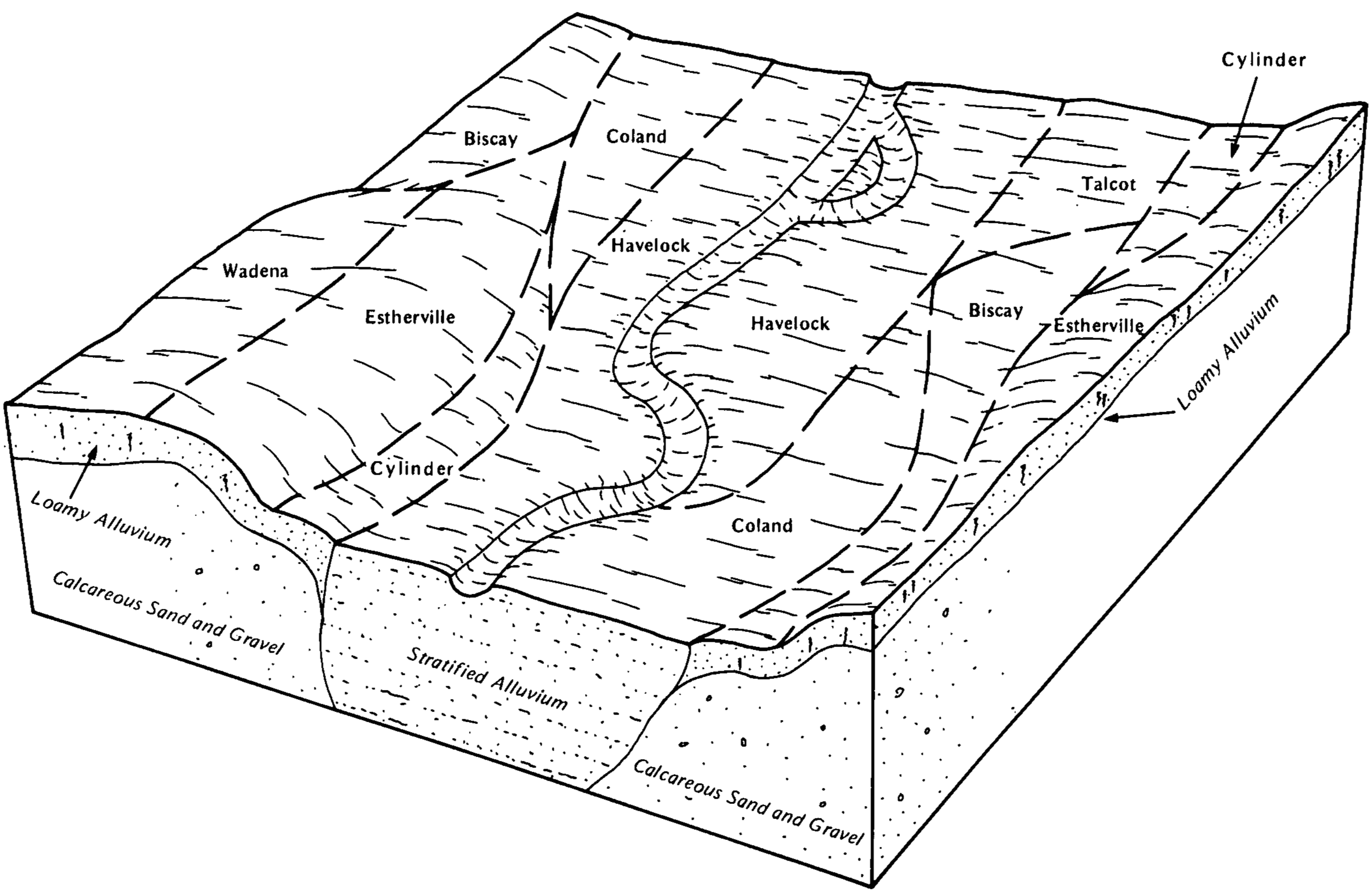

Figure 4.—Typical pattern of soils and parent material in the Havelock-Coland-Estherville association.

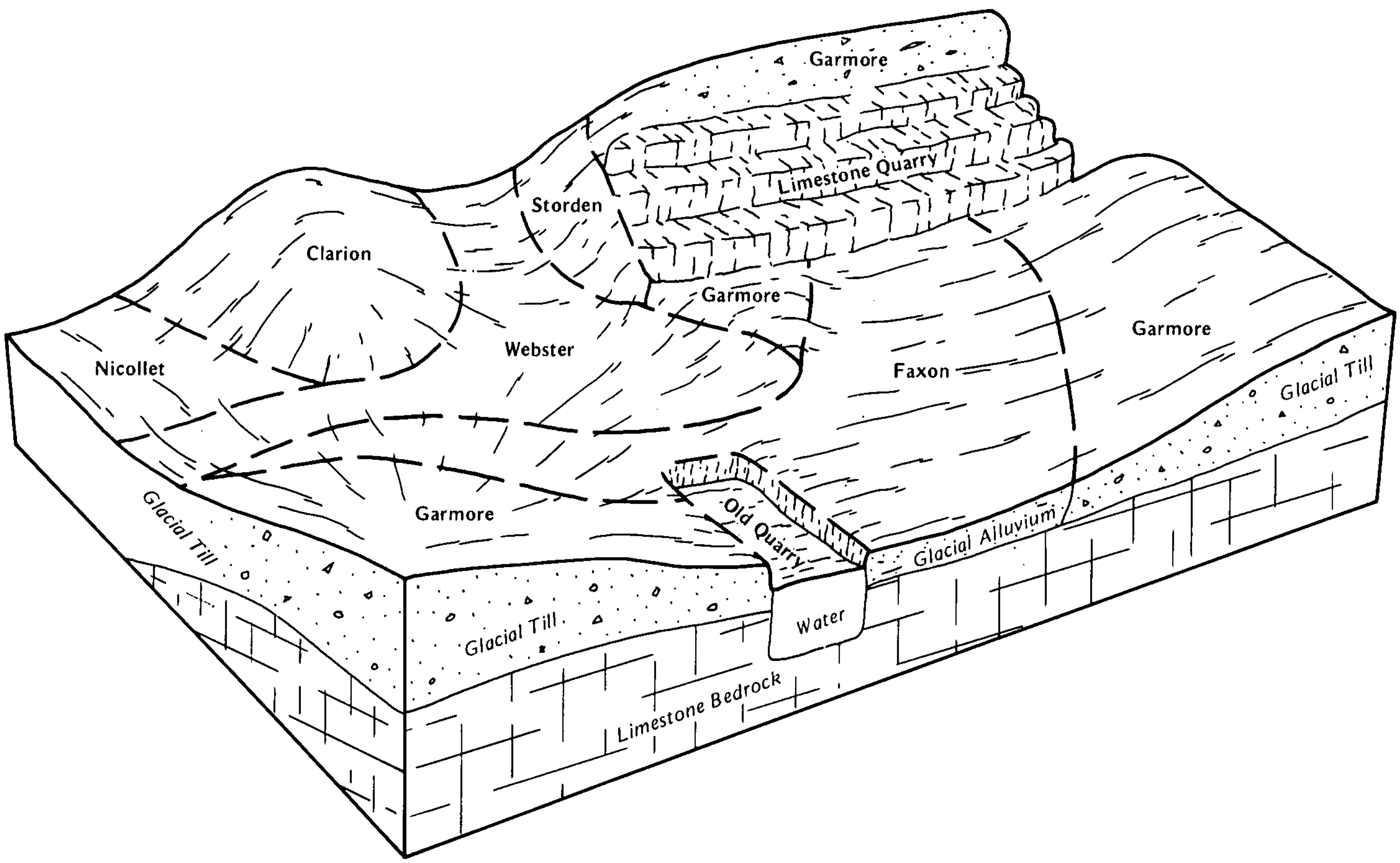

Figure 5.—Typical pattern of soils and parent material in the Garmore-Faxon association.

frequently flooded soils. Various kinds of farms are throughout the association. Some are general farms that raise beef cattle or cow-calf herds. Others raise swine. Others are grain farms where irrigation is common.

Flooding and drought are the main hazards in this association. Irrigation systems have been installed on some farms to help provide adequate water for crop production. Many of the soils are droughty because they are sandy or are underlain by sand and gravel.

The fields and pastures in areas of this association are irregular in shape and of various sizes. In many areas the field boundary is the irregular boundary with the channeled Havelock soils. Most areas of the Havelock soils are wooded and are not used for crops or pasture. The wood generally is not used commercially.

4. Garmore-Faxon association

Nearly level to gently sloping, moderately well drained and poorly drained, loamy and silty soils that formed in glacial till and local alluvium over limestone; on uplands

This association is an upland area that was influenced by the underlying limestone. Large pits, piles of spoil material, and limestone quarrying buildings, equipment, and transportation accessories are common in this area. Slope generally ranges from 0 to 5 percent.

This association makes up 1,560 acres in the county. It is about 47 percent Garmore and similar soils, 11 percent Faxon soils, and 42 percent soils of minor extent and Pits, limestone (fig. 5).

The moderately well drained Garmore soils are on knolls and flats. They are gently sloping to nearly level. The poorly drained, nearly level Faxon soils are in low lying swales. They are moderately deep.

Typically, the surface layer of the Garmore soils is black loam about 6 inches thick. The subsurface layer is black and very dark grayish brown loam about 12 inches thick. The subsoil is about 33 inches thick. It is dark brown, friable loam in the upper part; dark yellowish brown, friable clay loam in the next part; and yellowish

Figure 6.—Soybeans on the nearly level Garmore soils in the Garmore-Faxon association.

brown loam in the lower part. The substratum to a depth of about 60 inches is yellowish brown, calcareous loam.

Typically, the surface layer of the Faxon soils is black, calcareous silt loam about 10 inches thick. The subsurface layer is black silty clay loam about 9 inches thick. The subsoil is dark gray and olive gray, mottled silty clay loam about 16 inches thick. It is friable in the upper part and firm in the lower part. The substratum is dark gray and very dark gray clay about 2 inches thick. Limestone bedrock is at a depth of about 37 inches.

Minor in this association are the poorly drained Webster soils, the somewhat poorly drained Nicollet soils, and the well drained Clarion and Storden soils. All of the minor soils are deep. Webster soils are in positions on the landscape similar to those of the Faxon soils. The very gently sloping Nicollet soils are on rises and swells. The moderately sloping Clarion soils are on knolls and ridges. Storden soils are calcareous. They are moderately sloping and strongly sloping.

Most of the soils in this association are cultivated (fig. 6). They are well suited to cultivated crops. Grain is grown for cash on most of the farms. Little livestock is raised in the area. The main management needs are a drainage system, which is needed in the nearly level, poorly drained soils in low lying areas, and measures that help to control erosion on the more sloping soils.

The fields in this area are bounded by limestone pits. The pits are expanding in size.

Detailed Soil Map Units

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

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

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

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

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

Some map units are made up of two or more major soils. These map units are called soil complexes. A *soil complex* consists of two or more soils in such an intricate pattern or in such small areas that they cannot be shown separately on the soil maps. The pattern and proportion of the soils are somewhat similar in all areas. Estherville-Salida complex, 5 to 10 percent slopes, is an example.

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

This survey includes *miscellaneous areas*. Such areas have little or no soil material and support little or no vegetation. Pits, gravel, is an example. Miscellaneous areas are shown on the soil maps. Some that are too small to be shown are identified by a special symbol on the soil maps.

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

Soil Descriptions

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

Typically, the surface layer is black, calcareous silty clay loam about 9 inches thick. The subsurface layer also is black, calcareous silty clay loam. It is about 22 inches thick. The next 9 inches is very dark gray, mottled silty clay loam. The substratum to a depth of about 60 inches is gray and light gray, mottled, calcareous loam.

This soil is moderately slowly permeable. It has a seasonal high water table. Surface runoff is ponded. Available water capacity is very high. The content of organic matter is about 7 to 9 percent in the surface layer. The soil typically is moderately alkaline throughout. Below the surface layer, the supply of available phosphorus and potassium is very low.

Most areas are cultivated. If adequately drained, this soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Surface drains remove ponded water. Tile drains remove excess subsurface water. Even if the soil is drained, special care generally is needed to maintain good tilth in the surface layer. The availability of plant nutrients is adversely affected by the excess amount of lime in the soil. Soil structure tends to be weak and breaks down if the soil is cultivated when too wet. Puddling results from the breakdown of soil structure. In some areas where soybeans are grown, applications of ferrous sulfate or other iron compounds are needed.

Figure 7.—Ponding in an area of Okoboji silty clay loam, 0 to 1 percent slopes.

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

The land capability classification is IIIw.

6—Okoboji silty clay loam, 0 to 1 percent slopes. This level, very poorly drained soil is in upland depressions. It is subject to ponding (fig. 7). Areas dominantly are 2 to 10 acres in size but range to 50 acres. They are elliptical.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is black and very dark gray silty clay loam about 28 inches thick. It is mottled in the lower part. The subsoil is dark gray, mottled, friable silty clay loam about 11 inches thick. The substratum to a depth of about 60 inches is gray, mottled, calcareous silty clay loam.

This soil is moderately slowly permeable. It has a seasonal high water table. Surface runoff is ponded. Available water capacity is high. The content of organic matter is about 7 to 9 percent in the surface layer. Reaction typically is neutral in the surface layer and neutral or mildly alkaline in the subsurface layer and subsoil. The subsoil generally has a very low supply of available phosphorus and potassium.

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

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

The land capability classification is IIIw.

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

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer also is black loam. It is about 24 inches thick. The subsoil extends to a depth of 60 inches or more. It is dark brown, brown, and dark yellowish brown, friable loam. In places it is stratified loamy sand and sand.

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

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

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

The land capability classification is IIe.

34—Estherville sandy loam, 0 to 2 percent slopes. This nearly level, somewhat excessively drained soil is on terraces and in broad outwash areas. Slopes are slightly convex or concave. Areas are irregularly shaped and generally are 2 to 80 acres in size.

Typically, the surface layer is black sandy loam about 7 inches thick. The subsurface layer also is black sandy loam. It is about 6 inches thick. The subsoil is dark brown, very friable coarse sandy loam about 5 inches thick. The substratum to a depth of about 60 inches is multicolored, stratified, calcareous sand and gravel. In some places the surface layer is loam. In other places the surface layer and subsoil are loamy sand and have a very low content of gravel.

This soil is moderately rapidly permeable in the upper part and rapidly permeable in the substratum. Surface runoff is slow. Available water capacity is low. The content of organic matter is about 2 to 4 percent in the surface layer. The surface layer, the subsurface layer, and the subsoil typically are slightly acid or neutral. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. Some are used for pasture. Under natural conditions, this soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It is droughty because of the sandy and gravelly substratum. If the soil is irrigated and carefully managed, corn and soybeans can be grown successfully. A conservation tillage system that leaves a protective amount of crop residue on the surface conserves moisture and helps to prevent excessive soil blowing. Returning crop residue to the soil or regularly adding other organic material improves fertility, conserves moisture, and helps to control soil blowing. Good tilth can be easily maintained.

If this soil is used for windbreaks, ornamental plantings, or plantings for wildlife, drought is a severe hazard. Only the species that can withstand the droughtiness should be selected for planting, or irrigation water should be applied if irrigation is practical. A permanent plant cover helps to control soil blowing.

The land capability classification is IIIs.

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

Typically, the surface layer is black sandy loam about 7 inches thick. The subsurface layer also is black sandy loam. It is about 6 inches thick. The substratum to a depth of about 60 inches is multicolored, stratified, calcareous sand and gravel. In places the surface layer is loam. In some small areas it is calcareous sand and gravel. In other areas the surface layer and subsoil are loamy sand and have a very low content of gravel.

This soil is moderately rapidly permeable in the upper part and rapidly permeable in the substratum. Surface runoff is slow. Available water capacity is low. The content of organic matter is about 2 to 4 percent in the surface layer. The surface layer, the subsurface layer, and the subsoil typically are slightly acid or neutral. The subsoil generally has a very low supply of available phosphorus and potassium.

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

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

The land capability classification is IIIs.

34C2—Estherville sandy loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, somewhat excessively drained soil is on knolls, on the convex sides of terraces, in outwash areas, and on kames. Slopes typically are short. Areas generally are 2 to 5 acres in size. They are irregularly shaped.

Typically, the surface layer is black sandy loam about 7 inches thick. Plowing has mixed part of the subsoil with the surface layer. The subsoil is about 5 inches thick. It is dark brown, very friable coarse sandy loam in the upper part and dark yellowish brown loamy sand or sand in the lower part. The substratum to a depth of about 60 inches is multicolored, calcareous sand and gravel. In places the surface layer is dominantly loamy sand and sand in which the content of gravel is less than 10 percent. In some small areas, the surface layer is calcareous sand and gravel and many stones generally are on the surface.

This soil is moderately rapidly permeable in the upper part and rapidly permeable in the substratum. Surface runoff is slow. Available water capacity is low. The content of organic matter is about 1 to 2 percent in the surface layer. The surface layer and the upper part of the subsoil typically are slightly acid or neutral. The subsoil generally has a very low supply of available phosphorus and potassium.

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

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

The land capability classification is IVs.

41B—Sparta loamy fine sand, 2 to 5 percent slopes. This gently sloping, excessively drained soil is on broad, convex knolls on terraces along the Des Moines River. Areas generally are 5 to 30 acres in size. They are irregularly shaped.

Typically, the surface layer is very dark brown loamy fine sand about 10 inches thick. The subsurface layer is very dark grayish brown loamy fine sand about 3 inches thick. The subsoil is dark yellowish brown, very friable loamy fine sand about 18 inches thick. The substratum to a depth of about 60 inches is yellowish brown and dark yellowish brown sand.

This soil is rapidly permeable. Surface runoff is slow. Available water capacity is low. The content of organic matter is about 1 to 2 percent in the surface layer. The surface layer and the subsurface layer are medium acid to neutral. The subsoil is strongly acid or medium acid. It generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. Under natural conditions, this soil is poorly suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It is droughty because it has a high content of sand. Also, the hazard of soil blowing is severe. If the soil is irrigated and carefully managed, corn and soybeans can be grown successfully. A conservation tillage system that leaves a protective amount of crop residue on the surface conserves moisture and helps to prevent excessive soil blowing and the damage to crops caused by windblown sand particles. Returning crop residue to the soil or regularly adding other organic material improves fertility and conserves moisture. Overgrazing reduces the extent of the protective plant cover in pastured areas and increases the susceptibility to soil blowing. Good tilth can be easily maintained.

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

The land capability classification is IVs.

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

Typically, the surface layer is black, calcareous mucky silt loam about 8 inches thick. The subsurface layer is about 22 inches thick. It is black and calcareous. It is mucky silt loam and mucky silty clay loam in the upper part and silty clay loam in the lower part. The subsoil to a depth of about 60 inches is friable, calcareous silty clay loam. It is black in the upper part and very dark gray and mottled in the lower part. In places the lower part of the subsoil is stratified loam or silt loam and has lenses of sand and loamy sand.

This soil is moderately slowly permeable. It has a seasonal high water table. Surface runoff is ponded. Available water capacity is very high. The content of organic matter is about 10 to 15 percent in the surface layer. The soil typically is moderately alkaline or mildly alkaline throughout. Below the surface layer, the supply of available phosphorus and potassium is very low.

Most areas are cultivated. If adequately drained, this soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. An adequate subsurface and surface drainage system is needed. The availability of plant nutrients is limited by the excess amount of lime in the soil, as commonly is evidenced by stunted soybeans that have yellow leaves. Applications of phosphorus and potassium fertilizer are needed. In some areas applications of ferrous sulfate or other iron compounds also are needed. Special care generally is needed to maintain good tilth in the surface layer. Cultivating when the soil is wet hastens the breakdown of soil structure.

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

The land capability classification is IIIw.

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

Typically, the surface layer is black clay loam about 9 inches thick. The subsurface layer is black and very dark gray clay loam about 13 inches thick. The subsoil is dark grayish brown, friable clay loam about 9 inches thick. It is mottled in the lower part. The substratum to a depth of about 60 inches is grayish brown and light yellowish brown, mottled, calcareous loam.

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

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

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

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

The land capability classification is I.

62C2—Storden loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained, calcareous soil is on ridges and knolls and convex side slopes along streams and upland drainageways (fig. 8). Slopes generally are short. Areas are irregularly shaped or long and narrow. Most are 2 to 10 acres in size, but some are somewhat larger.

Typically, the surface layer is dark grayish brown, calcareous loam about 8 inches thick. Plowing has mixed some streaks and pockets of yellowish brown substratum material into the surface layer. The substratum to a depth of about 60 inches is multicolored, mottled, calcareous loam.

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

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

Most areas are cultivated. If erosion is controlled and fertility improved, this soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Erosion is a severe hazard. A

Figure 8.—An area of light colored Storden loam, 5 to 9 percent slopes, moderately eroded, on a knoll.

conservation tillage system that leaves a protective amount of crop residue on the surface and grassed waterways help to prevent excessive soil loss. Contour farming and terracing are practical in some areas but are not feasible in areas where slopes are short. Applications of a large amount of phosphorus and potassium fertilizer are needed because of the high content of lime. In some areas where soybeans are grown, applications of iron compounds are needed. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to control erosion and prevent surface crusting, and increases the infiltration rate.

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

The land capability classification is IIIe.

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

Typically, the surface layer is dark grayish brown, calcareous loam about 8 inches thick. Plowing has mixed some streaks and pockets of yellowish brown substratum material into the surface layer. The substratum to a depth of about 60 inches is multicolored, mottled, calcareous loam.

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

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

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

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

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

The land capability classification is IVe.

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

Typically, the surface layer is dark grayish brown, calcareous loam about 8 inches thick. The substratum to a depth of about 60 inches is multicolored, calcareous loam.

Included with this soil in mapping are some areas where the slope is less than 14 or more than 18 percent. These areas make up about 10 percent of the unit. Also included are some small areas of sandy or gravelly soils on knobs. These soils make up less than 5 percent of the unit.

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

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

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

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

The land capability classification is IVe.

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

Typically, the surface layer is dark grayish brown, calcareous loam about 6 inches thick. The substratum to a depth of about 60 inches is multicolored, calcareous loam.

Included with this soil in mapping are some areas where the slope is less than 18 or more than 25 percent. These areas make up about 10 percent of the unit.

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

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

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

The land capability classification is VIe.

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

Typically, the surface layer is dark grayish brown, calcareous loam about 6 inches thick. The substratum to a depth of about 60 inches is multicolored, calcareous loam. In some areas the slope is more than 40 percent.

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

Most areas are used for pasture. Some are used as woodland. This soil generally is unsuitable for cultivated crops or unlimited grazing because it is very steep and highly susceptible to erosion. It is poorly suited to hay because the slopes generally are too steep for the use of farm machinery. Controlled grazing is important because renovating pastures is very difficult. Trees or shrubs can be planted by hand but generally cannot be planted by machine because of the slope.

The land capability classification is VIIe.

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

Typically, the surface layer is black mucky silty clay loam about 9 inches thick. The subsurface layer is about 26 inches thick. It is black. The upper part is mucky silty clay loam, and the lower part is silty clay loam. The subsoil is dark gray, friable, mottled silty clay loam about 10 inches thick. The substratum to a depth of about 60 inches is gray, mottled, calcareous silty clay loam.

This soil is moderately slowly permeable. It has a seasonal high water table. Surface runoff is ponded. Available water capacity is high. The content of organic matter is about 10 to 15 percent in the surface layer. Reaction typically is strongly acid or medium acid in the surface layer and neutral or mildly alkaline in the subsurface layer and subsoil. The subsoil generally has a very low supply of available phosphorus and potassium.

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

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

The land capability classification is IIIw.

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

Typically, the surface layer is black, calcareous clay loam about 9 inches thick. The subsurface layer is calcareous clay loam about 10 inches thick. It is black in the upper part and very dark gray in the lower part. The subsoil is about 22 inches thick. It is calcareous. The upper part is olive gray clay loam, and the lower part is olive gray and gray, mottled loam. The substratum to a depth of about 60 inches is gray, mottled, calcareous loam.

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

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

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

The land capability classification is IIw.

107—Webster clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is in swales or slightly concave areas on uplands. Most areas are 5 to 200 acres in size and are long and wide, but some are as large as 1,000 acres and are irregularly shaped.

Typically, the surface layer is black clay loam about 9 inches thick. The subsurface layer is clay loam about 11 inches thick. It is black in the upper part and very dark gray in the lower part. The subsoil is olive gray, mottled, friable clay loam about 16 inches thick. The substratum to a depth of about 60 inches is olive gray, mottled, calcareous clay loam.

Included with this soil in mapping are some areas of somewhat poorly drained to well drained soils on the higher parts of the landscape. Also included are scattered areas of very poorly drained, calcareous soils and some areas of noncalcareous, very poorly drained soils in distinct depressions. Included soils make up less than 10 percent of the unit.

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

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

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

The land capability classification is IIw.

108—Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, well drained soil is on slightly convex slopes on stream terraces. Areas are irregularly shaped. Most are 5 to 20 acres in size.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is very dark grayish brown loam about 6 inches thick. The subsoil is about 12 inches thick. It is dark yellowish brown and very friable. It is loam in the upper part and sandy loam in the lower part. The substratum to a depth of about 60 inches is multicolored, calcareous sand and gravel. In some areas loamy sand or sand and gravel are as shallow as 18 inches.

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

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

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

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

The land capability classification is IIs.

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

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is very dark grayish brown loam about 6 inches thick. The subsoil is about 12 inches thick. It is dark yellowish brown and very friable. It is loam in the upper part and sandy loam in the lower part. The substratum to a depth of about 60 inches is multicolored, calcareous sand and gravel. In some small areas, the surface layer is sandy loam or gravelly loamy sand and the slope is more than 5 percent.

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

Most areas are cultivated. This soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard. Also, the soil is seasonally droughty because of the sandy and gravelly substratum. A conservation tillage system that leaves a protective amount of crop residue on the surface helps to control erosion. Overgrazing reduces the extent of the protective plant cover in pastured areas and increases the runoff rate and the susceptibility to erosion. Good tilth generally can be easily maintained.

If this soil is used for windbreaks or ornamental plantings, erosion is a slight hazard before the trees and shrubs are established. Also, the soil is seasonally droughty. The species that can withstand the droughtiness should be selected for planting, or irrigation water should be applied if irrigation is practical.

The land capability classification is IIe.

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

Typically, the surface layer is about 7 inches thick. It is very dark grayish brown loam mixed with some dark yellowish brown subsoil material. The subsoil is dark yellowish brown, very friable loam about 17 inches thick. The substratum to a depth of about 60 inches is multicolored, calcareous sand and gravel. In some areas the depth to calcareous gravelly loamy coarse sand is only about 15 inches. In other areas the surface layer and subsoil are sandy loam or sandy clay loam.

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

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

If this soil is used for windbreaks or ornamental plantings, further erosion is a slight hazard before the trees and shrubs are established. Also, the soil is seasonally droughty. The species that can withstand the droughtiness should be selected for planting, or irrigation water should be applied if irrigation is practical.

The land capability classification is IIIe.

135—Coland clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on bottom land and low terraces. It is subject to flooding. Areas generally range from 10 to 150 acres in size. They are long and narrow.

Typically, the surface layer is black clay loam about 7 inches thick. The subsurface layer is clay loam about 30 inches thick. It is black in the upper part and very dark gray in the lower part. The substratum to a depth of about 60 inches is very dark gray and black loam. It is calcareous in the lower part. In places the surface soil is only about 18 inches thick.

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

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

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

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

The land capability classification is IIw.

135B—Coland clay loam, 2 to 4 percent slopes. This gently sloping, poorly drained soil is in narrow drainageways on bottom land and foot slopes or is on alluvial fans. It is subject to flooding. Areas generally are 2 to 20 acres in size and are long and narrow.

Typically, the surface layer is black clay loam about 7 inches thick. The subsurface layer is about 30 inches thick. It is black clay loam in the upper part and very dark gray loam in the lower part. The substratum to a depth of about 60 inches is very dark gray and black loam. It is calcareous in the lower part.

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

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

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

The land capability classification is IIe.

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

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer also is loam about 8 inches thick. It is black in the upper part and very dark grayish brown in the lower part. The subsoil is friable loam about 25 inches thick. It is brown in the upper part and dark yellowish brown in the lower part. The substratum to a depth of about 60 inches is yellowish brown, mottled, calcareous loam. In some areas plowing has mixed part of the brown subsoil with the surface soil.

Included with this soil in mapping are some areas of the somewhat poorly drained Nicollet soils at the lower elevations. Also included are some small areas of sandy or gravelly soils on knobs and some areas of the calcareous Storden soils, which are higher on the landscape than the Clarion soil. Included soils make up less than 15 percent of the unit.

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

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

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

The land capability classification is IIe.

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

Typically, the surface layer is black loam about 7 inches thick. The subsurface layer also is loam about 7 inches thick. It is black in the upper part and very dark grayish brown in the lower part. The subsoil is friable loam about 20 inches thick. It is brown in the upper part and dark yellowish brown in the lower part. The substratum to a depth of about 60 inches is yellowish brown, mottled, calcareous loam. In some concave areas near the base of the slopes, the dark surface layer is as much as 24 to 30 inches thick.

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

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

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

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

The land capability classification is IIIe.

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

Typically, the surface layer is very dark grayish brown loam about 7 inches thick. Plowing has mixed part of the brown subsoil with the surface layer. The subsoil is friable loam about 20 inches thick. The upper part is brown, and the lower part is dark yellowish brown. The substratum to a depth of about 60 inches is yellowish brown, calcareous loam.

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

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

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

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

The land capability classification is IIIe.

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

Typically, the surface layer is very dark grayish brown loam about 6 inches thick. Plowing has mixed part of the brown subsoil with the surface layer. The subsoil is friable loam about 14 inches thick. It is brown in the upper part and dark yellowish brown and yellowish brown in the lower part. The substratum to a depth of about 60 inches is yellowish brown, calcareous loam.

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

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

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

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

The land capability classification is IIIe.

141—Watseka loamy sand, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is on low stream terraces. Slopes are plane or slightly convex.

Areas are 5 to 30 acres in size and are irregularly shaped.

Typically, the surface layer is black loamy sand about 10 inches thick. The subsurface layer is very dark gray loamy sand about 5 inches thick. The subsoil is about 22 inches thick. It is dark grayish brown and mottled. It is very friable loamy sand in the upper part and loose sand in the lower part. The substratum to a depth of about 60 inches is multicolored sand.

This soil is rapidly permeable. It has a seasonal high water table. Surface runoff is very slow. Available water capacity is low. The content of organic matter is about 2 to 3 percent in the surface layer. The soil typically is neutral or slightly acid throughout. The subsoil generally has a very low supply of available phosphorus and potassium.

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

Drought is a hazard if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. Generally, the trees and shrubs that can withstand both the seasonal wetness and the droughtiness should be selected for planting. A surface mulch conserves moisture. Irrigation water should be applied as needed if irrigation is practical.

The land capability classification is IIIs.

150—Hanska loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is in low lying glacial outwash areas. Areas are 15 to 40 acres in size and are irregularly shaped.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer also is black loam. It is about 12 inches thick. The subsoil is about 13 inches thick. It is dark gray, friable sandy loam in the upper part and gray, very friable loamy sand in the lower part. The substratum to a depth of about 60 inches is olive and pale olive sand and gravel. It is calcareous in the lower part. In some small areas the surface layer is clay loam.

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

Most areas are cultivated. If adequately drained, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It not only is seasonally wet but also is droughty during dry periods because of the sandy substratum. It is subject to soil blowing, especially when it is plowed in the fall. Tile drains remove excess subsurface water. In some areas installing the tile is difficult because the substratum is not stable. Suitable drainage outlets are not available in some areas. A conservation tillage system that leaves a protective amount of crop residue on the surface conserves moisture and helps prevent excessive soil blowing. Returning crop residue to the soil or regularly adding other organic material improves fertility, conserves moisture, and helps to control soil blowing. Good tilth generally can be easily maintained.

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

The land capability classification is IIw.

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

Typically, the surface layer is black clay loam about 9 inches thick. The subsurface layer is about 11 inches thick. It is very dark gray clay loam in the upper part and very dark grayish brown loam in the lower part. The subsoil is about 10 inches thick. It is mottled. It is dark grayish brown, friable loam in the upper part and grayish brown gravelly loam in the lower part. The substratum to a depth of about 60 inches is multicolored, calcareous sand and gravel.

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

Most areas are cultivated. This soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It has a high water table during wet periods but is droughty after brief dry periods. Tile drains generally are not installed because of the droughtiness during most of the growing season.

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

Drought is a hazard if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. Generally, the trees and shrubs that can withstand both the seasonal wetness and the droughtiness should be selected for planting. A surface mulch conserves moisture. Irrigation water should be applied as needed to overcome the droughtiness.

The land capability classification is IIs.

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

Typically, the surface layer is black clay loam about 9 inches thick. The subsurface layer is about 11 inches thick. It is very dark gray clay loam in the upper part and very dark grayish brown loam in the lower part. The subsoil is about 16 inches thick. It is mottled. It is dark grayish brown, friable loam in the upper part and grayish brown gravelly loam in the lower part. The substratum to a depth of about 60 inches is multicolored, calcareous sand and gravel.

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

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

Drought is a hazard if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. Generally, the trees and shrubs that can withstand both the seasonal wetness and the droughtiness should be selected for planting. A surface mulch conserves moisture. Irrigation water should be applied as needed to overcome the droughtiness.

The land capability classification is IIs.

224—Linder loam, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is on stream terraces and in outwash areas. Slopes are plane or slightly convex. Areas are 5 to 10 acres in size and are irregularly shaped.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is about 9 inches thick. It is black loam in the upper part and very dark gray sandy loam in the lower part. The subsoil is dark grayish brown, mottled, very friable sandy loam about 7 inches thick. The substratum to a depth of about 60 inches is light olive brown, olive brown, and yellowish brown, mottled sand and gravel. It is calcareous in the lower part.

This soil is moderately rapidly permeable in the upper part and very rapidly permeable in the substratum. It has a seasonal high water table. Surface runoff is slow. Available water capacity is low. The content of organic matter is about 3 to 4 percent in the surface layer. Reaction is mildly alkaline or neutral in most of the profile but is moderately alkaline in the lower part of the substratum. The subsoil generally has a very low supply of available phosphorus and potassium.

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

Drought is a hazard if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. Generally, the trees and shrubs that can withstand both the seasonal wetness and the droughtiness should be selected for planting. A surface mulch conserves moisture. Irrigation water should be applied as needed if irrigation is practical.

The land capability classification is IIs.

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

Typically, the surface layer is black clay loam about 9 inches thick. The subsurface layer is black and very dark gray clay loam about 10 inches thick. The subsoil is about 17 inches thick. It is mottled and friable. It is dark gray clay loam in the upper part and olive gray sandy clay loam in the lower part. The substratum to a depth of about 60 inches is olive gray, mottled, calcareous sand and gravel. In some small areas the soil is calcareous.

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

Most areas are cultivated. If adequately drained, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It not only is seasonlly wet but also is slightly droughty during some periods because of the gravelly substratum. Tile drains remove excess subsurface water. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, conserves moisture, and helps to control soil blowing.

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

The land capability classification is IIw.

274—Rolfe silt loam, 0 to 1 percent slopes. This level, very poorly drained soil is in small depressions in the uplands. It is subject to ponding. Areas generally are 2 or 3 acres in size and are nearly round or oblong.

Typically, the surface layer is black silt loam about 9 inches thick. The subsurface layer is dark gray and gray silt loam about 10 inches thick. The subsoil is mottled, firm silty clay about 32 inches thick. The upper part is very dark gray and dark olive gray, and the lower part is dark gray and olive gray. The substratum to a depth of about 60 inches is gray and olive gray, mottled, calcareous loam.

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

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

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

The land capability classification is IIIw.

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

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is very dark brown loam about 6 inches thick. The subsoil is about 22 inches thick. It is dark yellowish brown and very friable. It is loam in the upper part and sandy loam in the lower part. The substratum to a depth of about 60 inches is multicolored, calcareous sand and gravel.

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

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

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

The land capability classification is IIe.

330—Kingston silty clay loam, 0 to 3 percent slopes. This nearly level and very gently sloping, somewhat poorly drained soil is on concave slopes on terraces. Areas are 5 to 20 acres in size and are irregularly shaped.

Typically, the surface layer is black silty clay loam about 10 inches thick. The subsurface layer is black and very dark gray silty clay loam about 11 inches thick. The subsoil is mottled, friable silty clay loam about 18 inches thick. It is dark grayish brown in the upper part and brown in the lower part. The substratum to a depth of about 60 inches is light olive brown, mottled, calcareous silty clay loam.

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

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

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

The land capability classification is I.

338—Garmore loam, 0 to 2 percent slopes. This nearly level, moderately well drained soil is on concave to convex slopes in the uplands. Areas range from 2 to 40 acres in size and are irregularly shaped.

Typically, the surface layer is black loam about 6 inches thick. The subsurface layer is black and very dark grayish brown loam about 12 inches thick. The subsoil is about 33 inches thick. It is dark brown, friable loam in the upper part; dark yellowish brown, friable clay loam in the next part; and yellowish brown loam in the lower part. The substratum to a depth of about 60 inches is yellowish brown, calcareous loam. In some small areas the soil has a thicker surface layer and is somewhat poorly drained. In other small areas it is well drained and has a calcareous substratum at a depth of about 40 inches.

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

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Good tilth generally can be easily maintained. Soil blowing is a hazard if large areas of the soil are plowed in the fall. Returning crop residue to the soil or regularly adding other organic material helps to prevent excessive soil loss and surface crusting and increases the infiltration rate.

Few limitations affect the use of this soil as a site for the trees and shrubs grown as windbreaks or ornamental plantings. Almost any species suited to the climate can be grown.

The land capability classification is I.

338B—Garmore loam, 2 to 5 percent slopes. This gently sloping, moderately well drained soil is on convex upland slopes. Areas are 2 to 20 acres in size and are irregularly shaped.

Typically, the surface layer is black loam about 6 inches thick. The subsurface layer is black and very dark grayish brown loam about 10 inches thick. The subsoil is about 33 inches thick. It is dark brown, friable loam in the upper part; dark yellowish brown, friable clay loam in the next part; and yellowish brown loam in the lower part. The substratum to a depth of about 60 inches is yellowish brown, calcareous loam. In some small areas the soil is well drained and has a calcareous substratum at a depth of about 40 inches.

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

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

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

The land capability classification is IIe.

339B—Truman silt loam, 2 to 6 percent slopes. This gently sloping, well drained soil is on convex slopes on terraces. Areas are 5 to 20 acres in size and are irregularly shaped.

Typically, the surface layer is very dark brown silt loam about 10 inches thick. The subsurface layer is very dark grayish brown and dark brown silt loam about 5 inches thick. The subsoil is dark yellowish brown, friable silt loam about 17 inches thick. The substratum to a depth of about 60 inches is calcareous silt loam. It is yellowish brown in the upper part and brownish yellow and light yellowish brown and mottled in the lower part. In some small areas the surface layer is very fine sandy loam. In other small areas it is calcareous.

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

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

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

The land capability classification is IIe.

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

Typically, the surface layer is black silty clay loam about 9 inches thick. The subsurface layer is black and very dark gray silty clay loam about 12 inches thick. The subsoil is silty clay loam about 9 inches thick. The upper part is dark gray and firm, and the lower part is gray, mottled, friable, and calcareous. The substratum to a depth of about 60 inches is gray, mottled, calcareous silty clay loam and loam.

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

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

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

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

The land capability classification is IIw.

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

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is black and very dark brown loam about 41 inches thick. The substratum to a depth of about 60 inches is very dark grayish brown and dark grayish brown, mottled, stratified loam and sandy loam.

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

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

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

The land capability classification is IIw.

485B—Spillville loam, 2 to 5 percent slopes. This gently sloping, moderately well drained or somewhat poorly drained soil is on foot slopes and alluvial fans. Areas are long and narrow. Most are 2 to 5 acres in size.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is black and very dark brown loam about 38 inches thick. The substratum to a depth of about 60 inches is very dark grayish brown and dark grayish brown, mottled, stratified loam and sandy loam.

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

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

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

The land capability classification is IIe.

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

Typically, the surface layer is black silty clay loam about 9 inches thick. The subsurface layer also is black silty clay loam. It is about 3 inches thick. Below this is a transition layer of very dark gray and gray, mottled silty clay loam about 3 inches thick. The upper part of the substratum is olive gray, mottled, calcareous silty clay loam. The lower part to a depth of about 60 inches is olive gray and gray, mottled, calcareous silt loam. In some areas the surface layer is mucky silty clay loam.

This soil is moderately permeable. It has a seasonal high water table. Surface runoff is ponded. Available water capacity is very high. The content of organic matter is about 6 to 8 percent in the surface layer. This layer is neutral. The subsurface layer is neutral or mildly alkaline. The substratum is neutral to moderately alkaline. It generally has a very low supply of available phosphorus and a low supply of available potassium.

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

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

The land capability classification is IIIw.

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

Typically, the surface layer is black, calcareous clay loam about 10 inches thick. The subsurface layer also is calcareous clay loam about 10 inches thick. It is black in the upper part and very dark gray and mottled in the lower part. The subsoil is dark gray and grayish brown, mottled, friable, calcareous clay loam about 15 inches thick. The substratum to a depth of about 60 inches is olive gray, mottled, calcareous clay loam. In places the surface layer is not calcareous.

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

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

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

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

The land capability classification is IIw.

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

Typically, the surface layer is black, calcareous silty clay loam about 9 inches thick. The subsurface layer also is black, calcareous silty clay loam. It is about 6 inches thick. The subsoil is olive gray, mottled, friable, calcareous silty clay loam about 6 inches thick. The substratum to a depth of about 60 inches is olive gray and light olive gray, mottled, calcareous silty clay loam.

This soil is moderately permeable. It has a seasonal high water table. Surface runoff is ponded. Available water capacity is very high. The content of organic matter is about 6 to 8 percent in the surface layer. The soil typically is moderately alkaline or mildly alkaline throughout. The subsoil generally has a very low supply of available phosphorus and a low supply of available potassium.

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

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

The land capability classification is IIIw.

511—Blue Earth mucky silty clay loam, 0 to 1 percent slopes. This level, very poorly drained, calcareous soil is in upland depressions, most of which formerly were shallow lake basins. It is subject to ponding. Areas range from 40 to more than 500 acres in size. They are irregularly shaped.

Typically, the surface layer is black, calcareous mucky silty clay loam about 9 inches thick. The substratum to a depth of about 60 inches is very dark gray and black, calcareous mucky silty clay loam. It is mottled in the lower part.

This soil is moderately permeable. It has a seasonal high water table. Surface runoff is ponded. Available water capacity is very high. The content of organic matter is about 15 to 25 percent in the surface layer. The soil is moderately alkaline throughout. Below the surface layer, the supply of available phosphorus and potassium is very low.

Most areas are cultivated. If adequately drained, this soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. An adequate subsurface and surface drainage system is needed (fig. 9). The availability of plant nutrients is limited by the excess amount of lime in the soil, as commonly is evidenced by stunted soybeans that have yellow leaves. Applications of phosphorus and potassium fertilizer are needed. In some areas applications of ferrous sulfate or other iron compounds also are needed. Frost often injures crops late in spring or early in fall because the soil is in a low lying position on the landscape. Small grain tends to lodge and can be of poor quality. Legumes for hay grow poorly and are often winterkilled. Special care generally is needed to maintain good tilth in the surface layer. Cultivating when the soil is wet hastens the breakdown of soil structure. Soil blowing is a hazard if large areas of the soil are plowed in the fall. It can be controlled, however, by a cover of crop residue.

Most undrained areas are suitable as habitat for wetland wildlife. These areas support native marsh grasses and sedges.

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

The land capability classification is IIIw.

541C—Estherville-Salida complex, 5 to 10 percent slopes. These moderately sloping soils are in glacial outwash areas and on glacial moraines. Generally, the

Figure 9.—A drainage ditch in a cultivated area of Blue Earth mucky silty clay loam, 0 to 1 percent slopes.

somewhat excessively drained Estherville soil is in the least convex areas and the excessively drained Salida soil in the most convex and most eroded areas. Slopes are short and typically are convex. Areas generally are 2 to 10 acres in size. They are about 60 to 80 percent Estherville soil and 20 to 40 percent Salida soil. The two soils occur as areas so closely intermingled or so small that mapping them separately was not practical.

Typically, the Estherville soil has a surface layer of black sandy loam about 7 inches thick. The subsurface layer also is black sandy loam. It is about 6 inches thick. The subsoil is about 5 inches thick. It is dark brown, very friable coarse sandy loam in the upper part and yellowish brown, loose sand and gravel in the lower part. The substratum to a depth of about 60 inches is multicolored, stratified, calcareous sand and gravel.

Typically, the Salida soil has a surface layer of very dark grayish brown, calcareous gravelly sandy loam about 9 inches thick. The substratum to a depth of about 60 inches is variegated yellowish brown, calcareous very gravelly coarse sand.

The Estherville soil is moderately rapidly permeable in the upper part and rapidly permeable in the lower part. The Salida soil is very rapidly permeable. Surface runoff is slow on both soils. Available water capacity is low in the Estherville soil and very low in the Salida soil. The content of organic matter is about 1.0 to 2.0 percent in the surface layer of the Estherville soil and 0.5 to 1.0 percent in the surface layer of the Salida soil. The surface layer and the upper part of the subsoil in the Estherville soil typically are slightly acid or neutral. The surface layer of the Salida soil is moderately alkaline. The substratum of both soils is moderately alkaline. Below the surface layer, the supply of available phosphorus and potassium is very low.

Many areas are cultivated because they are managed with the adjoining areas. Some areas are used for pasture. These soils are not suited to corn, soybeans, or small grain or to legumes for hay and pasture. They are poorly suited to grasses for pasture. They are very droughty because of the sandy and gravelly substratum. Regularly adding organic material to the soils improves fertility, increases the available water capacity, and improves the pasture.

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

The land capability classification is VIs.

559—Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, poorly drained, calcareous soil is in swales in outwash areas. Areas range from 5 to 100 acres in size and are irregularly shaped.

Typically, the surface layer is black, calcareous clay loam about 9 inches thick. The subsurface layer is black and very dark gray, calcareous clay loam about 9 inches thick. The subsoil is about 16 inches thick. It is dark gray and olive gray, mottled, friable, and calcareous. It is clay loam in the upper part and loam in the lower part. The substratum to a depth of about 60 inches is olive, mottled, calcareous sand.

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

Most areas are cultivated. If adequately drained, this soil is moderately suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It not only is seasonally wet but also is slightly droughty during some periods because the available water capacity is very low in the sandy and gravelly substratum. Tile drains remove excess subsurface water. Special care generally is needed to maintain good tilth in the surface layer. Cultivating when the soil is too wet causes surface compaction and cloddiness. Chisel plowing increases the infiltration rate by making the surface more pervious to water. Returning crop residue to the soil or regularly adding other organic material helps to prevent excessive soil blowing and surface crusting and increases the infiltration rate. The high content of lime adversely affects the availability of some of the plant nutrients. In some areas where soybeans are grown, applications of iron compounds are needed.

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

The land capability classification is IIw.

651—Faxon silt loam, 0 to 2 percent slopes. This moderately deep, nearly level, poorly drained soil is in plane or slightly concave areas on uplands. Areas are irregular in shape and range from 5 to 100 acres in size.

Typically, the surface layer is black, calcareous silt loam about 10 inches thick. The subsurface layer is black silty clay loam about 9 inches thick. The subsoil is dark gray and olive gray, mottled silty clay loam about 16 inches thick. It is friable in the upper part and firm in the lower part. The substratum is dark gray and very dark gray clay about 2 inches thick. Limestone bedrock is at a depth of about 37 inches.

This soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is moderate. The content of organic matter is about 5 to 6 percent in the surface layer. The surface layer typically is mildly alkaline. The subsurface layer and subsoil typically are neutral. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. If adequately drained, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Subsurface tile drains and surface drainage ditches remove excess water. Installing a subsurface drainage system can be difficult, however, because of the moderate depth to limestone. Special care generally is needed to maintain good tilth in the surface layer. Cultivating when the soil is too wet causes surface compaction and cloddiness. Chisel plowing increases the infiltration rate by making the surface more pervious to water. Returning crop residue to the soil or regularly adding other organic material helps to prevent excessive soil blowing and surface crusting and increases the infiltration rate.

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

The land capability classification is IIIw.

655—Crippin loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on slightly convex knolls or ridges near areas of depressional soils in the uplands. Areas generally are 2 to 10 acres in size. They are irregularly shaped.

Typically, the surface layer is black, calcareous loam about 9 inches thick. The subsurface layer is very dark gray, calcareous loam about 6 inches thick. The subsoil is friable, calcareous loam about 20 inches thick. It is dark grayish brown in the upper part and brown and mottled in the lower part. The substratum to a depth of about 60 inches is grayish brown, mottled, calcareous loam.

Included with this soil in mapping are small areas of well drained soils on knobs. These soils make up less than 5 percent of the unit. Also included are some small areas of poorly drained soils in depressions or on other low lying parts of the landscape. These soils make up about 10 percent of the unit.

The Crippin soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 5 to 6 percent in the surface layer. The soil typically is mildly alkaline or moderately alkaline throughout. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. The seasonal wetness can delay fieldwork, but it can be overcome by installing tile drains. Good tilth generally can be easily maintained. Cultivating or grazing when the soil is too wet, however, causes surface compaction. Soil blowing is a hazard if large areas of the soil are plowed in the fall. Returning crop residue to the soil or regularly adding other organic material helps to prevent excessive soil loss and surface crusting and increases the infiltration rate. The high content of lime adversely affects the availability of plant nutrients. In some areas where soybeans are grown, applications of iron compounds are needed.

The seasonal high water table and the high content of lime are moderate limitations if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. These limitations generally can be overcome, however, by selecting the species that can withstand occasional wetness and a calcareous soil.

The land capability classification is I.

735—Havelock clay loam, 0 to 2 percent slopes. This nearly level, poorly drained, calcareous soil is on bottom land. It is subject to flooding. Most areas are 10 to 50 acres in size and are irregularly shaped, but some are more than 150 acres and are long and narrow.

Typically, the surface layer is black, calcareous clay loam about 9 inches thick. The subsurface layer is calcareous clay loam about 31 inches thick. It is black in the upper part and very dark gray in the lower part. The upper part of the substratum is gray, calcareous loam. The lower part to a depth of about 60 inches is gray, mottled, calcareous sandy loam.

This soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 6 to 7 percent in the surface layer. The surface layer and subsurface layer are mildly alkaline or moderately alkaline. Below the surface layer, the supply of available phosphorus is medium and the supply of available potassium very low.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture if it is adequately drained and if flooding is controlled. Special care generally is needed to maintain good tilth in the surface layer. Cultivating when the soil is too wet causes surface compaction and cloddiness. Because of the excess lime, the soil structure tends to be weak and breaks down easily. Puddling results from the breakdown of soil structure. Chisel plowing increases the infiltration rate by making the surface more pervious to water. Returning crop residue to the soil or regularly adding other organic material helps to prevent excessive soil blowing and surface crusting and increases the infiltration rate. The high content of lime adversely affects the availability of plant nutrients. In some areas where soybeans are grown, applications of iron compounds are needed.

Some areas that are isolated by meandering streams are used for pasture. Most of these areas are accessible to farm machinery. Weed control is needed in areas where weed seeds are carried in by floodwater.

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

The land capability classification is IIw.

1048—Knoke mucky silt loam, ponded, 0 to 1 percent slopes. This level, very poorly drained, calcareous soil is in upland depressions. It is subject to ponding. Areas generally range from 5 to 100 acres in size and are irregularly shaped.

Typically, a few inches of partly decomposed plant residue is at the surface. The surface layer is black, calcareous mucky silt loam about 10 inches thick. The subsurface layer is about 19 inches thick. It is very dark gray and calcareous. It is silt loam in the upper part and silty clay loam in the lower part. The substratum to a depth of about 60 inches is very dark gray and olive gray, mottled loam.

This soil is moderately slowly permeable. It has a seasonal high water table. Surface runoff is ponded. Available water capacity is very high. The content of organic matter is about 12 to 18 percent in the surface

Figure 10.—An area of Knoke mucky silt loam, ponded, 0 to 1 percent slopes. This soil provides good habitat for waterfowl and other wetland wildlife.

layer. The soil typically is moderately alkaline throughout. Below the surface layer, the supply of available phosphorus and potassium is very low.

This soil supports aquatic vegetation. It is suited to wetland wildlife habitat (fig. 10). The trees and shrubs planted in areas of wildlife habitat should be those that can grow well in an extremely wet soil.

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

The land capability classification is VIIw.

1585B—Coland-Spillville complex, channeled, 2 to 5 percent slopes. These gently sloping soils are in long, narrow valleys cut by meandering stream channels. The poorly drained Coland soil is near the stream channels and is subject to flooding. The moderately well drained or somewhat poorly drained Spillville soil is at the base of upland slopes along the boundary of the mapped areas. Areas generally are 2 to 10 acres in size. They are about 60 to 70 percent Coland soil and 30 to 40 percent Spillville soil. The two soils occur as areas so closely intermingled or so small that mapping them separately was not practical.

Typically, the Coland soil has a surface layer of black clay loam about 7 inches thick. The subsurface layer is about 30 inches of black and very dark gray clay loam and loam. The substratum to a depth of about 60 inches is very dark gray and black loam. It is calcareous in the lower part.

Typically, the Spillville soil has a surface layer of black loam about 8 inches thick. The subsurface layer is black and very dark brown loam about 41 inches thick. The substratum to a depth of about 60 inches is very dark grayish brown and dark grayish brown loam and sandy loam.

These soils are moderately permeable. They have a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 5 to 7 percent in the surface layer of the Coland soil and 4 to 5 percent in the surface layer of the Spillville soil. The surface layer and subsurface layer of both soils typically are slightly acid or neutral. The supply of available phosphorus is medium below the surface layer of the Coland soil and very low below the surface layer of the Spillville soil. The supply of available potassium is very low in both soils.

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

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

The land capability classification is Vw.

1735—Havelock clay loam, channeled, 0 to 2 percent slopes. This nearly level, poorly drained, calcareous soil is on bottom land along the larger streams. It is subject to flooding. Areas range from 10 to more than 200 acres in size and are irregularly shaped.

Typically, the surface layer is black, calcareous clay loam about 9 inches thick. The subsurface layer is calcareous clay loam about 31 inches thick. It is black in the upper part and very dark gray in the lower part. The upper part of the substratum is gray, calcareous loam. The lower part to a depth of about 60 inches is gray, mottled, calcareous sandy loam.

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

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

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

The land capability classification is Vw.

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

Most of the pits have a seasonal high water table. Also, the low lying areas are ponded during wet periods. Stones and cobbles commonly are on the surface.

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

No land capability classification is assigned.

5030—Pits, limestone. These are pits resulting from the mining of limestone used for roadbuilding and agricultural lime (fig. 11). They are in a 390-acre area northwest of Gilmore City. They are surrounded by piles of spoil material.

The spoil material is loamy. Before being scraped aside, it was calcareous glacial till. Typically, it is moderately alkaline and calcareous. The content of organic matter is less than 1 percent in the surface layer.

In some areas the spoil material supports grasses, weeds, and scrub trees. These areas are suitable for wildlife habitat. Inactive pits contain water that is a few feet to many feet deep. Because of the alkaline limestone, the water is not inhabited by fish, but it provides habitat for some waterfowl. These pits are dangerous as recreational areas because of the steep side walls, the variable depth of the water, and the blasting in nearby active pits.

No land capability classification is assigned.

5040—Orthents, loamy. These nearly level to strongly sloping, well drained to somewhat poorly drained soils are in borrow areas, cut and fill areas, and reclaimed gravel pits. These areas are still suitable for plants. They are about 2 to 20 acres in size. They commonly are square or rectangular, but some are irregularly shaped.

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

Most areas that have not been developed for urban uses could be used for corn and soybeans. Unless tilth and fertility are improved, however, many areas are better suited to hay or pasture. Also, the more sloping areas are subject to erosion if they are cultivated.

Figure 11.—Mining in an area of Pits, limestone.

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

No land capability classification is assigned.

Prime Farmland

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

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

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

About 309,210 acres in Pocahontas County, or about 83 percent of the total acreage, meets the requirements for prime farmland. Nearly all of this farmland is used for crops, mainly corn and soybeans. The crops grown on this land account for an estimated 90 percent of the county's total agricultural income each year.

The map units in Pocahontas County that are considered prime farmland are listed in table 5. This list does not constitute a recommendation for a particular land use. The extent of each listed map unit is shown in table 4. The location is shown on the detailed soil maps at the back of this publication.

Some of the soils that have a seasonal high water table qualify for prime farmland only in areas where this limitation has been overcome by a drainage system. The need for drainage is indicated in parentheses after the name of these soils in table 5. Onsite evaluation is needed to determine whether or not this limitation has been overcome by corrective measures.

Use and Management of the Soils

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

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

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

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

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

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

Crops and Pasture

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

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

In 1980, about 358,400 acres in the survey area was used for agricultural purposes (*4*). Of this total, about 327,000 acres was used for row crops, mainly corn and soybeans; 6,720 acres for pasture; 5,500 acres for close-grown crops, mainly oats and wheat; 4,300 acres for hay; and 14,880 acres for other purposes. Productivity could be increased by extending the latest crop production technology to all of the cropland in the county. This soil survey can greatly facilitate the application of this technology.

The main management needs in the areas used for crops and pasture are measures that help to control erosion and soil blowing, that drain naturally wet soils, and that improve fertility and tilth.

Water erosion is the major problem on about two-thirds of the cropland and pasture in Pocahontas County. It is a hazard if the slope is more than 2 percent. Loss of the surface layer through erosion reduces the productivity of soils and results in sedimentation in streams. Productivity is reduced as the surface layer is lost and part of the subsoil is incorporated into a plow layer. Loss of the surface layer is especially damaging on soils that tend to be droughty, such as Estherville, Wadena, and Watseka soils. Runoff from eroding soils commonly deposits sediment in streams. Control of erosion not only helps to maintain the productivity of soils but also improves the quality of water for municipal use, for recreation, and for fish and wildlife by minimizing the pollution of streams.

Erosion-control measures provide a protective cover of plants or crop residue, reduce the runoff rate, and increase the rate of water infiltration. A cropping system that keeps a plant cover on the surface for extended periods can hold soil losses to an amount that will not reduce the productive capacity of the soils. On livestock farms, where part of the acreage is hayland or pasture, including forage crops in the cropping sequence not only provides nitrogen and improves tilth for the next cropping season but also provides a protective plant cover on the more sloping soils.

A conservation tillage system that leaves a protective amount of crop residue on the surface after planting is effective in controlling erosion. Following are examples of the major kinds of conservation tillage. No-till, slot, or zero tillage is a system in which the seedbed is prepared and the seed planted in one operation. The surface is disturbed only in the immediate area of the planted seed row. A protective cover of crop residue is left on at least 90 percent of the surface. Strip-till also is a system in which the seedbed is prepared and the seed planted in one operation. Tillage is limited to a strip not wider than one-third of the row. A protective cover of crop residue is left on two-thirds of the surface. Chisel-disk or rotary tillage is a system in which the soil is loosened throughout the field and part of the crop residue is incorporated into the soil. Seedbed preparation and planting can be one or separate operations.

Terraces and diversions control runoff and erosion by reducing the length of slopes. They are most effective on well drained, gently sloping or moderately sloping soils that have smooth slopes. Examples are the gently sloping Clarion and Truman soils. In areas of Clarion, Truman, Storden, and other soils having a subsoil that formed partly or entirely in glacial till, the topsoil should be stockpiled when the terraces are constructed and the exposed subsoil should be covered after construction is complete.

Contour farming and contour stripcropping are effective in controlling erosion in Pocahontas County. They are most effective on soils that have smooth, uniform slopes, such as Wadena soils and some areas of Clarion soils. Contour farming and terracing are not practical in some areas of Clarion and Storden soils. On these soils, erosion can be controlled by a protective plant cover and conservation tillage.

The cropland in the county should not be plowed in the fall. The suceptibiltiy to erosion is increased if the soils are fall-plowed.

Soil blowing is a hazard on the sandy Estherville and Sparta soils. It can damage these soils in a few hours if the winds are strong and the soils are dry and bare. A plant cover, surface mulching, windbreaks, and tillage methods that keep the surface rough minimize soil blowing.

Information about the design of practices that help to control erosion and soil blowing on each kind of soil is contained in the Technical Guide, available in local offices of the Soil Conservation Service.

Soil drainage is a major management concern on the poorly drained or very poorly drained soils in the uplands, such as Blue Earth, Canisteo, Harps, Knoke, Okoboji, Rolfe, Wacousta, and Webster soils. It also is a concern on Coland and other poorly drained soils on bottom land and in waterways. All of these soils are more productive if they are tiled, but tiling is not effective in some areas of Knoke, Rolfe, and Wacousta soils.

Soil fertility is affected by the supply of available phosphorus and potassium in the subsoil, by the content of organic matter in the surface layer, and by reaction. It is naturally low in most of the upland soils in the survey area. Most of these soils are neutral in reaction. The soils on flood plains, such as Coland and Spillville, are slightly acid to moderately alkaline. The Clarion and Nicollet soils on uplands are slightly acid or neutral. If these soils have never been limed, applications of ground limestone may be needed to raise the pH level sufficiently for good growth of alfalfa and other crops that grow well only on neutral or nearly neutral soils. On all soils the kinds and amounts of lime and fertilizer needed should be determined by the results of soil tests, the needs of the crop, and the expected level of yields. The Cooperative Extension Service can help in determining the kinds and amounts of fertilizer and lime that should be applied.

Tilth is an important factor in the germination of seeds and in the infiltration of water into the soil. Soils with good tilth generally have a high content of organic matter and are granular and porous. Most of the soils used for crops in the survey area have a loam, silty clay loam, or loam surface layer. On Storden and other soils that have a low content of organic matter, a surface crust forms during periods of intense rainfall. The crust is hard when dry. It reduces the rate of water infiltration and increases the runoff rate. Regularly adding crop residue, manure, or other organic material improves soil structure and helps to prevent surface crusting.

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

Specialty crops are grown commercially to a limited extent in the survey area. Tomatoes and apples are the only specialty crops grown. Most of the well drained soils are suitable for orchards and nursery plants. The soils in low positions where frost is frequent and air drainage is poor, however, generally are poorly suited to early vegetables, small fruits, and orchards. The latest information about growing specialty crops can be obtained from local offices of the Cooperative Extension Service and the Soil Conservation Service.

Yields Per Acre

The average yields per acre that can be expected of the principal crops under a high level of management are shown in table 6. In any given year, yields may be higher or lower than those indicated in the table because of variations in rainfall and other climatic factors.

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

The management needed to obtain the indicated yields of the various crops depends on the kind of soil and the crop. Management can include drainage, erosion control, and protection from flooding; the proper planting and seeding rates; suitable high-yielding crop varieties; appropriate and timely tillage; control of weeds, plant diseases, and harmful insects; favorable soil reaction and optimum levels of nitrogen, phosphorus, potassium, and trace elements for each crop; effective use of crop residue, barnyard manure, and green manure crops; and harvesting that insures the smallest possible loss.

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

Crops other than those shown in table 6 are grown in the survey area, but estimated yields are not listed because the acreage of such crops is small. The local office of the Soil Conservation Service or of the Cooperative Extension Service can provide information about the management and productivity of the soils for those crops.

Land Capability Classification

Land capability classification shows, in a general way, the suitability of soils for most kinds of field crops. Crops that require special management are excluded. The soils are grouped according to their limitations for field crops, the risk of damage if they are used for crops, and the way they respond to management. The criteria used in grouping the soils do not include major and generally expensive landforming that would change slope, depth, or other characteristics of the soils, nor do they include possible but unlikely major reclamation projects. Capability classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for rangeland, for woodland, and for engineering purposes.

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

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

Class I soils have 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 or that require special conservation practices, or both.

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

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

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

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

Class VIII soils and miscellaneous areas have limitations that nearly preclude their use for commercial crop production.

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

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

The acreage of soils in each capability class and subclass is shown in table 7. The capability classification of each map unit is given in the section "Detailed Soil Map Units."

Windbreaks and Environmental Plantings

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

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

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

Table 8 shows the height that locally grown trees and shrubs are expected to reach in 20 years on various soils. The estimates in table 8 are based on measurements and observation of established plantings that have been given adequate care. They can be used as a guide in planning windbreaks and screens. Additional information on planning windbreaks and screens and planting and caring for trees and shrubs can be obtained from local offices of the Soil Conservation Service or the Cooperative Extension Service or from a nursery.

Recreation

According to the Pocahontas County Comprehensive Park, Recreation, and Open Space Plan, about 1,400 acres in the county is used for outdoor recreation. Of this total 1,100 acres is state recreation facilities. The county has set aside or developed 300 acres for outdoor recreation. Municipalities provide opportunities for golf, swimming, tennis, baseball, softball, picnicking, and many other recreational activities. The public recreation facilities are in scattered areas throughout the county. They generally are in or near unique natural areas. Many forested areas along the Des Moines River and Lizard Creek are potential sites for outdoor recreation.

The soils of the survey area are rated in table 9 according to limitations that affect their suitability for recreation. The ratings are based on restrictive soil features, such as wetness, slope, and texture of the surface layer. Susceptibility to flooding is considered. Not considered in the ratings, but important in evaluating a site, are the location and accessibility of the area, the size and shape of the area and its scenic quality, vegetation, access to water, potential water impoundment sites, and access to public sewerlines. The capacity of the soil to absorb septic tank effluent and the ability of the soil to support vegetation are also important. Soils subject to flooding are limited for recreation use by the duration and intensity of flooding and the season when flooding occurs. In planning recreation facilities, onsite assessment of the height, duration, intensity, and frequency of flooding is essential.

In table 9, the degree of soil limitation is expressed as slight, moderate, or severe. *Slight* means that soil properties are generally favorable and that limitations are minor and easily overcome. *Moderate* means that limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or by a combination of these measures.

The information in table 9 can be supplemented by other information in this survey, for example, interpretations for septic tank absorption fields in table 12 and interpretations for dwellings without basements and for local roads and streets in table 11.

Camp areas require site preparation, such as shaping and leveling the tent and parking areas, stabilizing roads and intensively used areas, and installing sanitary facilities and utility lines. Camp areas are subject to heavy foot traffic and some vehicular traffic. The best soils have mild slopes and are not wet or subject to flooding during the period of use. The surface has few or no stones or boulders, absorbs rainfall readily but remains firm, and is not dusty when dry. Strong slopes and stones or boulders can greatly increase the cost of constructing campsites.

Picnic areas are subject to heavy foot traffic. Most vehicular traffic is confined to access roads and parking areas. The best soils for picnic areas are firm when wet, are not dusty when dry, are not subject to flooding during the period of use, and do not have slopes or stones or boulders that increase the cost of shaping sites or of building access roads and parking areas.

Playgrounds require soils that can withstand intensive foot traffic. The best soils are almost level and are not wet or subject to flooding during the season of use. The surface is free of stones and boulders, is firm after rains, and is not dusty when dry. If grading is needed, the depth of the soil over bedrock should be considered.

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

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

Wildlife Habitat

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

In table 10, the soils in the survey area are rated according to their potential for providing habitat for various kinds of wildlife. This information can be used in planning parks, wildlife refuges, nature study areas, and other developments for wildlife; in selecting soils that are suitable for establishing, improving, or maintaining specific elements of wildlife habitat; and in determining the intensity of management needed for each element of the habitat.

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

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

Grain and seed crops are domestic grains and seed-producing herbaceous plants. Soil properties and features that affect the growth of grain and seed crops are depth of the root zone, texture of the surface layer, available water capacity, wetness, slope, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of grain and seed crops are corn, wheat, oats, and barley.

Grasses and legumes are domestic perennial grasses and herbaceous legumes. Soil properties and features that affect the growth of grasses and legumes are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, flood hazard, and slope. Soil temperature and soil moisture are also considerations. Examples of grasses and legumes are fescue, orchardgrass, bromegrass, clover, and alfalfa.

Wild herbaceous plants are native or naturally established grasses and forbs, including weeds. Soil properties and features that affect the growth of these plants are depth of the root zone, texture of the surface layer, available water capacity, wetness, surface stoniness, and flood hazard. Soil temperature and soil moisture are also considerations. Examples of wild herbaceous plants are bluestem, goldenrod, beggarweed, wheatgrass, and grama.

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

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

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

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

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

Habitat for openland wildlife consists of cropland, pasture, meadows, and areas that are overgrown with grasses, herbs, shrubs, and vines. These areas produce grain and seed crops, grasses and legumes, and wild herbaceous plants. The wildlife attracted to these areas include bobwhite quail, pheasant, meadowlark, field sparrow, cottontail, and red fox.

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

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

Wildlife resources in Pocahontas County have important recreational and esthetic values. Ringneck pheasant, various waterfowl, and white-tailed deer are the chief game species. Most of the white-tailed deer are in wooded areas adjacent to the rivers and creeks. Some deer are also attracted to the wooded areas surrounding many of the lakes and to the larger marshes. Many other species of mammals and birds inhabit the county. Fishing generally is good in the lakes and streams.

In the past the waterfowl habitat was excellent. Intensive farming and the installation of drainage systems in many small sloughs have reduced the extent

Figure 12.—Wetland wildlife habitat in an area of Knoke mucky silt loam, ponded, 0 to 1 percent slopes. The aquatic vegetation provides food and cover for waterfowl.

of this habitat, but many migratory ducks and geese rest and feed each fall on the remaining wetlands (fig. 12).

Whitetail jackrabbit, cottontail rabbit, red fox, mink, beaver, muskrat, and Hungarian partridge find food and cover in various parts of the county. The common songbirds are robins, English sparrows, meadowlarks, blackbirds, mourning doves, purple martins, wrens, bluebirds, chickadees, brown thrashers, swallows, orioles, woodpeckers, and starlings.

Ringneck pheasants, an introduced species, have adapted well to the county. Their population varies from year to year, depending on the amount of nesting cover. It is greatly reduced by the lack of cover in winter and at nesting time and by the severe weather at nesting time.

In intensively farmed areas, road ditches and fence lines provide the most successful nesting sites, but these are few and are used by only a limited number of pheasants. According to the Iowa Conservation Commission, the pheasant population can be significantly increased if the plant cover in the ditches and along the fence lines is left unclipped until early in summer.

Winter cover for wildlife can be provided by farmstead windbreaks and wildlife plantings. It should be near a source of food. A few rows of grain left in a field adjacent to a windbreak or other wildlife planting provide an excellent source of food.

Small, odd-shaped tracts that are unsuitable for farming can provide excellent wildlife habitat. These are likely to be in areas of the moderately sloping to steep Storden soils, the Estherville-Salida complex, 5 to 10 percent slopes, and the marshes and depressional soils. Small areas of steep, eroded, or gravelly soils used for crops, railroad rights-of-way, and tracts cut off from the rest of a field by a stream or drainage ditch also can be well suited to wildlife habitat. The type of plant cover and the location of the odd-shaped areas determine whether or not any additional seeding or planting is needed. In many of these small areas, the only measures needed to develop habitat for wildlife are those that prevent fires and keep out grazing animals. In others, however, additional planting and measures that maintain the habitat are needed.

In a successful area of wildlife habitat, close-growing cover, such as grasses and legumes, provides nesting sites and some food, a taller cover of grasses and shrubs provides refuge, and clumps of evergreen trees and shrubs provide winter cover. Because of the need for protecting ground-nesting birds and rabbits, the habitat is not mowed before midsummer. A good cover of grasses and legumes is maintained by measures that control invading woody plants and by occasionally reseeding. Assistance in managing wildlife areas can be obtained from the local office of the Soil Conservation Service or the wildlife management biologists of the Iowa Conservation Commission.

Two major natural lakes, Lizard Lake and Sunken Island, provide excellent fishing in Pocahontas County. Yellow perch, bullhead, bass, and bluegill are the most numerous species. A few walleye and northern pike also inhabit the lakes. Carp are abundant. They cause damage in spawning areas and are harmful to young fish. Winterkill is a problem in both of the lakes. It is the result of an insufficient supply of oxygen when the lake is covered with ice. The oxygen supply is limited because of the shallowness of the water and the high content of organic matter on the lake bottom. Fishing is fair in the Des Moines River. The most numerous fish are bullhead and carp, but channel catfish, walleye pike, and northern pike are common.

Engineering

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

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

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

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

Soil properties, site features, and observed performance were considered in determining the ratings in this section. During the fieldwork for this soil survey, determinations were made about grain-size distribution, liquid limit, plasticity index, soil reaction, depth to bedrock, hardness of bedrock within 5 to 6 feet of the surface, soil wetness, depth to a seasonal high water table, slope, likelihood of flooding, natural soil structure aggregation, and soil density. Data were collected about kinds of clay minerals, mineralogy of the sand and silt fractions, and the kind of adsorbed cations. Estimates were made for erodibility, permeability, corrosivity, shrink-swell potential, available water capacity, and other behavioral characteristics affecting engineering uses.

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

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

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

Building Site Development

Table 11 shows the degree and kind of soil limitations that affect shallow excavations, dwellings with and without basements, small commercial buildings, local roads and streets, and lawns and landscaping. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required. Special feasibility studies may be required where the soil limitations are severe.

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

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

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

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

Sanitary Facilities

Table 12 shows the degree and kind of soil limitations that affect septic tank absorption fields, sewage lagoons, and sanitary landfills. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required.

Table 12 also shows the suitability of the soils for use as daily cover for landfills. A rating of *good* indicates that soil properties and site features are favorable for the use and good performance and low maintenance can be expected; *fair* indicates that soil properties and site features are moderately favorable for the use and one or more soil properties or site features make the soil less desirable than the soils rated good; and *poor* indicates that one or more soil properties or site features are unfavorable for the use and overcoming the unfavorable properties requires special design, extra maintenance, or costly alteration.

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

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

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

Table 12 gives ratings for the natural soil that makes up the lagoon floor. The surface layer and, generally, 1 or 2 feet of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features, and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock, flooding, large stones, and content of organic matter.

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

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

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

The ratings in table 12 are based on soil properties, site features, and observed performance of the soils. Permeability, depth to bedrock, a high water table, slope, and flooding affect both types of landfill. Texture, stones and boulders, highly organic layers, and soil reaction affect trench type landfills. Unless otherwise stated, the ratings apply only to that part of the soil within a depth of about 6 feet. For deeper trenches, a limitation rated slight or moderate may not be valid. Onsite investigation is needed.

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

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

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

Construction Materials

Table 13 gives information about the soils as a source of roadfill, sand, gravel, and topsoil. The soils are rated *good, fair,* or *poor* as a source of roadfill and topsoil. They are rated as a *probable* or *improbable* source of sand and gravel. The ratings are based on soil properties and site features that affect the removal of the soil and its use as construction material. Normal compaction, minor processing, and other standard construction practices are assumed. Each soil is evaluated to a depth of 5 or 6 feet.

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

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

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

Soils rated *good* contain significant amounts of sand or gravel or both. They have at least 5 feet of suitable material, low shrink-swell potential, few cobbles and stones, and slopes of 15 percent or less. Depth to the water table is more than 3 feet. Soils rated *fair* are more than 35 percent silt- and clay-sized particles and have a plasticity index of less than 10. They have moderate shrink-swell potential, slopes of 15 to 25 percent, or many stones. Depth to the water table is 1 to 3 feet. Soils rated *poor* have a plasticity index of more than 10, a high shrink-swell potential, many stones, or slopes of more than 25 percent. They are wet, and the depth to the water table is less than 1 foot. They may have layers of suitable material, but the material is less than 3 feet thick.

Sand and gravel are natural aggregates suitable for commercial use with a minimum of processing. Sand and gravel are used in many kinds of construction. Specifications for each use vary widely. In table 13, only the probability of finding material in suitable quantity is evaluated. The suitability of the material for specific purposes is not evaluated, nor are factors that affect excavation of the material.

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

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

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

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

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

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

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

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

Water Management

Table 14 gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas and for embankments, dikes, and levees. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and are easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increase in construction costs, and possibly increased maintenance are required.

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

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

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

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

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

Drainage is the removal of excess surface and subsurface water from the soil. How easily and effectively the soil is drained depends on the depth to bedrock or to other layers that affect the rate of water movement; permeability; depth to a high water table or depth of standing water if the soil is subject to ponding; slope; susceptibility to flooding; subsidence of organic layers; and potential frost action. Excavating and grading and the stability of ditchbanks are affected by depth to bedrock, large stones, slope, and the hazard of cutbanks caving. The productivity of the soil after drainage is adversely affected by extreme acidity or by toxic substances in the root zone, such as a high content of calcium carbonate. Availability of drainage outlets is not considered in the ratings.

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

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

Grassed waterways are natural or constructed channels, generally broad and shallow, that conduct surface water to outlets at a nonerosive velocity. Large stones, wetness, slope, and depth to bedrock affect the construction of grassed waterways. A hazard of soil blowing, low available water capacity, restricted rooting depth, and restricted permeability adversely affect the growth and maintenance of the grass after construction.

Soil Properties

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

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

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

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

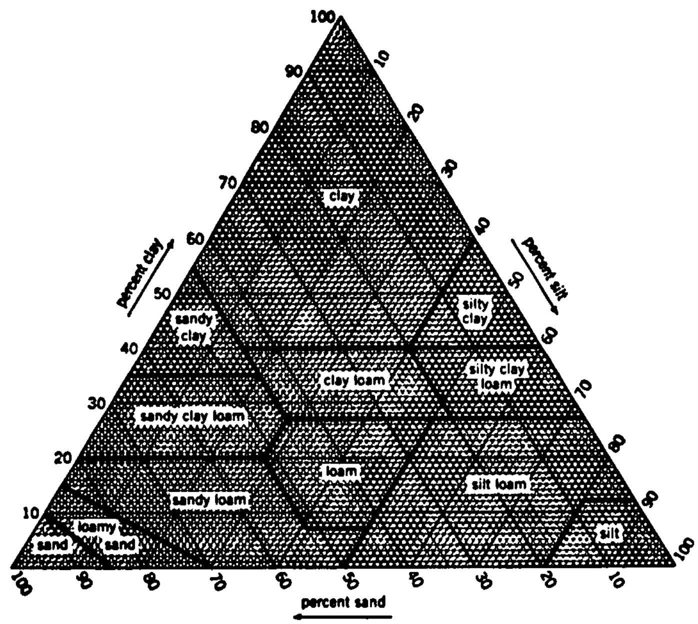

Figure 13.—Percentages of clay, silt, and sand in the basic USDA textural classes.

Engineering Index Properties

Table 15 gives estimates of the engineering classification and of the range of index properties for the major layers of each soil in the survey area. Most soils have layers of contrasting properties within the upper 5 or 6 feet.

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

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter (fig. 13). "Loam," for example, is soil that is 7 to 27 percent clay, 28 to 50 percent silt, and less than 52 percent sand. If the content of particles coarser than sand is as much as about 15 percent, an appropriate modifier is added, for example, "gravelly." Textural terms are defined in the Glossary.

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

The Unified system classifies soils according to properties that affect their use as construction material. Soils are classified according to grain-size distribution of the fraction less than 3 inches in diameter and according to plasticity index, liquid limit, and organic matter content. Sandy and gravelly soils are identified as GW, GP, GM, GC, SW, SP, SM, and SC; silty and clayey soils as ML, CL, OL, MH, CH, and OH; and highly organic soils as PT. Soils exhibiting engineering properties of two groups can have a dual classification, for example, SP-SM.

The AASHTO system classifies soils according to those properties that affect roadway construction and maintenance. In this system, the fraction of a mineral soil that is less than 3 inches in diameter is classified in one of seven groups from A-1 through A-7 on the basis of grain-size distribution, liquid limit, and plasticity index. Soils in group A-1 are coarse grained and low in content of fines (silt and clay). At the other extreme, soils in group A-7 are fine grained. Highly organic soils are classified in group A-8 on the basis of visual inspection.

If laboratory data are available, the A-1, A-2, and A-7 groups are further classified as A-1-a, A-1-b, A-2-4, A-2-5, A-2-6, A-2-7, A-7-5, or A-7-6. As an additional refinement, the suitability of a soil as subgrade material can be indicated by a group index number. Group index numbers range from 0 for the best subgrade material to 20 or higher for the poorest.

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

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

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

Physical and Chemical Properties

Table 16 shows estimates of some characteristics and features that affect soil behavior. These estimates are given for the major layers of each soil in the survey area. The estimates are based on field observations and on test data for these and similar soils.

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

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

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

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

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

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

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

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

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

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

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

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

1. Sands, coarse sands, fine sands, and very fine sands. These soils are generally not suitable for crops. They are extremely erodible, and vegetation is difficult to establish.

2. Loamy sands, loamy fine sands, and loamy very fine sands. These soils are very highly erodible. Crops can be grown if intensive measures to control soil blowing are used.

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

4L. Calcareous loamy soils that are less than 35 percent clay and more than 5 percent finely divided calcium carbonate. These soils are erodible. Crops can be grown if intensive measures to control soil blowing are used.

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

5. Loamy soils that are less than 18 percent clay and less than 5 percent finely divided calcium carbonate and sandy clay loams and sandy clays that are less than 5 percent finely divided calcium carbonate. These soils are slightly erodible. Crops can be grown if measures to control soil blowing are used.

6. Loamy soils that are 18 to 35 percent clay and less than 5 percent finely divided calcium carbonate, except silty clay loams. These soils are very slightly erodible. Crops can easily be grown.

7. Silty clay loams that are less than 35 percent clay and less than 5 percent finely divided calcium carbonate. These soils are very slightly erodible. Crops can easily be grown.

8. Stony or gravelly soils and other soils not subject to soil blowing.

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

In table 16, the estimated content of organic matter is expressed as a percentage, by weight, of the soil material that is less than 2 millimeters in diameter.

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

Soil and Water Features

Table 17 gives estimates of various soil and water features. The estimates are used in land use planning that involves engineering considerations.

Hydrologic soil groups are used to estimate runoff from precipitation. Soils not protected by vegetation are assigned to one of four groups. They are grouped according to the intake of water when the soils are thoroughly wet and receive precipitation from long-duration storms.

The four hydrologic soil groups are:

Group A. Soils having a high infiltration rate (low runoff potential) when thoroughly wet. These consist mainly of deep, well drained to excessively drained sands or gravelly sands. These soils have a high rate of water transmission.

Group B. Soils having a moderate infiltration rate when thoroughly wet. These consist chiefly of moderately deep or deep, moderately well drained or well drained soils that have moderately fine texture to moderately coarse texture. These soils have a moderate rate of water transmission.

Group C. Soils having a slow infiltration rate when thoroughly wet. These consist chiefly of soils having a layer that impedes the downward movement of water or soils of moderately fine texture or fine texture. These soils have a slow rate of water transmission.

Group D. Soils having a very slow infiltration rate (high runoff potential) when thoroughly wet. These consist chiefly of clays that have a high shrink-swell potential, soils that have a permanent high water table, soils that have a claypan or clay layer at or near the surface, and soils that are shallow over nearly impervious material. These soils have a very slow rate of water transmission.

In table 17, some soils are assigned to two hydrologic groups. The first letter is for drained areas, and the second is for undrained areas.

Flooding, the temporary inundation of an area, is caused by overflowing streams and by runoff from adjacent slopes. Water standing for short periods after rainfall or snowmelt is not considered flooding, nor is water in swamps and marshes.

Table 17 gives the frequency and duration of flooding and the time of year when flooding is most likely.

Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, common, occasional, and frequent. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions; *common* that it is likely under normal conditions; *occasional* that it occurs, on the average, once or less in 2 years; and *frequent* that it occurs, on the average, more than once in 2 years. Duration is expressed as *very brief* if less than 2 days, *brief* if 2 to 7 days, and *long* if more than 7 days. Probable dates are expressed in months; November-May, for example, means that flooding can occur during the period November through May.

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

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

High water table (seasonal) is the highest level of a saturated zone in the soil in most years. The depth to a seasonal high water table applies to undrained soils. The estimates are based mainly on the evidence of a saturated zone, namely grayish colors or mottles in the soil. Indicated in table 17 are the depth to the seasonal high water table, the kind of water table, and the months of the year that the water table commonly is high. A water table that is seasonally high for less than 1 month is not indicated in table 17. An *apparent* water table is a thick zone of free water in the soil. It is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil.

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

Depth to bedrock is given if bedrock is within a depth of 5 feet. The depth is based on many soil borings and on observations during soil mapping. The rock is specified as either soft or hard. If the rock is soft or fractured, excavations can be made with trenching machines, backhoes, or small rippers. If the rock is hard or massive, blasting or special equipment generally is needed for excavation.

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

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

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

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

Classification of the Soils

The system of soil classification used by the National Cooperative Soil Survey has six categories (*16*). Beginning with the broadest, these categories are the order, suborder, great group, subgroup, family, and series. Classification is based on soil properties observed in the field or inferred from those observations or from laboratory measurements. Table 18 shows the classification of the soils in the survey area. The categories are defined in the following paragraphs.

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

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

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

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

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

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

Soil Series and Their Morphology

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

Characteristics of the soil and the material in which it formed are identified for each series. The soil is compared with similar soils and with nearby soils of other series. A pedon, a small three-dimensional area of soil, that is typical of the series in the survey area is described. The detailed description of each soil horizon follows standards in the *Soil Survey Manual* (*15*). Many of the technical terms used in the descriptions are defined in *Soil Taxonomy* (*16*). Unless otherwise stated, colors in the descriptions are for moist soil. Following the pedon description is the range of important characteristics of the soils in the series.

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

Biscay Series

The Biscay series consists of poorly drained soils in outwash areas and on terraces. These soils formed in alluvium and glacial outwash consisting of loamy material over calcareous, sandy and gravelly sediments. The native vegetation was prairie grasses. Permeability is moderate in the solum and rapid in the substratum. Slope ranges from 0 to 2 percent.

Biscay soils are similar to Hanska and Talcot soils and commonly are adjacent to Cylinder and Talcot soils. Hanska soils contain more sand in the solum than the Biscay soils. Talcot soils are calcareous throughout.

Cylinder soils are somewhat poorly drained and are on knolls.

Typical pedon of Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, 120 feet south and 795 feet east of the northwest corner of sec. 13, T. 93 N., R. 33 W.

Ap—0 to 9 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak fine and very fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

A—9 to 13 inches; black (10YR 2/1) clay loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure; friable; neutral; gradual smooth boundary.

AB—13 to 19 inches; very dark gray (10YR 3/1) clay loam, gray (10YR 5/1) dry; weak fine and medium subangular blocky structure; friable; neutral; clear smooth boundary.

Bg—19 to 28 inches; dark gray (5Y 4/1) clay loam; few fine prominent brownish yellow (10YR 6/8) mottles in the lower part; moderate fine and medium subangular blocky structure; friable; large very dark gray (10YR 3/1) krotovinas; black (10YR 2/1) material in worm channels; common dark accumulations (iron oxide); neutral; clear smooth boundary.

BCg—28 to 36 inches; olive gray (5Y 5/2) sandy clay loam; few medium prominent yellowish brown (10YR 5/8) and few fine faint brownish yellow (10YR 6/8) mottles; moderate medium subangular blocky structure; friable; few dark accumulations (iron oxide); neutral; abrupt smooth boundary.

2Cg1—36 to 44 inches; olive gray (5Y 5/2) fine sand and gravel; few fine distinct yellowish brown (10YR 5/6) mottles; single grain; loose; slight effervescence; mildly alkaline; clear smooth boundary.

2Cg2—44 to 60 inches; olive gray (5Y 5/2) coarse sand and gravel; single grain; loose; many small white accumulations of lime; violent effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 20 to 40 inches. The thickness of the mollic epipedon ranges from 16 to 24 inches.

The A horizon either has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 1 or is neutral in hue and has value of 2 or 3 and chroma of 0. It is clay loam or loam. The B horizon has chroma of 1 to 3. It is loam, clay loam, or sandy clay loam. It is neutral or mildly alkaline. The 2C horizon is loamy coarse sand, loamy sand, coarse sand, sand, or fine sand. The content of gravel in this horizon ranges from 5 to 50 percent.

Blue Earth Series

The Blue Earth series consists of very poorly drained, depressional, moderately permeable, calcareous soils in shallow glacial lake basins. These soils formed in silty, water-worked glacial sediments or local alluvium. The native vegetation was marsh grasses or sedges. Slope is 0 to 1 percent.

Blue Earth soils commonly are adjacent to Knoke, Okoboji, and Wacousta soils. All of the adjacent soils are in upland depressions. Knoke soils have a lower content of organic matter than the Blue Earth soils. In areas where their surface layer is mucky silt loam, this texture extends to a depth of only 20 inches. Okoboji soils are noncalcareous. The solum of Wacousta soils ranges from 10 to 24 inches in thickness and is noncumulic.

Typical pedon of Blue Earth mucky silty clay loam, 0 to 1 percent slopes, 2,540 feet west and 2,470 feet north of the southeast corner of sec. 16, T. 93 N., R. 34 W.

Ap—0 to 9 inches; black (10YR 2/1) mucky silty clay loam, gray (5Y 5/1) dry; weak very fine subangular blocky structure parting to weak fine granular; very friable; many small snail shell fragments; strong effervescence; moderately alkaline; abrupt smooth boundary.

C1—9 to 23 inches; very dark gray (10YR 3/1) mucky silty clay loam, gray (5Y 6/1) dry; weak thick platy structure parting to weak fine subangular blocky and weak fine granular; very friable; many small snail shell fragments; reddish iron stains in root channels; strong effervescence; moderately alkaline; clear smooth boundary.

C2—23 to 39 inches; very dark gray (10YR 3/1) mucky silty clay loam, gray (5Y 5/1) dry; few fine faint dark brown (7.5YR 3/4) and few fine faint dark reddish brown (2.5YR 3/4) mottles; weak thick platy structure parting to weak very fine subangular blocky and weak fine granular; very friable; few small snail shell fragments; reddish iron stains in root channels; strong effervescence; moderately alkaline; clear smooth boundary.

C3—39 to 50 inches; black (10YR 2/1) mucky silty clay loam, dark gray (5Y 4/1) dry; common medium distinct dusky red (2.5YR 3/2) mottles; weak thick platy structure parting to weak fine granular; very friable; few small snail shell fragments; reddish iron stains in root channels; strong effervescence; moderately alkaline; clear smooth boundary.

Cg—50 to 60 inches; black (5Y 2/1) and very dark gray (5Y 3/1) mucky silty clay loam, gray (5Y 5/1) dry; common medium distinct dark yellowish brown (10YR 3/6) and dusky red (2.5YR 3/2) mottles; massive; very friable; many small snail shell fragments; reddish iron stains in root channels; strong effervescence; moderately alkaline.

The thickness of the mucky material ranges from 30 to 60 inches or more. Reaction is moderately alkaline or mildly alkaline throughout the profile.

The A horizon is black (N 2/0 or 10YR 2/1), very dark brown (10YR 2/2), or very dark gray (10YR 3/1 or N 3/0). The C horizon is black (N 2/0, 5Y 2/1, or 10YR 2/1), very dark gray (10YR 3/1 or 5Y 3/1), or olive gray (5Y 4/2 or 5/2). It is 30 to 60 or more inches thick. It is silt loam, silty clay loam, loam, clay loam, or mucky silty clay loam.

Calcousta Series

The Calcousta series consists of very poorly drained, moderately permeable, calcareous soils in upland depressions. These soils formed in silty glacial sediments. The native vegetation was prairie grasses. Slope is 0 to 1 percent.

Calcousta soils are similar to Canisteo and Wacousta soils and commonly are adjacent to Canisteo and Harps soils. Canisteo and Harps soils are slightly higher on the landscape than the Calcousta soils. Also, Canisteo soils contain more sand. Harps soils have a calcic horizon. Wacousta soils are noncalcareous.

Typical pedon of Calcousta silty clay loam, 0 to 1 percent slopes, 1,860 feet north and 290 feet west of the southeast corner of sec. 29, T. 92 N., R. 31 W.

Ap—0 to 9 inches; black (N 2/0) silty clay loam, very dark gray (N 3/0) dry; weak medium subangular blocky structure; friable; few small snail shell fragments; strong effervescence; moderately alkaline; abrupt smooth boundary.

A—9 to 15 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak medium subangular blocky structure; friable; olive gray (5Y 4/2) streaks and pockets in the lower part; some dark gray (5Y 4/1) material in root channels; slight effervescence; mildly alkaline; abrupt smooth boundary.

Bg—15 to 21 inches; olive gray (5Y 4/2) silty clay loam; common fine faint olive (5Y 5/4) mottles; weak fine subangular blocky structure; friable; very dark gray (5Y 3/1) coatings on faces of peds; strong effervescence; moderately alkaline; clear smooth boundary.

Cg—21 to 60 inches; olive gray (5Y 5/2) and light olive gray (5Y 6/2) silty clay loam; common fine prominent yellowish red (5YR 4/6) and common medium distinct strong brown (7.5YR 5/8) mottles; massive; friable; few soft white (5Y 8/1) accumulations of lime; strong effervescence; moderately alkaline.

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

The A horizon is black (N 2/0, 10YR 2/1, or 2.5Y 2/1). It is silty clay loam, silt loam, or mucky silt loam. It is mildly alkaline or moderately alkaline. The Bg horizon has hue of 5Y, value of 4 to 6, and chroma of 1 or 2. The Cg horizon has hue of 5Y, value of 5 or 6, and chroma of 1 or 2. It is silt loam or silty clay loam.

Canisteo Series

The Canisteo series consists of poorly drained, moderately permeable, calcareous soils on uplands. These soils formed in local alluvium and in the underlying glacial till. The native vegetation was prairie grasses. Slope ranges from 0 to 2 percent.

Canisteo soils are similar to Calcousta and Webster soils and commonly are adjacent to Nicollet, Okoboji, and Webster soils. Calcousta soils contain less sand than the Canisteo soils. Webster soils have a noncalcareous solum. Nicollet soils also have a noncalcareous solum. They are somewhat poorly drained and are on knolls. Okoboji soils are very poorly drained and are in depressions. They are cumulic.

Typical pedon of Canisteo clay loam, 0 to 2 percent slopes, 130 feet north and 125 feet east of the southwest corner of sec. 19, T. 93 N., R. 31 W.

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

A—10 to 16 inches; black (10YR 2/1) clay loam, dark gray (10YR 4/1) dry; weak very fine subangular blocky structure; friable; strong effervescence; moderately alkaline; clear irregular boundary.

AB—16 to 20 inches; very dark gray (N 3/0) clay loam, gray (10YR 5/1) dry; few fine distinct grayish brown (2.5Y 5/2) and few fine distinct gray (10YR 5/1) mottles; weak very fine subangular blocky structure; friable; strong effervescence; moderately alkaline; clear irregular boundary.

Bg1—20 to 24 inches; dark gray (10YR 4/1) clay loam; very dark gray (10YR 3/1) coatings on faces of peds; few fine distinct light olive brown (2.5Y 5/4) mottles; weak very fine subangular blocky structure; friable; strong effervescence; moderately alkaline; clear wavy boundary.

Bg2—24 to 35 inches; grayish brown (2.5Y 5/2) clay loam; few fine distinct strong brown (7.5YR 5/6) mottles; weak fine and very fine subangular blocky structure; friable; about 2 percent coarse fragments; strong effervescence; moderately alkaline; clear wavy boundary.

Cg—35 to 60 inches; olive gray (5Y 5/2) clay loam; many medium distinct strong brown (7.5YR 5/6) and common medium distinct strong brown (7.5YR 4/6) mottles; massive; friable; strong effervescence; moderately alkaline.

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

The A horizon either has value of 2 or 3 and chroma of 1 or is neutral in hue and has value of 2 or 3 and chroma of 0. It is clay loam, silty clay loam, or loam. The Bg horizon has hue of 10YR, value of 4 or 5, and chroma of 1 or has hue of 2.5Y, value of 4 or 5, and chroma of 1 or 2. It is loam or clay loam. The Cg horizon has value of 5 or 6 and chroma of 2 to 4.

Clarion Series

The Clarion series consists of well drained, moderately permeable soils on uplands. These soils formed in loamy glacial till. The native vegetation was prairie grasses. Slope ranges from 2 to 14 percent.

Clarion soils are similar to Garmore and Truman soils and commonly are adjacent to Nicollet and Webster soils. Garmore soils have a solum that is thicker than that of the Clarion soils and are leached of carbonates to a greater depth. Truman soils are finer textured than the Clarion soils. Nicollet soils are somewhat poorly drained and are on the less sloping parts of the landscape. Webster soils are finer textured than the Clarion soils. They are poorly drained and nearly level and are in the lower areas or in waterways.

Typical pedon of Clarion loam, 2 to 5 percent slopes, 2,140 feet east and 300 feet north of the southwest corner of sec. 19, T. 91 N., R. 33 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, very dark grayish brown (10YR 3/2) dry; weak fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

A—8 to 12 inches; black (10YR 2/1) loam, dark grayish brown (10YR 4/2) dry; weak fine and medium subangular blocky structure; friable; neutral; clear smooth boundary.

AB—12 to 16 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; common black (10YR 2/1) coatings on faces of peds; weak fine and medium subangular blocky structure; friable; neutral; gradual smooth boundary.

Bw—16 to 26 inches; brown (10YR 4/3) loam; common very dark grayish brown (10YR 3/2) coatings on faces of peds in the upper part; weak fine subangular blocky structure; friable; neutral; gradual smooth boundary.

BC—26 to 41 inches; dark yellowish brown (10YR 4/4) loam; weak fine subangular blocky structure; friable; neutral; clear smooth boundary.

C—41 to 60 inches; yellowish brown (10YR 5/4) loam; common fine faint yellowish brown (10YR 5/6), few medium distinct strong brown (7.5YR 5/8), and common medium distinct light brownish gray (10YR 6/2) mottles; massive; friable; few small white accumulations of lime; few dark accumulations (iron oxide); strong effervescence; moderately alkaline.

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

The A horizon has value of 2 or 3 and chroma of 1 or 2. The Bw horizon has value of 4 or 5 and chroma of 3 or 4. It is neutral or slightly acid. The content of clay in this horizon ranges from 18 to 28 percent. The C horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 2 to 6.

The eroded Clarion soils are taxadjuncts to the Clarion series because they do not have a mollic epipedon, which is definitive for the series. Their A horizon is 6 to 9 inches thick.

Coland Series

The Coland series consists of poorly drained, moderately permeable soils on bottom land, low terraces, foot slopes, and alluvial fans. These soils formed in loamy alluvium. The native vegetation was prairie grasses. Slope ranges from 0 to 5 percent.

Coland soils are similar to Havelock soils and commonly are adjacent to Havelock and Spillville soils. Havelock soils are calcareous throughout. Spillville soils contain more sand throughout than the Coland soils. They are somewhat poorly drained or moderately well drained and are on small knolls or the slightly higher parts of the landscape.

Typical pedon of Coland clay loam, 0 to 2 percent slopes, 2,140 feet east and 840 feet south of the northwest corner of sec. 33, T. 93 N., R. 31 W.

Ap—0 to 7 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; moderate fine granular structure; friable; slightly acid; abrupt smooth boundary.

A1—7 to 15 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; friable; slightly acid; abrupt smooth boundary.

A2—15 to 32 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak very fine and fine subangular blocky structure; friable; neutral; clear smooth boundary.

AC—32 to 37 inches; very dark gray (5Y 3/1) clay loam, dark gray (10YR 4/1) dry; weak fine prismatic structure parting to weak fine subangular blocky; friable; neutral; clear smooth boundary.

Cg1—37 to 44 inches; very dark gray (5Y 3/1) loam, dark gray (10YR 4/1) dry; weak fine prismatic structure parting to weak fine subangular blocky; friable; neutral; clear smooth boundary.

Cg2—44 to 49 inches; black (5Y 2/1) loam, very dark gray (10YR 3/1) dry; moderate fine and very fine subangular blocky structure; friable; mildly alkaline; clear smooth boundary.

Cg3—49 to 60 inches; very dark gray (5Y 3/1) loam, dark gray (10YR 4/1) dry; weak very fine and fine subangular blocky structure; friable; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 36 to 48 inches. The depth to free carbonates commonly is 48 inches or more.

The A horizon is black (N 2/0 or 10YR 2/1) or very dark gray (10YR 3/1 or N 3/0). It is dominantly clay loam or silty clay loam that has a moderate content of sand. In some pedons, however, the upper 10 inches is loam. The AC horizon is black (5Y 2/1), very dark gray (5Y 3/1), or dark gray (5Y 4/1). The Cg horizon has hue of 2.5Y or 5Y, value of 2 to 5, and chroma of 1. Sand or gravel is below a depth of 48 inches in some pedons.

Crippin Series

The Crippin series consists of somewhat poorly drained, moderately permeable, calcareous soils on uplands. These soils formed in calcareous, loamy glacial till. The native vegetation was prairie grasses. Slope ranges from 1 to 3 percent.

Crippin soils are similar to Nicollet soils and commonly are adjacent to Canisteo and Okoboji soils. Nicollet soils are noncalcareous. The poorly drained Canisteo soils are in low areas bordering depressions. The very poorly drained Okoboji soils are in the depressions.

Typical pedon of Crippin loam, 1 to 3 percent slopes, 2,100 feet north and 255 feet west of the southeast corner of sec. 25, T. 90 N., R. 34 W.

Ap—0 to 9 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak medium and fine subangular blocky structure; friable; slight effervescence; mildly alkaline; abrupt smooth boundary.

A—9 to 15 inches; very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure; friable; strong effervescence; moderately alkaline; clear smooth boundary.

BA—15 to 20 inches; dark grayish brown (10YR 4/2) loam; weak fine subangular blocky structure; friable; strong effervescence; moderately alkaline; clear smooth boundary.

Bw—20 to 31 inches; brown (10YR 5/3) loam; few fine distinct yellowish brown (10YR 5/8) mottles; weak fine subangular blocky structure; friable; strong effervescence; moderately alkaline; clear smooth boundary.

BC—31 to 35 inches; brown (10YR 5/3) loam; common fine distinct yellowish brown (10YR 5/8) mottles; weak fine subangular blocky structure; friable; few white (5Y 8/1) accumulations of lime; many dark accumulations (iron oxide); strong effervescence; moderately alkaline; clear smooth boundary.

C1—35 to 51 inches; grayish brown (10YR 5/2) loam; common medium distinct yellowish brown (10YR 5/8) and few fine faint brownish yellow (10YR 6/8) mottles; massive; friable; few white (5Y 8/1) accumulations of lime; few dark accumulations (iron oxide); strong effervescence; moderately alkaline; clear smooth boundary.

C2—51 to 60 inches; grayish brown (10YR 5/2) loam; many medium prominent yellowish brown (10YR 5/8) and few fine faint light brownish gray (10YR 6/2) and brownish yellow (10YR 6/8) mottles; massive; friable; few white (5Y 8/1) accumulations of lime; few dark accumulations (iron oxide); strong effervescence; moderately alkaline.

The thickness of the solum ranges from 20 to 48 inches. The thickness of the mollic epipedon ranges from 10 to 18 inches. Reaction is mildly alkaline or moderately alkaline throughout the profile.

The A horizon is black (N 2/0 or 10YR 2/1) or very dark gray (10YR 3/1). It is loam or clay loam. The BA horizon is very dark gray (10YR 3/1), very dark grayish brown (10YR 3/2), or dark grayish brown (10YR 4/2). The Bw and BC horizons are dark grayish brown (10YR or 2.5Y 4/2) or brown (10YR 5/3). They are loam or clay loam. The C horizon has hue of 10YR to 5Y, value of 4 or 5, and chroma of 2 to 4. It is loam or clay loam.

Cylinder Series

The Cylinder series consists of somewhat poorly drained soils on stream terraces and in glacial outwash areas. These soils formed in loamy alluvial or glacial material over calcareous, sandy and gravelly sediments. The native vegetation was prairie grasses. Permeability is moderate in the solum and very rapid in the substratum. Slope ranges from 0 to 2 percent.

Cylinder soils are similar to Nicollet soils and commonly are adjacent to Biscay and Wadena soils. Nicollet soils have a loamy substratum. Biscay soils are poorly drained and are in the lower areas. Wadena soils are well drained and are on the higher knolls.

Typical pedon of Cylinder clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, 1,150 feet north and 1,375 feet east of the southwest corner of sec. 26, T. 93 N., R. 32 W.

Ap—0 to 9 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A—9 to 15 inches; very dark gray (10YR 3/1) clay loam, dark grayish brown (10YR 4/2) dry; some black (10YR 2/1) coatings on faces of peds; weak very fine subangular blocky structure; friable; neutral; clear smooth boundary.

AB—15 to 20 inches; very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) dry; weak fine and medium subangular blocky structure; friable; neutral; clear smooth boundary.

Bw1—20 to 26 inches; dark grayish brown (2.5Y 4/2) loam; few very dark grayish brown (10YR 3/2) coatings on faces of peds; weak fine and medium subangular blocky structure; friable; neutral; clear smooth boundary.

Bw2—26 to 31 inches; dark grayish brown (10YR 4/2) loam; very few fine faint yellowish brown (10YR 5/6) mottles; weak fine and medium subangular blocky structure; friable; neutral; abrupt smooth boundary.

BC—31 to 36 inches; grayish brown (2.5Y 5/2) gravelly loam; common fine faint light olive brown (2.5Y 5/6) mottles; weak fine subangular blocky structure; friable; strong effervescence; moderately alkaline; abrupt smooth boundary.

2C—36 to 60 inches; brown (10YR 4/3), dark yellowish brown (10YR 4/4), and yellowish brown (10YR 5/6) coarse sand and gravel (estimated 15 percent gravel); single grain; loose; strong effervescence; moderately alkaline.

The thickness of the solum, or the depth to sand and gravel, ranges from 24 to 40 inches. The depth to free carbonates ranges from 30 to 50 inches. The thickness of the mollic epipedon ranges from 10 to 24 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is slightly acid or neutral loam or clay loam. The Bw horizon has hue of 2.5Y or 10YR, value of 4 or 5, and chroma of 2 or 3. It generally has the same range in reaction and texture as the A horizon, but in some pedons it is coarser textured in the lower part. The 2C horizon is moderately alkaline or mildly alkaline sand or coarse sand and gravel.

Estherville Series

The Estherville series consists of somewhat excessively drained soils in broad outwash areas and on terraces and kames. These soils formed in alluvium or glacial outwash. The native vegetation was prairie grasses. Permeability is moderately rapid in the solum and rapid in the substratum. Slope ranges from 0 to 9 percent.

Estherville soils are similar to Wadena soils and commonly are adjacent to Cylinder and Wadena soils. Wadena soils are well drained. They are 24 to 40 inches deep to sand and gravel. Their positions on the landscape are similar to those of the Estherville soils. Cylinder soils are somewhat poorly drained and are on the lower parts of the landscape.

Typical pedon of Estherville sandy loam, 2 to 5 percent slopes, 1,266 feet west and 36 feet north of the southeast corner of sec. 13, T. 93 N., R. 31 W.

Ap—0 to 7 inches; black (10YR 2/1) sandy loam, very dark gray (10YR 3/1) dry; weak very fine granular structure; very friable; slightly acid; abrupt smooth boundary.

A—7 to 13 inches; black (10YR 2/1) sandy loam, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; very friable; slightly acid; abrupt wavy boundary.

Bw—13 to 18 inches; dark brown (10YR 3/3) coarse sandy loam; weak fine and very fine subangular blocky structure; very friable; neutral; abrupt wavy boundary.

2C1—18 to 20 inches; brown (7.5YR 4/4) sand and about 50 percent gravel; single grain; loose; strong effervescence; moderately alkaline; clear smooth boundary.

2C2—20 to 60 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4 and 5/6) stratified coarse sand and sand and gravel; single grain; loose; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 15 to 24 inches. The thickness of the mollic epipedon ranges from 10 to 18 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is sandy loam or loam. The Bw horizon has value and chroma of 3 or 4. It is medium acid to neutral. It is sandy loam, loamy sand, coarse sandy loam, or loam. The content of clay in this horizon is less than 18 percent. The 2C horizon has chroma of 2 to 6.

Estherville sandy loam, 5 to 9 percent slopes, moderately eroded, is a taxadjunct to the Estherville series because it does not have a mollic epipedon, which is definitive for the series.

Faxon Series

The Faxon series consists of moderately deep, poorly drained, moderately permeable soils on uplands. These soils formed in 20 to 40 inches of loamy alluvium derived from glacial till. They are underlain by limestone bedrock. The native vegetation was prairie grasses. Slope ranges from 0 to 2 percent.

Faxon soils are similar to Webster soils and commonly are adjacent to Garmore soils. Webster soils are not underlain by limestone bedrock and are not calcareous in the surface layer. The moderately well drained, nearly level to gently sloping Garmore soils are on ridges. They are deeper over limestone bedrock than the Faxon soils.

Typical pedon of Faxon silt loam, 0 to 2 percent slopes, 2,535 feet north and 175 feet east of the southwest corner of sec. 36, T. 92 N., R. 31 W.

Ap—0 to 10 inches; black (10YR 2/1) silt loam, very dark gray (10YR 3/1) dry; weak fine and very fine subangular blocky structure; friable; mildly alkaline; abrupt smooth boundary.

A—10 to 19 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine and very fine subangular blocky structure; friable; neutral; clear smooth boundary.
Bg1—19 to 25 inches; dark gray (5Y 4/1) silty clay loam; many very dark gray (5Y 3/1) coatings on faces of peds; few medium distinct olive (5Y 5/3) and few fine faint yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to weak medium and fine subangular blocky; friable; neutral; clear smooth boundary.
Bg2—25 to 31 inches; olive gray (5Y 4/2) silty clay loam; dark gray (5Y 4/1) coatings on faces of peds; few medium faint olive gray (5Y 5/2) and few fine distinct yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to weak medium and fine subangular blocky; friable; neutral; clear smooth boundary.
BCg—31 to 35 inches; olive gray (5Y 4/2) silty clay loam; few fine faint olive gray (5Y 5/2) and few fine distinct yellowish brown (10YR 5/4) mottles; weak medium prismatic structure parting to weak medium and fine subangular blocky; firm; neutral; abrupt smooth boundary.
2Cg—35 to 37 inches; mixed dark gray (5Y 4/1) and very dark gray (5Y 3/1) clay; many small decomposing limestone fragments; stratified residuum; very firm; slight effervescence; neutral; abrupt smooth boundary.
2R—37 inches; hard limestone bedrock.

The thickness of the solum and the depth to limestone bedrock range from 20 to 40 inches. The thickness of the mollic epipedon ranges from 10 to 20 inches. Reaction is neutral or mildly alkaline throughout the profile.

The A horizon has value of 2 or 3 and chroma of 1 or is neutral in hue and has value of 2 or 3 and chroma of 0. It is loam, silt loam, clay loam, sandy clay loam, or silty clay loam. The Bg horizon has hue of 2.5Y or 5Y and value of 4 or 5. It has chroma of 1 or 2 in the upper part and chroma of 1 to 4 in the lower part. It is dominantly sandy loam, loam, sandy clay loam, silt loam, clay loam, or silty clay loam, but in some pedons it is clay in the lower part. The content of coarse fragments is as much as 35 percent in the lower part of some pedons.

Garmore Series

The Garmore series consists of moderately well drained, moderately permeable soils on uplands. These soils formed in glacial till. They are underlain by limestone bedrock at a depth of about 10 to 20 feet. The native vegetation was prairie grasses. Slope ranges from 0 to 5 percent.

Garmore soils are similar to Clarion soils and commonly are adjacent to Clarion and Faxon soils. They generally are less sloping than Clarion soils. Also, they have a thicker solum and are leached of carbonates to a greater depth. Faxon soils are poorly drained and are lower on the landscape than the Garmore soils.

Typical pedon of Garmore loam, 0 to 2 percent slopes, 2,350 feet west and 200 feet north of the southeast corner of sec. 25, T. 92 N., R. 31 W.

Ap—0 to 6 inches; black (10YR 2/1) loam, very dark grayish brown (10YR 3/2) dry; weak fine granular structure; friable; neutral; abrupt smooth boundary.
A1—6 to 13 inches; black (10YR 2/1) loam, very dark grayish brown (10YR 3/2) dry; weak fine and very fine subangular blocky structure parting to weak fine granular; friable; slightly acid; clear smooth boundary.
A2—13 to 18 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; many black (10YR 2/1) coatings on faces of peds; weak fine and very fine subangular blocky structure parting to weak fine granular; friable; slightly acid; abrupt smooth boundary.
BA—18 to 23 inches; dark brown (10YR 3/3) loam; some very dark gray (10YR 3/1) material in root channels; weak fine and very fine subangular blocky structure parting to weak fine granular; friable; slightly acid; clear smooth boundary.
Bw—23 to 42 inches; dark yellowish brown (10YR 4/4) clay loam; many brown (10YR 4/3) coatings on faces of peds; weak fine and medium subangular blocky structure; friable; many discontinuous clay films; few reddish accumulations (iron oxide); neutral; abrupt smooth boundary.
BC—42 to 51 inches; yellowish brown (10YR 5/6) loam; weak coarse subangular blocky structure; very friable; few reddish accumulations (iron oxide); neutral; abrupt smooth boundary.
C—51 to 60 inches; yellowish brown (10YR 5/6) loam; massive; very friable; few reddish and dark accumulations (iron oxide); few small pebbles; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 42 to 72 inches. The A horizon is 12 to 18 inches thick. It has value of 2 or 3 and chroma of 1 or 2. It is loam or silt loam. The Bw horizon has value of 4 or 5 and chroma of 3 to 6. The C horizon has hue of 10YR or 2.5Y, value of 5, and chroma of 4 or 6.

Hanska Series

The Hanska series consists of poorly drained soils in glacial outwash areas. These soils formed in loamy and sandy glacial outwash. The native vegetation was prairie grasses. Permeability is moderately rapid in the upper part of the profile and rapid in the lower part. Slope ranges from 0 to 2 percent.

Hanska soils are similar to Biscay soils and commonly are adjacent to Linder and Watseka soils. Biscay soils contain more clay in the solum than the Hanska soils. The somewhat poorly drained Linder and Watseka soils are on small knolls and on terraces and are slightly higher on the landscape than the Hanska soils. Also, Watseka soils contain more sand in the solum.

Typical pedon of Hanska loam, 0 to 2 percent slopes, 930 feet west and 222 feet north of the southeast corner of sec. 24, T. 93 N., R. 31 W.

Ap—0 to 9 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak medium subangular blocky structure parting to moderate medium granular; friable; neutral; abrupt smooth boundary.

A1—9 to 16 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak medium subangular blocky structure; friable; neutral; clear smooth boundary.

A2—16 to 21 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak medium subangular blocky structure; friable; neutral; clear smooth boundary.

Bg1—21 to 26 inches; dark gray (5Y 4/1) sandy loam; weak coarse subangular blocky structure; friable; neutral; clear smooth boundary.

Bg2—26 to 30 inches; dark gray (5Y 4/1) sandy loam; weak coarse subangular blocky structure; friable; neutral; clear smooth boundary.

2BCg—30 to 34 inches; gray (5Y 5/1) loamy sand; weak medium subangular blocky structure; very friable; neutral; clear smooth boundary.

2C1—34 to 46 inches; olive (5Y 5/3) sand; single grain; loose; neutral; abrupt smooth boundary.

2C2—46 to 49 inches; olive (5Y 5/3) sand and gravel; single grain; loose; slight effervescence; mildly alkaline; abrupt smooth boundary.

2C3—49 to 60 inches; pale olive (5Y 6/3) sand and a few pebbles; single grain; loose; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 24 to 56 inches. The depth to free carbonates ranges from 30 to 55 inches.

The A horizon has value of 2 or 3 and chroma of 1 or is neutral in hue and has value of 2 or 3 and chroma of 0. It is sandy loam, fine sandy loam, or loam. It commonly is neutral but in some pedons is slightly acid or mildly alkaline. The Bg horizon has value of 4 or 5 and chroma of 1 or 2. It typically is sandy loam but in some pedons is coarse sandy loam or loam. The 2BC horizon typically is loamy sand but in some pedons is loamy coarse sand, sand, or coarse sand. The Bg and 2BCg horizons generally are neutral or slightly acid, but in some pedons the 2BCg horizon is mildly alkaline. The 2C horizon has value of 5 or 6 and chroma of 2 or 3. It is sand or coarse sand in which the content of fine gravel is as much as 10 percent.

Harps Series

The Harps series consists of poorly drained, moderately permeable, highly calcareous soils on rims and low ridges around and between upland depressions. These soils formed in glacial till or local alluvium. The native vegetation was prairie grasses. Slope ranges from 0 to 2 percent.

Harps soils commonly are adjacent to Canisteo, Okoboji, and Webster soils. Canisteo soils do not have a calcic horizon and have a lower calcium carbonate equivalent than the Harps soils. Their positions on the landscape are similar to those of the Harps soils. Okoboji soils are in depressions. They are noncalcareous, and their A horizon is thicker than that of the Harps soils. Webster soils are noncalcareous and contain more clay in the solum than the Harps soils. They are in swales.

Typical pedon of Harps clay loam, 0 to 2 percent slopes, 2,125 feet east and 546 feet north of the southwest corner of sec. 3, T. 93 N., R. 31 W.

Ap—0 to 9 inches; black (10YR 2/1) clay loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to weak fine granular; friable; many small snail and clam shell fragments; violent effervescence; moderately alkaline; abrupt smooth boundary.

Ak—9 to 12 inches; black (10YR 2/1) clay loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to weak fine granular; friable; few small snail and clam shell fragments; violent effervescence; moderately alkaline; clear smooth boundary.

ABk—12 to 19 inches; very dark gray (10YR 3/1) clay loam, gray (10YR 5/1) dry; weak fine subangular blocky structure parting to weak fine granular; friable; violent effervescence; moderately alkaline; clear smooth boundary.

Bgk1—19 to 29 inches; olive gray (5Y 5/2) clay loam; weak fine granular structure; friable; violent effervescence; moderately alkaline; clear smooth boundary.

Bgk2—29 to 35 inches; olive gray (5Y 5/2) and gray (5Y 5/1) loam; few fine distinct light olive brown (2.5Y 5/4) mottles; weak medium prismatic structure parting to weak medium subangular blocky; friable; violent effervescence; moderately alkaline; clear smooth boundary.

BCg—35 to 41 inches; olive gray (5Y 5/2) loam; few fine distinct light olive brown (2.5Y 5/6) mottles; massive; friable; strong effervescence; moderately alkaline; clear smooth boundary.

Cg—41 to 60 inches; gray (5Y 5/1) loam; common medium prominent yellowish brown (10YR 5/6 and 5/8) mottles; massive; friable; many medium distinct yellowish red (5YR 4/6) iron stains; strong effervescence; moderately alkaline.

The solum ranges from 30 to 50 inches in thickness. It has free carbonates throughout. The thickness of the mollic epipedon ranges from 10 to 20 inches.

The A horizon has value of 2 or 3 and chroma of 1. It is loam or clay loam. The Bgk horizon has value of 5 or 6 and chroma of 1 or 2. It is loam, clay loam, or sandy clay loam. The Cg horizon generally has colors similar to those of the Bgk horizon, but in some pedons colors of high chroma are dominant in the upper part.

Havelock Series

The Havelock series consists of poorly drained, moderately permeable, calcareous soils on bottom land. These soils formed in loamy alluvium. The native vegetation was prairie grasses. Slope ranges from 0 to 2 percent.

Havelock soils are similar to Coland soils and commonly are adjacent to Coland and Spillville soils. Coland soils are not calcareous. Spillville soils have a higher content of sand and a lower content of clay than the Havelock soils. They are moderately well drained or somewhat poorly drained and are on small knolls or the slightly higher parts of the landscape.

Typical pedon of Havelock clay loam, 0 to 2 percent slopes, 1,800 feet north and 120 feet west of the southeast corner of sec. 1, T. 93 N., R. 34 W.

Ap—0 to 9 inches; black (N 2/0) clay loam, very dark gray (N 3/0) dry; weak fine and very fine subangular blocky structure; friable; few fine snail shell fragments; slight effervescence; mildly alkaline; clear smooth boundary.

A1—9 to 13 inches; black (N 2/0) clay loam, very dark gray (N 3/0) dry; weak fine and very fine subangular blocky structure; friable; few fine snail shell fragments; strong effervescence; moderately alkaline; gradual smooth boundary.

A2—13 to 24 inches; very dark gray (10YR 3/1) clay loam, dark gray (10YR 4/1) dry; weak fine and very fine subangular blocky structure; friable; few fine snail shell fragments; strong effervescence; moderately alkaline; gradual smooth boundary.

A3—24 to 40 inches; very dark gray (5Y 3/1) clay loam, gray (5Y 5/1) dry; weak fine and very fine subangular blocky structure; friable; few fine snail shell fragments; strong effervescence; moderately alkaline; clear smooth boundary.

Cg1—40 to 53 inches; gray (5Y 5/1) loam; massive; friable; strong effervescence; few fine snail shell fragments; moderately alkaline; clear smooth boundary.

Cg2—53 to 60 inches; gray (5Y 5/1 and 6/1) sandy loam; common fine prominent yellowish brown (10YR 5/6) mottles; massive; friable; about 5 percent gravel; many small and medium white (5Y 8/1) accumulations of lime; strong effervescence; moderately alkaline.

The mollic epipedon ranges from 36 to 50 inches in thickness. The A horizon ranges from 36 to 48 inches in thickness . It either has hue of 10YR or 5Y or is neutral in hue and has value of 2 and chroma of 0. Some pedons have a Bg horizon. This horizon either is neutral in hue and has value of 3 and chroma of 0 or has hue of 2.5Y or 5Y, value of 2 to 5, and chroma of 1. It is loam or clay loam. The C horizon dominantly is loam or clay loam in the upper part and sandy loam in the lower part. In some pedons, however, it has thin strata of other textures.

Kingston Series

The Kingston series consists of somewhat poorly drained, moderately permeable soils on terraces. These soils formed in silty glacial sediments. The native vegetation was prairie grasses. Slope ranges from 0 to 3 percent.

Kingston soils are similar to Nicollet soils and commonly are adjacent to Truman soils. Nicollet soils contain more sand in the solum than the Kingston soils. The well drained, gently sloping Truman soils are on ridges. They contain less clay than the Kingston soils.

Typical pedon of Kingston silty clay loam, 0 to 3 percent slopes, 420 feet east and 135 feet south of the northwest corner of sec. 1, T. 92 N., R. 31 W.

Ap—0 to 10 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to weak fine granular; friable; slightly acid; abrupt smooth boundary.

A—10 to 16 inches; black (10YR 2/1) silty clay loam, dark grayish brown (10YR 4/2) dry; weak fine and very fine subangular blocky structure; friable; neutral; clear smooth boundary.

AB—16 to 21 inches; very dark gray (10YR 3/1) silty clay loam, grayish brown (10YR 5/2) dry; weak fine and very fine subangular blocky structure; friable; neutral; clear smooth boundary.

Bw1—21 to 25 inches; dark grayish brown (2.5Y 4/2) silty clay loam; common medium distinct light olive brown (2.5Y 5/4) mottles; weak fine and very fine subangular blocky structure; friable; some very dark grayish brown (10YR 3/2) coatings on faces of peds; neutral; clear smooth boundary.

Bw2—25 to 39 inches; brown (10YR 4/3) silty clay loam; common medium distinct dark grayish brown (2.5Y 4/2) and few fine faint light olive brown (2.5Y 5/4) mottles; weak fine and very fine subangular blocky structure; friable; very few very dark grayish brown (10YR 3/2) coatings on faces of peds; neutral; abrupt smooth boundary.

C—39 to 60 inches; light olive brown (2.5Y 5/4) silty clay loam; common medium distinct gray (5Y 5/1) mottles; massive; friable; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 20 to 40 inches. The mollic epipedon ranges from 12 to 24 inches in thickness.

The A horizon is black (10YR 2/1) or very dark gray (10YR 3/1). It is medium acid to neutral. The Bw horizon has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 2 to 4. It typically is silty clay loam, but the range includes silt loam. The C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 2 to 4. It is silt loam or silty clay loam.

Knoke Series

The Knoke series consists of very poorly drained, calcareous, moderately slowly permeable soils in upland depressions. These soils formed in silty local alluvium and in the underlying glacial till. The native vegetation was prairie grasses, sedges, and reeds. Slope is 0 to 1 percent.

Knoke soils are similar to Okoboji soils and commonly are adjacent to Canisteo and Harps soils. Okoboji soils are noncalcareous. Canisteo and Harps soils are on the rims of the depressions. Their mollic epipedon is thinner than that of the Knoke soils.

Typical pedon of Knoke silty clay loam, 0 to 1 percent slopes, 2,280 feet south and 460 feet west of the northeast corner of sec. 23, T. 92 N., R. 31 W.

Ap—0 to 9 inches; black (N 2/0) silty clay loam, black (5Y 2/1) dry; weak fine and very fine subangular blocky structure; friable; few snail shell fragments; strong effervescence; moderately alkaline; abrupt smooth boundary.

A1—9 to 13 inches; black (N 2/0) silty clay loam, black (5Y 2/1) dry; weak fine and very fine subangular blocky structure; friable; few snail shell fragments; strong effervescence; moderately alkaline; clear smooth boundary.

A2—13 to 27 inches; black (5Y 2/1) silty clay loam, very dark gray (5Y 3/1) dry; weak fine and very fine subangular blocky structure; friable; few snail shell fragments; strong effervescence; moderately alkaline; clear smooth boundary.

A3—27 to 31 inches; black (5Y 2/1) silty clay loam, very dark gray (5Y 3/1) dry; weak fine and very fine subangular blocky structure; friable; few snail shell fragments; strong effervescence; moderately alkaline; clear smooth boundary.

ACg—31 to 40 inches; very dark gray (5Y 3/1) silty clay loam, dark gray (5Y 4/1) dry; few fine distinct olive (5Y 5/6) and olive gray (5Y 5/2) mottles; weak fine and very fine subangular blocky structure; friable; few snail shell fragments; strong effervescence; moderately alkaline; abrupt smooth boundary.

Cg—40 to 60 inches; gray (5Y 6/1) and light gray (5Y 7/1) loam; few fine distinct olive (5Y 5/6) mottles; massive; firm; many small white (10YR 8/1) lime threads; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 30 to 60 inches. The thickness of the mollic epipedon ranges from 24 to 60 inches.

The A horizon either has hue of 5Y, value of 2 or 3, and chroma of 1 or is neutral in hue and has value of 2 or 3 and chroma of 0. It is mucky silt loam, silty clay loam, or mucky silty clay loam in the upper 10 to 18 inches. The lower part of the A horizon and the B horizon, if one occurs, are silty clay loam or silty clay. The C horizon has value of 4 to 7 and chroma of 1 or 2. It is dominantly loam, but the range includes silt loam and silty clay loam.

Kossuth Series

The Kossuth series consists of poorly drained soils on uplands. These soils formed in lacustrine sediments over glacial till. The native vegetation was prairie grasses. Permeability is moderately slow in the solum and moderate in the substratum. Slope ranges from 0 to 2 percent.

Kossuth soils are similar to Webster soils and commonly are adjacent to Clarion and Nicollet soils. Webster soils have a lower content of clay than the Kossuth soils. Clarion soils are well drained and are on the steeper ridges. Nicollet soils are somewhat poorly drained and are on small knolls.

Typical pedon of Kossuth silty clay loam, 0 to 2 percent slopes, 1,100 feet south and 450 feet west of the northeast corner of sec. 5, T. 90 N., R. 32 W.

Ap—0 to 9 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

A—9 to 17 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine prismatic structure parting to weak fine subangular blocky; friable; neutral; clear smooth boundary.

AB—17 to 21 inches; very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; some dark gray (10YR 4/1) coatings on faces of peds; weak fine prismatic structure parting to weak fine subangular blocky; friable; neutral; clear smooth boundary.

Bg—21 to 27 inches; dark gray (5Y 4/1) silty clay loam; some dark olive gray (5Y 3/2) coatings on faces of peds; weak fine prismatic structure parting to weak fine subangular blocky; firm; neutral; abrupt smooth boundary.

BCg—27 to 30 inches; gray (5Y 5/1) silty clay loam; few fine faint dark gray (5Y 4/1) and common medium faint light gray (5Y 6/1) mottles; weak fine subangular blocky structure; friable; slight effervescence; mildly alkaline; clear smooth boundary.

Cg1—30 to 44 inches; gray (5Y 5/1) silty clay loam; common medium distinct light gray (5Y 6/1) and dark gray (5Y 4/1) mottles; massive; friable; strong effervescence; moderately alkaline; clear smooth boundary.

2Cg2—44 to 60 inches; gray (5Y 5/1) loam; few fine distinct yellowish brown (10YR 5/6) and few fine faint brownish yellow (10YR 6/8) mottles; massive; friable; few small white (5Y 8/1) accumulations of lime; few dark accumulations (iron oxide); strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 26 to 48 inches. The thickness of the mollic epipedon ranges from 14 to 24 inches. Reaction is slightly acid or neutral in the A horizon and the upper part of the B horizon and neutral or mildly alkaline in the lower part of the B horizon.

Linder Series

The Linder series consists of somewhat poorly drained soils on stream terraces and in outwash areas. These soils formed in alluvium and glacial outwash. The native vegetation was prairie grasses. Permeability is moderately rapid in the solum and very rapid in the substratum. Slope ranges from 0 to 2 percent.

Linder soils are similar to Watseka soils and commonly are adjacent to Cylinder, Estherville, and Hanska soils. Watseka soils contain more sand than the Linder soils. Cylinder soils contain more clay and less sand in the upper part than the Linder soils. Their positions on the landscape are similar to those of the Linder soils. Estherville soils are somewhat excessively drained and are on the higher terraces. Hanska soils are poorly drained and are on the lower parts of the landscape.

Typical pedon of Linder loam, 0 to 2 percent slopes, 440 feet west and 1,400 feet south of the northeast corner of sec. 36, T. 93 N., R. 31 W.

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

A—8 to 11 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak medium subangular blocky structure parting to weak fine granular; friable; neutral; clear smooth boundary.

AB—11 to 17 inches; very dark gray (10YR 3/1) sandy loam, dark gray (10YR 4/1) dry; weak medium prismatic structure; very friable; some olive brown (2.5Y 4/4) material in root channels; neutral; abrupt smooth boundary.

Bw—17 to 24 inches; dark grayish brown (2.5Y 4/2) sandy loam; few fine faint olive brown (2.5Y 4/4) mottles; weak medium subangular blocky structure; very friable; neutral; clear wavy boundary.

C1—24 to 33 inches; light olive brown (2.5Y 5/4) and olive brown (2.5Y 4/4) sand; few fine distinct grayish brown (2.5Y 5/2) mottles; single grain; loose; few dark accumulations (iron oxide); neutral; clear wavy boundary.

C2—33 to 37 inches; yellowish brown (10YR 5/4 and 5/6) sand; single grain; loose; few dark accumulations (iron oxide); strong effervescence; moderately alkaline; abrupt smooth boundary.

2C3—37 to 60 inches; yellowish brown (10YR 5/6) sand and gravel; single grain; loose; strata of gravel in the upper part and a 2-inch band of grayish brown (2.5Y 5/2) sand below the gravel; few accumulations of lime; strong effervescence; moderately alkaline.

The solum ranges from 20 to 42 inches in thickness. It is slightly acid to mildly alkaline. The depth to loamy sand, sand, or sand and gravel ranges from 24 to 36 inches. The thickness of the mollic epipedon ranges from 10 to 20 inches.

The Ap or A horizon is black (10YR 2/1 or N 2/0) or very dark brown (10YR 2/2). The AB horizon is very dark gray (10YR 3/1), very dark grayish brown (10YR 3/2), or very dark brown (10YR 2/2) loam or sandy loam. The Bw horizon has hue of 2.5Y, value of 4 or 5, and chroma of 2 or 3. It is dominantly sandy loam but in some pedons is loamy sand in the lower few inches. The C and 2C horizons have hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 2 to 6.

Nicollet Series

The Nicollet series consists of somewhat poorly drained, moderately permeable soils on uplands. These soils formed in loamy glacial till. The native vegetation was prairie grasses. Slope ranges from 1 to 3 percent.

Nicollet soils are similar to Crippin, Cylinder, and Kingston soils and commonly are adjacent to Clarion and Webster soils. Crippin soils are calcareous throughout. Cylinder soils have a substratum of sand and gravel. Kingston soils contain more clay and silt and less sand than the Nicollet soils. Clarion soils are well drained and are on the more sloping parts of the landscape. Webster soils are poorly drained and nearly level and are in the lower areas or in waterways.

Typical pedon of Nicollet clay loam, 1 to 3 percent slopes, 900 feet east and 150 feet north of the southwest corner of sec. 25, T. 90 N., R. 32 W.

Ap—0 to 9 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak medium subangular blocky structure parting to weak fine granular; friable; neutral; abrupt smooth boundary.

A—9 to 18 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; moderate fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

AB—18 to 22 inches; very dark gray (10YR 3/1) clay loam, dark gray (10YR 4/1) dry; few black (10YR 2/1) coatings on faces of peds; moderate medium subangular blocky structure; friable; neutral; clear smooth boundary.

Bw1—22 to 26 inches; dark grayish brown (2.5Y 4/2) clay loam; few very dark gray (10YR 3/1) organic coatings on faces of peds; very weak medium prismatic structure parting to weak medium subangular blocky; friable; neutral; clear smooth boundary.

Bw2—26 to 31 inches; dark grayish brown (2.5Y 4/2) clay loam; few fine faint yellowish brown (10YR 5/4) mottles; very weak medium prismatic structure parting to weak medium subangular blocky; friable; very few fine dark accumulations (iron oxide); neutral; abrupt smooth boundary.

C1—31 to 44 inches; grayish brown (2.5Y 5/2) loam; many fine faint light olive brown (2.5Y 5/4) mottles; massive; friable; few small white (5Y 8/1) accumulations of lime; strong effervescence; moderately alkaline; clear smooth boundary.

C2—44 to 60 inches; grayish brown (2.5Y 5/2) and light yellowish brown (2.5Y 6/4) loam; few fine prominent yellowish red (5YR 4/8) mottles; massive; friable; few small white (5Y 8/1) accumulations of lime; few dark accumulations (iron oxide); strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 20 to 48 inches. The thickness of the mollic epipedon ranges from 10 to 22 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is loam or clay loam. It is slightly acid or neutral. The Bw horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 2 or 3 in the upper part and hue of 2.5Y, value of 4 or 5, and chroma of 2 to 4 in the lower part. It is loam or clay loam. It is slightly acid or neutral in the upper part and slightly acid to mildly alkaline in the lower part. The C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 2 to 4. It is loam or clay loam. It is mildly alkaline or moderately alkaline.

Okoboji Series

The Okoboji series consists of very poorly drained, moderately slowly permeable soils in upland depressions. These soils formed in silty local alluvium and in the underlying glacial till. The native vegetation was prairie grasses. Slope is 0 to 1 percent.

Okoboji soils are similar to Knoke soils and commonly are adjacent to Canisteo and Harps soils. Knoke soils are calcareous. Canisteo and Harps soils also are calcareous. They are on the rims of the depressions.

Typical pedon of Okoboji silty clay loam, 0 to 1 percent slopes, 1,020 feet north and 100 feet east of the southwest corner of sec. 19, T. 93 N., R. 31 W.

Ap—0 to 8 inches; black (N 2/0) silty clay loam, black (5Y 2/1) dry; weak fine subangular blocky structure parting to weak fine granular; friable; neutral; abrupt smooth boundary.

A1—8 to 17 inches; black (N 2/0) silty clay loam, black (5Y 2/1) dry; weak fine and very fine subangular blocky structure; friable; neutral; clear smooth boundary.

A2—17 to 29 inches; black (N 2/0) silty clay loam, very dark gray (5Y 3/1) dry; few fine distinct olive gray (5Y 4/2) mottles; weak fine and very fine subangular blocky structure; friable; neutral; clear smooth boundary.

A3—29 to 36 inches; very dark gray (N 3/0) silty clay loam, dark gray (N 4/0) dry; few fine distinct olive gray (5Y 4/2) mottles; weak medium prismatic structure parting to weak fine subangular blocky; friable; neutral; abrupt smooth boundary.

Bg—36 to 47 inches; dark gray (5Y 4/1) silty clay loam; common medium distinct olive (5Y 5/3) mottles; weak medium prismatic structure parting to weak fine subangular blocky; friable; few dark krotovinas; mildly alkaline; clear smooth boundary.

Cg1—47 to 56 inches; gray (5Y 5/1) silty clay loam; common medium distinct yellowish brown (10YR 5/8) mottles; massive; firm; few white (5Y 8/1) accumulations of lime; few dark krotovinas; strong effervescence; moderately alkaline; clear smooth boundary.

Cg2—56 to 60 inches; gray (5Y 5/1) silty clay loam; few fine distinct olive yellow (5Y 6/6) and yellowish brown (10YR 5/8) mottles; massive; firm; few dark krotovinas; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 40 to 60 inches. The depth to free carbonates ranges from 20 to 50 inches. The thickness of the mollic epipedon ranges from 24 to 36 inches.

The A horizon is silty clay loam, silt loam, mucky silty clay loam, or mucky silt loam in the upper 10 to 18 inches. The lower part of the A horizon and the Bg horizon are silty clay loam or silty clay. The Cg horizon generally is silty clay loam but is silt loam or loam in some pedons. The mottles in the Bg and Cg horizons have value of 4 to 6 and chroma of 2 to 8.

Okoboji mucky silt loam, 0 to 1 percent slopes, is a taxadjunct to the Okoboji series because it is somewhat more acid in the upper 18 to 24 inches than is definitive for the series.

Rolfe Series

The Rolfe series consists of very poorly drained, slowly permeable soils in upland depressions. These soils formed in glacial sediments and local alluvium. The native vegetation was prairie grasses, marsh grasses, and sedges. Slope is 0 to 1 percent.

Rolfe soils commonly are adjacent to Nicollet and Webster soils. The adjacent soils are higher on the landscape than the Rolfe soils. They do not have an E horizon or a distinct argillic horizon. Nicollet soils are somewhat poorly drained, and Webster soils are poorly drained.

Typical pedon of Rolfe silt loam, 0 to 1 percent slopes, 240 feet west and 1,300 feet south of the northeast corner of sec. 22, T. 93 N., R. 31 W.

Ap—0 to 9 inches; black (10YR 2/1) silt loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure; friable; medium acid; abrupt smooth boundary.

E1—9 to 15 inches; dark gray (10YR 4/1) and gray (10YR 5/1) silt loam, gray (10YR 6/1) dry; moderate medium platy structure; friable; medium acid; abrupt smooth boundary.

E2—15 to 19 inches; dark gray (10YR 4/1) silt loam, gray (10YR 6/1) dry; moderate medium and fine subangular blocky structure; friable; medium acid; abrupt smooth boundary.

Btg1—19 to 28 inches; very dark gray (5Y 3/1) silty clay; many thick black (5Y 2/2) organic coatings on faces of peds; few medium distinct grayish brown (10YR 5/2) mottles; moderate medium prismatic structure parting to moderate fine and medium angular and subangular blocky; firm; few thin continuous clay films on faces of peds; slightly acid; clear smooth boundary.

Btg2—28 to 36 inches; dark olive gray (5Y 3/2) silty clay; common medium distinct gray (5Y 5/1) mottles; moderate medium prismatic structure parting to moderate medium angular and subangular blocky; firm; few thin continuous clay films on faces of peds; slightly acid; clear smooth boundary.

Btg3—36 to 42 inches; dark gray (5Y 4/1) silty clay; common fine distinct brown (7.5YR 5/4) and strong brown (7.5YR 5/6) mottles; moderate medium prismatic structure parting to moderate fine and medium angular and subangular blocky; firm; few thin continuous clay films on faces of peds; neutral; clear smooth boundary.

BCg—42 to 51 inches; olive gray (5Y 4/2) silty clay; common medium prominent strong brown (7.5YR 5/6 and 5/8) mottles; massive; firm; common medium distinct strong brown (7.5YR 5/6) iron stains; mildly alkaline; abrupt smooth boundary.

Cg—51 to 60 inches; gray (5Y 5/1) and olive gray (5Y 5/2) clay loam; common medium prominent reddish yellow (7.5YR 6/6 and 6/8) mottles; massive; firm; common medium distinct strong brown (7.5YR 5/6) iron stains; strong effervescence; moderately alkaline.

The depth to free carbonates ranges from 42 to 60 inches. The Ap horizon has value of 2 or 3 and chroma of 1. It is silt loam, loam, or silty clay loam. The E horizon generally has value of 4 to 6, but in some pedons it has value of 3 and has lighter colored coatings. It is silt loam or loam. The Btg horizon has hue of 10YR or 5Y, value of 3 to 6, and chroma of 1 or 2. It is silty clay or clay loam. It is slightly acid or neutral. The C horizon is loam or clay loam.

Salida Series

The Salida series consists of excessively drained, very rapidly permeable, calcareous soils in glacial outwash areas. These soils formed in sandy and gravelly glacial outwash sediments. The native vegetation was prairie grasses. Slope ranges from 5 to 10 percent.

Salida soils commonly are adjacent to Estherville and Wadena soils. The adjacent soils generally are on the less sloping parts of the landscape. Estherville soils are somewhat excessively drained. They have a lower content of coarse fragments than the Salida soils and are not calcareous in the surface layer. Wadena soils are well drained. They are loamy to a depth of 24 to 40 inches.

Typical pedon of Salida gravelly sandy loam, in an area of Estherville-Salida complex, 5 to 10 percent slopes, 1,600 feet north and 780 feet east of the southwest corner of sec. 13, T. 92 N., R. 31 W.

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) gravelly sandy loam, brown (10YR 4/3) dry; weak fine and very fine subangular blocky structure; very friable; strong effervescence; moderately alkaline; abrupt smooth boundary.

C—9 to 60 inches; variegated yellowish brown (10YR 5/4 and 5/6) very gravelly coarse sand; estimated 50 percent fine and medium gravel; single grain; loose; strong effervescence; moderately alkaline.

The solum ranges from 7 to 20 inches in thickness. It has free carbonates throughout. The thickness of the mollic epipedon ranges from 7 to 14 inches. In the 10- to 40-inch control section, the content of coarse fragments of mixed lithology ranges from 35 to 85 percent.

The A horizon has value of 2 or 3 and chroma of 1 to 3. It is gravelly sandy loam, sand, loamy sand, or sandy loam. The B horizon, if one occurs, is sand or loamy sand. The C horizon has value of 3 to 6 and chroma of 2 to 6. It is very gravelly coarse sand or very gravelly sand.

Sparta Series

The Sparta series consists of excessively drained, rapidly permeable soils on stream terraces. These soils formed in sandy material that was reworked by the wind. The native vegetation was prairie grasses. Slope ranges from 2 to 5 percent.

Sparta soils commonly are adjacent to Hanska and Watseka soils. The poorly drained Hanska and somewhat poorly drained Watseka soils are on the lower parts of the landscape.

Typical pedon of Sparta loamy fine sand, 2 to 5 percent slopes, 2,121 feet west and 620 feet north of the southeast corner of sec. 25, T. 93 N., R. 31 W.

Ap—0 to 10 inches; very dark brown (10YR 2/2) loamy fine sand, dark grayish brown (10YR 4/2) dry; weak medium and fine subangular blocky structure; very friable; neutral; abrupt smooth boundary.

AB—10 to 13 inches; very dark grayish brown (10YR 3/2) loamy fine sand, brown (10YR 4/3) dry; weak medium subangular blocky structure; very friable; neutral; abrupt smooth boundary.

Bw—13 to 31 inches; dark yellowish brown (10YR 4/4) loamy fine sand; weak medium subangular blocky structure; very friable; medium acid; abrupt smooth boundary.

C1—31 to 42 inches; yellowish brown (10YR 5/6) sand; single grain; loose; medium acid; clear smooth boundary.

C2—42 to 60 inches; dark yellowish brown (10YR 4/4) sand; single grain; loose; medium acid.

The thickness of the solum ranges from 24 to 40 inches. The thickness of the mollic epipedon ranges from 10 to 18 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is loamy sand, loamy fine sand, fine sand, or sand. It is medium acid to neutral. The Bw horizon has a range in texture similar to that of the A horizon. It is strongly acid or medium acid. It has value and chroma of 3 to 6. The C horizon is sand or fine sand. It has value of 4 to 6 and chroma of 3 to 6.

Spillville Series

The Spillville series consists of moderately well drained or somewhat poorly drained, moderately permeable soils on bottom land, foot slopes, and alluvial fans. These soils formed in loamy alluvium. The native vegetation was prairie grasses. Slope ranges from 0 to 5 percent.

Spillville soils are similar to Terril soils and commonly are adjacent to Coland and Terril soils. The A horizon of Terril soils is thinner than that of the Spillville soils. Coland soils are poorly drained and are lower on the landscape than the Spillville soils.

Typical pedon of Spillville loam, 0 to 2 percent slopes, 825 feet north and 1,300 feet west of the southeast corner of sec. 1, T. 92 N., R. 31 W.

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

A1—8 to 30 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure; friable; slightly acid; gradual smooth boundary.

A2—30 to 49 inches; very dark brown (10YR 2/2) loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure; friable; neutral; gradual smooth boundary.

C—49 to 60 inches; very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2) stratified loam and sandy loam; few fine faint very dark gray (10YR 3/1) mottles; massive; friable; few dark accumulations (iron oxide); neutral.

The thickness of the solum ranges from 30 to 56 inches. The depth to free carbonates typically is 48 inches or more. The thickness of the mollic epipedon ranges from 36 to more than 60 inches. The A horizon has value of 2 or 3 and chroma of 1 or 2. It is loam or silt loam.

Storden Series

The Storden series consists of well drained, moderately permeable, calcareous soils on uplands. These soils formed in calcareous, loamy glacial till. The native vegetation was prairie grasses. Slope ranges from 5 to 40 percent.

Storden soils commonly are adjacent to Clarion and Terril soils. Clarion soils have a black, noncalcareous surface layer. They generally are on the less sloping parts of the landscape. Terril soils are noncalcareous to a depth of 40 inches or more. They are lower on the landscape than the Storden soils.

Typical pedon of Storden loam, 9 to 14 percent slopes, moderately eroded, 2,175 feet north and 155 feet east of the southwest corner of sec. 18, T. 93 N., R. 31 W.

Ap—0 to 8 inches; dark grayish brown (10YR 4/2) loam; some streaks and pockets of yellowish brown (10YR 5/6) substratum material; weak fine granular structure; friable; strong effervescence; moderately alkaline; abrupt smooth boundary.

C1—8 to 20 inches; yellowish brown (10YR 5/6) loam; weak very fine subangular blocky structure; friable; strong effervescence; moderately alkaline; clear smooth boundary.

C2—20 to 32 inches; light yellowish brown (10YR 6/4) loam; few fine faint brownish yellow (10YR 6/6) mottles; massive; friable; strong effervescence; moderately alkaline; clear smooth boundary.

C3—32 to 60 inches; brownish yellow (10YR 6/6) loam; few fine distinct strong brown (7.5YR 5/8) mottles; massive; friable; few dark accumulations (iron oxide); few soft white (10YR 8/1) accumulations of calcium carbonate; strong effervescence; moderately alkaline.

The A horizon is 6 to 10 inches thick. It has value of 4 or 5 and chroma of 2 or 3. It is mildly alkaline or moderately alkaline loam or silt loam. The C horizon has value of 5 or 6 and chroma of 2 to 6. It is loam or silt loam.

Talcot Series

The Talcot series consists of poorly drained soils in outwash areas. These soils formed in loamy alluvial and glacial outwash material over sand and gravel. The native vegetation was prairie grasses. Permeability is moderate in the solum and rapid in the substratum. Slope ranges from 0 to 2 percent.

Talcot soils are similar to Biscay soils and commonly are adjacent to Biscay and Cylinder soils. Biscay soils are noncalcareous in the upper part of the solum. Cylinder soils are somewhat poorly drained and are slightly higher on the landscape than the Talcot soils.

Typical pedon of Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, 1,600 feet east and 105 feet south of the northwest corner of sec. 12, T. 91 N., R. 31 W.

Ap—0 to 9 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; strong effervescence; moderately alkaline; abrupt smooth boundary.

A1—9 to 14 inches; black (5Y 2/1) clay loam, very dark gray (5Y 3/1) dry; weak fine subangular blocky structure; friable; strong effervescence; moderately alkaline; clear smooth boundary.

A2—14 to 18 inches; very dark gray (5Y 3/1) clay loam, dark gray (5Y 4/1) dry; weak fine subangular blocky structure; friable; strong effervescence; moderately alkaline; clear smooth boundary.

Bg1—18 to 24 inches; dark gray (5Y 4/1) clay loam; few fine distinct olive (5Y 5/3) mottles; weak fine subangular blocky structure; friable; few very dark gray (5Y 3/1) tongues; few small white (5Y 8/1) accumulations of lime; strong effervescence; moderately alkaline; clear smooth boundary.

Bg2—24 to 30 inches; olive gray (5Y 5/2) clay loam; few very dark gray (5Y 3/1) coatings on faces of peds; few fine distinct olive (5Y 5/4) mottles; weak fine subangular blocky structure; friable; few small white (5Y 8/1) accumulations of lime; strong effervescence; moderately alkaline; clear smooth boundary.

BCg—30 to 34 inches; olive gray (5Y 5/2) loam; few fine distinct olive yellow (2.5Y 6/6) and common medium prominent pale olive (5Y 6/3) mottles; weak fine subangular blocky structure; friable; strong effervescence; moderately alkaline; clear smooth boundary.

2Cg—34 to 60 inches; olive (5Y 5/4) coarse sand and sand; few fine faint light olive brown (2.5Y 5/4) and few medium prominent dark yellowish brown (10YR 4/6) mottles; single grain; loose; strong effervescence; moderately alkaline.

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

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

Terril Series

The Terril series consists of moderately well drained, moderately permeable soils on upland foot slopes and convex alluvial fans. These soils formed in loamy local alluvium derived from glacial till. The native vegetation was prairie grasses. Slope ranges from 2 to 5 percent.

Terril soils are similar to Spillville soils and commonly are adjacent to Spillville and Storden soils. The A horizon of Spillville soils is thicker than that of the Terril soils. Storden soils are well drained and are higher on the landscape than the Terril soils. They are calcareous throughout.

Typical pedon of Terril loam, 2 to 5 percent slopes, 1,665 feet north and 110 feet west of the southeast corner of sec. 14, T. 91 N., R. 31 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure parting to weak fine granular; friable; few sand grains on faces of some peds; neutral; abrupt smooth boundary.

A1—8 to 20 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine and very fine subangular blocky structure; friable; neutral; gradual smooth boundary.

A2—20 to 32 inches; black (10YR 2/1) loam, very dark grayish brown (10YR 3/2) dry; weak fine and medium subangular blocky structure; friable; neutral; gradual smooth boundary.

BA—32 to 38 inches; dark brown (10YR 3/3) loam; common black (10YR 2/1) coatings on faces of peds; weak fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

Bw—38 to 50 inches; brown (10YR 4/3) loam; weak fine and medium subangular blocky structure; friable; slightly acid; gradual smooth boundary.

BC—50 to 60 inches; brown (10YR 4/3) and dark yellowish brown (10YR 4/4) loam; weak medium subangular blocky structure; friable; neutral.

The thickness of the solum ranges from 36 to 72 inches. The depth to free carbonates is more than 50 inches. The thickness of the mollic epipedon ranges from 24 to 38 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is loam, silt loam, or clay loam. The Bw horizon has chroma of 3 or 4. It is loam or clay loam. It is neutral or slightly acid.

Truman Series

The Truman series consists of well drained, moderately permeable soils on stream terraces. These soils formed in silty glacial sediments. The native vegetation was prairie grasses. Slope ranges from 2 to 6 percent.

Truman soils are similar to Clarion soils and commonly are adjacent to Clarion and Kingston soils. Clarion soils contain more sand than the Truman soils. Kingston soils are somewhat poorly drained and are lower on the landscape than the Truman soils.

Typical pedon of Truman silt loam, 2 to 6 percent slopes, 489 feet east and 175 feet north of southwest corner of sec. 36, T. 93 N., R. 31 W.

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

A—10 to 15 inches; very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) silt loam, grayish brown (10YR 5/2) and brown (10YR 5/3) dry; weak fine subangular blocky structure; friable; neutral; clear smooth boundary.

BA—15 to 22 inches; dark yellowish brown (10YR 3/4) silt loam; dark brown (10YR 3/3) coatings on faces of peds; weak fine subangular blocky structure; friable; neutral; clear smooth boundary.

Bw—22 to 32 inches; dark yellowish brown (10YR 4/4) silt loam; weak fine subangular blocky structure; friable; neutral; abrupt smooth boundary.

C1—32 to 38 inches; yellowish brown (10YR 5/4) silt loam; massive; very friable; mildly alkaline; clear smooth boundary.

C2—38 to 46 inches; brownish yellow (10YR 6/6) silt loam; few fine faint gray (10YR 6/1) mottles; massive; very friable; strong effervescence; moderately alkaline; abrupt smooth boundary.

C3—46 to 49 inches; brownish yellow (10YR 6/6) and light yellowish brown (10YR 6/4) silt loam; few fine faint light gray (10YR 7/1) mottles; massive; very friable; strong effervescence; moderately alkaline; abrupt smooth boundary.

C4—49 to 60 inches; light yellowish brown (10YR 6/4) silt loam; few fine faint light gray (10YR 7/1) mottles; massive; very friable; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 18 to 56 inches. The thickness of the mollic epipedon ranges from 10 to 18 inches.

The A horizon has value of 2 or 3 and chroma of 1 to 3. It is slightly acid or neutral. The Bw horizon has value of 3 to 5 and chroma of 3 to 6. It is silt loam or silty clay loam. It is slightly acid to moderately alkaline. The C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 4 to 6. It is mottled in some pedons. It is mildly alkaline or moderately alkaline.

Wacousta Series

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

Wacousta soils are similar to Calcousta and Webster soils and commonly are adjacent to Canisteo and Harps soils. Calcousta, Canisteo, and Harps soils are calcareous. Canisteo and Harps soils are slightly higher on the landscape than the Wacousta soils. Webster soils contain more sand than the Wacousta soils.

Typical pedon of Wacousta silty clay loam, 0 to 1 percent slopes, 2,490 feet south and 150 feet west of the northeast corner of sec. 29, T. 92 N., R. 31 W.

Ap—0 to 9 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak fine and very fine subangular blocky structure; friable; neutral; clear smooth boundary.

A—9 to 12 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; moderate fine and medium subangular blocky structure; friable; neutral; clear wavy boundary.

AC—12 to 15 inches; very dark gray (5Y 3/1) and gray (5Y 5/1) silty clay loam; few fine faint yellowish brown (10YR 5/6) mottles; moderate medium subangular blocky structure; friable; few soft accumulations of calcium carbonate; neutral; clear irregular boundary.

Cg1—15 to 24 inches; olive gray (5Y 5/2) silty clay loam; common fine distinct light olive brown (2.5Y 5/4) mottles; weak fine prismatic structure; friable; some dark olive gray (5Y 3/2) material in root channels; strong effervescence; moderately alkaline; clear wavy boundary.

Cg2—24 to 47 inches; olive gray (5Y 5/2) silt loam; many coarse prominent yellowish red (5YR 4/6) and common coarse prominent yellowish red (5YR 5/6) mottles; massive; friable; some dark olive gray (5Y 3/2) material in root channels; strong effervescence; moderately alkaline; gradual wavy boundary.

Cg3—47 to 60 inches; gray (5Y 5/1) silt loam; common medium distinct yellowish red (5YR 4/6) and strong brown (7.5YR 5/6) mottles; massive; friable; some dark olive gray (5Y 3/2) material in root channels; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 10 to 24 inches. The depth to free carbonates ranges from 12 to 20 inches. The thickness of the mollic epipedon ranges from 8 to 18 inches.

The A horizon either has hue of 2.5Y or 5Y, value of 2 to 5, and chroma of 1 or is neutral in hue and has value of 2 and chroma of 0. It is silty clay loam, silt loam, or mucky silt loam. It is neutral or slightly acid. The AC horizon has hue of 5Y, value of 2 to 6, and chroma of 1 or 2. The Cg horizon has hue of 5Y, value of 5 or 6, and chroma of 1 or 2. It is silt loam or silty clay loam.

Wadena Series

The Wadena series consists of well drained soils on stream terraces and uplands. These soils formed in loamy alluvial and glacial outwash material over calcareous, sandy and gravelly sediments. The native vegetation was prairie grasses. Permeability is moderately rapid in the solum and very rapid in the substratum. Slope ranges from 0 to 9 percent.

Wadena soils are similar to Estherville soils and commonly are adjacent to Cylinder and Estherville soils. Estherville soils are in positions on the landscape similar to those of the Wadena soils. They are somewhat excessively drained. They are coarser textured than the Wadena soils; their content of clay is less than 18 percent. Cylinder soils are somewhat poorly drained and are in the lower swales.

Typical pedon of Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes, 2,125 feet south and 105 feet west of the northeast corner of sec. 15, T. 90 N., R. 34 W.

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

A—8 to 14 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; many black (10YR 2/1) coatings on faces of peds; weak fine and very fine subangular blocky structure parting to weak fine granular; friable; slightly acid; clear smooth boundary.

Bw—14 to 23 inches; dark yellowish brown (10YR 3/4) loam; weak fine and very fine subangular blocky structure parting to weak fine granular; very friable; neutral; clear smooth boundary.

BC—23 to 26 inches; dark yellowish brown (10YR 3/4) sandy loam; weak fine and very fine subangular blocky structure; very friable; neutral; abrupt smooth boundary.

2C1—26 to 40 inches; dark yellowish brown (10YR 4/4) coarse sand; single grain; loose; about 30 percent gravel; neutral; clear wavy boundary.

2C2—40 to 47 inches; yellowish brown (10YR 5/4) sand; single grain; loose; strong effervescence; moderately alkaline; abrupt smooth boundary.

2C3—47 to 60 inches; brown (10YR 4/3) sand and gravel; some dark yellowish brown (10YR 4/6) masses; single grain; loose; strong effervescence; moderately alkaline.

The thickness of the solum, or the depth to sand and gravel, ranges from 24 to 40 inches. The depth to free carbonates ranges from 30 to 50 inches. The thickness of the mollic epipedon ranges from 7 to 20 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is slightly acid or neutral loam or clay loam. The Bw horizon has value of 3 to 5 and chroma of 3 or 4. The reaction and texture of this horizon are similar to those of the A horizon, but the range includes coarser textures. The 2C horizon has value of 4 to 6 and chroma of 2 to 4. It is neutral in the upper part and mildly alkaline or moderately alkaline in the lower part. It is sand or coarse sand and gravel.

Wadena loam, 24 to 32 inches to sand and gravel, 5 to 9 percent slopes, moderately eroded, is a taxadjunct to the Wadena series because it does not have a mollic epipedon, which is definitive for the series. The A horizon of this soil is 7 to 9 inches thick.

Watseka Series

The Watseka series consists of somewhat poorly drained, rapidly permeable soils on stream terraces. These soils formed in sandy and gravelly alluvium. The native vegetation was prairie grasses. Slope ranges from 0 to 2 percent.

Watseka soils are similar to Linder soils and commonly are adjacent to Estherville, Hanska, and Linder soils. Linder soils are finer textured than the Watseka soils. Estherville soils are somewhat excessively drained and are on the higher, more sloping parts of the landscape. They have a gravelly C horizon. Hanska soils are poorly drained and are in the lower areas.

Typical pedon of Watseka loamy sand, 0 to 2 percent slopes, 900 feet west and 400 feet south of the northeast corner of sec. 36, T. 93 N., R. 31 W.

Ap—0 to 10 inches; black (10YR 2/1) loamy sand, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; very friable; neutral; abrupt smooth boundary.

A—10 to 15 inches; very dark gray (10YR 3/1) loamy sand, dark grayish brown (10YR 4/2) dry; weak fine and very fine subangular blocky structure parting to weak fine granular; very friable; neutral; clear smooth boundary.

Bw—15 to 21 inches; dark grayish brown (2.5Y 4/2) loamy sand; common medium distinct dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/6) mottles; weak fine and very fine subangular blocky structure parting to weak fine granular; very friable; neutral; abrupt smooth boundary.

BC—21 to 37 inches; dark grayish brown (2.5Y 4/2) sand; common medium distinct dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) and few fine faint olive gray (5Y 5/2) mottles; single grain; loose; few reddish iron stains; few dark accumulations (iron oxide); neutral; clear wavy boundary.

C1—37 to 44 inches; dark grayish brown (2.5Y 4/2) and olive brown (2.5Y 4/4) sand; common medium distinct yellowish brown (10YR 5/4) and dark gray (10YR 4/1) mottles; single grain; loose; common black and reddish accumulations (iron oxide); many strong brown (7.5YR 4/6) iron stains; about 10 percent gravel; neutral; clear wavy boundary.

C2—44 to 60 inches; grayish brown (10YR 5/2) and dark gray (10YR 4/1) sand; single grain; loose; common dark accumulations (iron oxide); about 10 percent gravel; neutral.

The thickness of the solum ranges from 24 to 38 inches. The thickness of the mollic epipedon ranges from 10 to 20 inches.

The A horizon has value of 2 or 3 and chroma of 1 or 2. It is loamy sand, loamy fine sand, or sand. In some pedons it has a small amount of very coarse sand and small particles of gravel. The Bw horizon has hue of 2.5Y or 10YR, value of 4 to 6, and chroma of 2. It typically is loamy sand but is fine sand or sand in some pedons. In the BC horizon, the content of coarse sand and fine gravel is 10 to 15 percent. The C horizon has hue of 2.5Y or 10YR, value of 4 or 5, and chroma of 1 to 4. It is neutral to medium acid. It is fine sand or sand in which the content of gravel is as much as 10 percent.

Webster Series

The Webster series consists of poorly drained, moderately permeable soils on uplands. These soils formed in local alluvium and in the underlying glacial till. The native vegetation was prairie grasses. Slope ranges from 0 to 2 percent.

Webster soils are similar to Canisteo, Faxon, Kossuth, and Wacousta soils and commonly are adjacent to Canisteo, Clarion, and Nicollet soils. Canisteo soils are calcareous throughout. Faxon soils are underlain by limestone bedrock. Kossuth soils have a higher content of clay than the Webster soils. Wacousta soils have a lower content of sand than the Webster soils. Clarion soils are well drained and are on the steeper parts of the landscape. Nicollet soils are somewhat poorly drained and are on small knolls and on ridges.

Typical pedon of Webster clay loam, 0 to 2 percent slopes, 1,110 feet north and 160 feet east of the southwest corner of sec. 23, T. 90 N., R. 32 W.

Ap—0 to 9 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure; friable; slightly acid; abrupt smooth boundary.

A—9 to 15 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure; friable; neutral; clear smooth boundary.

AB—15 to 20 inches; very dark gray (5Y 3/1) clay loam, dark gray (5Y 4/1) dry; many black (5Y 2/1) coatings on faces of peds; weak fine subangular blocky structure; friable; neutral; clear smooth boundary.

Bg1—20 to 28 inches; olive gray (5Y 5/2) clay loam; few fine faint yellowish brown (10YR 5/8) mottles; weak medium subangular blocky structure; friable; many dark gray (5Y 4/1) fillings in root channels; neutral; clear smooth boundary.

Bg2—28 to 36 inches; olive gray (5Y 5/2) clay loam; few fine faint light olive brown (2.5Y 5/6) mottles; weak medium subangular blocky structure; friable; few white (5Y 8/1) accumulations of lime; mildly alkaline; clear smooth boundary.

Cg1—36 to 45 inches; olive gray (5Y 5/2) clay loam; common medium distinct strong brown (7.5YR 5/8) mottles; massive; friable; many white (5Y 8/1) accumulations of lime; strong effervescence; moderately alkaline; clear smooth boundary.

Cg2—45 to 60 inches; olive gray (5Y 5/2) clay loam; common medium distinct yellowish brown (10YR 5/8) mottles; massive; friable; few small white (5Y 8/1) accumulations of lime; strong effervescence; moderately alkaline.

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

The A and Bg horizons are clay loam or silty clay loam. The Bg horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. It is neutral or mildly alkaline. The C horizon is clay loam or loam.

Formation of the Soils

The paragraphs that follow relate the major factors of soil formation to the soils in Pocahontas County. They also describe the processes of horizon differentiation.

Factors of Soil Formation

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

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

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

Parent Material

The accumulation of parent material is the first step in the formation of a soil. The parent material in Pocahontas County generally was transported from the site of the parent rock and deposited at a new location through the action of glacial ice, water, wind, or gravity. The soils formed mainly in glacial till, other kinds of glacial drift, glacial outwash, alluvium, and lacustrine sediments. The bedrock underlying these materials has been buried so far beneath the surface that it has had no influence on the soils.

Pocahontas County has been affected by three major glaciations: the Nebraskan, the Kansan, and the Wisconsin. The Kansan and Nebraskan till has been buried and cannot be observed. The county lies within the area covered by the Des Moines Lobe of the Late Wisconsin Glaciation. Radiocarbon dates indicate that Cary till was deposited about 13,000 years ago (*8, 9, 13*). Evidence of the relative youth of this material is the lack of deep weathering, unleached calcareous till close to the surface, a very poorly expressed surface drainage pattern, and many closed depressions.

Clarion, Nicollet, and Storden are the major soils that formed in glacial till. Estherville and Salida soils formed in morainal areas where sandy and gravelly knobs are surrounded by glacial till. Canisteo and Webster soils formed in glacial till and glacial sediments or reworked glacial till overlying glacial till (*18, 19*). Knoke, Okoboji, Rolfe, and Wacousta soils formed in reworked glacial till and local alluvium. Outwash material deposited by glacial melt water is an important geologic deposit in the county. Extensive deposits of sand and gravel are on the terraces along the Des Moines River and Cedar Creek. Similar deposits of lesser extent and depth are along other streams and near moraines in other parts of the county. Biscay, Cylinder, Estherville, Hanska, Linder, Talcot, and Wadena soils formed in this material.

The Cylinder and Wadena soils mainly are nearly level to moderately sloping and are on stream terraces and uplands. Estherville soils are in areas of outwash and on stream terraces. The three soils generally are adjacent to the Des Moines River. They are made up of loamy material, sand, and gravel deposited by water. Some areas have been reworked by the wind.

Soils that formed in alluvium are along the streams. The channeled Havelock soils formed in recent deposits. Coland soils formed in older alluvium. Spillville soils formed in relatively recent local alluvium that eroded from adjacent slopes. Faxon soils formed in 20 to 40 inches of loamy alluvium derived from glacial till. They are underlain by limestone bedrock.

Kossuth soils formed in water-laid lacustrine sediments. These deposits are underlain by medium textured and moderately fine textured glacial drift or glacial sediments.

Climate

The soils in Pocahontas County formed under a variety of climatic conditions (*18*). In the post-Cary glaciation period, 13,000 to 10,500 years ago, the climate was cool and the vegetation was dominantly conifers. During the period beginning about 10,500 years ago and ending about 8,000 years ago, a warming trend changed the vegetation from conifers to mixed hardwoods. Beginning about 8,000 years ago, the climate became warmer and drier and herbaceous prairie vegetation became dominant. Probably about 3,000 years ago, a change from a dry to a more moist climate began (*5*). The soils in the county formed under the influence of this subhumid, midcontinental climate.

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

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

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

Plant and Animal Life

Plant and animal life is an important factor in the formation of soils. Plants are especially significant because differences in the kind of vegetation commonly cause the most marked differences between soils (*5*). As plants grow and die, their remains are added to the soil. Burrowing animals, earthworms, bacteria, protozoa, and fungi help to convert these raw plant remains into organic matter. Many kinds of micro-organisms are needed to transform organic remains into stable humus from which plants can obtain nutrients. The humus results in dark surface soil.

Because grasses have many roots and tops that decay on or below the surface, soils that formed under prairie vegetation have a thick, dark surface layer. In contrast, soils that formed under forest vegetation have a thinner, lighter colored surface layer because the organic matter generally was derived only from leaves on the surface.

The main native vegetation was tall prairie grasses when the county was settled. For the last 5,000 years, the environment in Iowa favored prairie vegetation (*9*). From 5,000 to 16,000 years ago, however, a cooler, more moist climate favored forest vegetation. The effect of the earlier period of forest vegetation is not reflected in the morphology of Clarion, Nicollet, Webster, and other dark soils that formed under the more recent prairie grasses. Trees grow in areas adjacent to the streams and lakes, but they have not significantly altered the morphology of the soils. The native vegetation in potholes and other depressions was sedges, cattails, rushes, and similar plants.

Relief

Relief indirectly affects soil formation through its effect on drainage, runoff, and erosion. More water runs off the steeper slopes, and less soaks into the soil. The higher runoff rate results in less leaching of carbonates and less movement of clay from the surface horizon into the B horizon. The susceptibility to erosion increases as slope increases. Much of Pocahontas County is nearly level to gently rolling, but small areas are rolling to very steep.

Aspect also affects soil formation. South-facing slopes, for example, generally are warmer and drier than north-facing slopes. As a result, they support a different kind of vegetation.

The moderately sloping to very steep Storden, gently sloping to strongly sloping Clarion, and very gently sloping Nicollet soils, which formed in the same kind of parent material and under similar vegetation, differ because of differences in topographic position. The thickness and color of the A horizon and the thickness of the solum in these soils are affected by slope. The A horizon and the solum are thicker and the A horizon is darker in the less sloping soils.

The nearly level or depressional soils in the county commonly have a gray or mottled subsoil because of poor aeration and restricted drainage. Webster soils are an example. In some depressional areas, water is periodically impounded on the surface. As this water percolates through the soil, clay is removed from the surface layer and deposited in the subsoil. This movement of clay accelerates the formation of very poorly drained soils that have a distinct, light colored subsurface layer and a gray subsoil. Rolfe soils are an example.

The microrelief of the nearly level Coland and Spillville soils on bottom land affects runoff, depth to the water table, and the rate at which new sediments are deposited. Coland soils are in low positions on the landscape, generally some distance from the major stream channels. They are poorly drained and impound water for short periods. Spillville soils are higher on the landscape than Coland soils and are better drained and less clayey. The gently sloping Spillville soils on foot slopes have properties related to the upslope soils from which they receive sediments.

Time

The passage of time enables relief, climate, and plant and animal life to bring about changes in the parent material. If these factors are active for long periods, very similar kinds of soil can form in widely different kinds of parent material, but soil formation generally is interrupted by geologic events that expose new parent material. In Pocahontas County, new parent material has been added to the uplands at least four times (*13, 19*). The bedrock was twice covered by glacial till, and then loess was deposited. Another glacier subsequently deposited the present surface material.

Geologically, the soils of Pocahontas County are young (*7, 8, 9*). The radiocarbon technique for determining the age of carbonaceous material found in till has made it possible to determine the approximate age of the soils and Pleistocene deposits in Iowa. The Cary substage of the Late Wisconsin Glaciation has been determined to be 13,000 years old. All soils formed in Cary till are 13,000 years old or younger. Examples are Clarion, Nicollet, Storden, and Webster soils.

In much of Iowa, including Pocahontas County, erosion has leveled and, in places, removed material on side slopes and deposited new sediments downslope (*10*). The surface of nearly level upland summits is older than the side slopes that ascend to the summits. The side slopes are less than 13,000 years old. Some side slopes in the Wisconsin till areas in central Iowa are less than 3,000 years old (*18*). The sediment stripped from the side slopes accumulated as local alluvium. The surface layer of the soils on the summits is older than the surface layer of the soils on foot slopes and toe slopes (*7*). Clarion and Storden soils are on the summits and side slopes. In some areas Spillville soils formed in the local alluvium.

Cylinder, Wadena, and other soils that formed in glacial outwash on terraces are less than 13,000 years old. Spillville soils and, in some areas, the channeled Havelock soils formed in recently deposited alluvium. Coland soils formed in older alluvium. These older sediments are not more than 13,000 years old and are probably much younger.

Older soils generally have more distinct horizons than younger soils. The horizons of the soils in Pocahontas County range from clearly defined to poorly defined, depending in part on the intensity of the weathering factors and the resistance of the soil material to weathering. Rolfe soils were exposed to more intense soil formation than some of the other soils in the county. As a result, they have distinct horizons. The gently sloping Clarion soils have moderately distinct horizons. Webster soils have less distinct horizons because they are in areas where a fluctuating water table modifies the normal effect of time. Storden soils, which formed on steep side slopes, are calcareous throughout and show little evidence of horizon development. Clarion, Storden, and other soils on side slopes are subject to geologic erosion, which exposes fresh soil material. As a result, these soils range in age from the time that their parent material was deposited to recent. Soils that formed in alluvial deposits adjacent to the major streams show little or no evidence of profile development.

Human Activities

Important changes have taken place in the soils of Pocahontas County since the period of settlement. Breaking the prairie sod and draining some of the many depressions have changed the protective cover. The most apparent changes are those caused by water erosion. As the soils were brought under cultivation, the runoff rate increased and the rate at which water penetrates the surface decreased. The increased runoff rate resulted in accelerated erosion, which has removed part or all of the surface layer from many cultivated areas of the more sloping soils. In some areas a few shallow gullies have formed. Erosion has changed not only the thickness of the surface layer but also the structure. In many severely eroded areas, the plow layer includes material from the upper part of the subsoil. In Storden soils, it is material from the upper part of the substratum.

Erosion and cultivation also affect the soil by reducing the content of organic matter, the available water capacity, and the level of fertility. Even in areas that are not subject to erosion, compaction by heavy machinery reduces the thickness of the surface layer and alters the structure. The granular structure characteristic of native grassland breaks down under intensive cropping. The high content of organic matter characteristic of grassland cannot be maintained if the soil is cultivated. Erosion is the main cause of a reduction in the content of organic matter. As much as one-third of the organic matter, however, can be lost through other causes (*14*).

Some management measures have increased soil productivity, decreased the susceptibility to erosion, and reclaimed areas not suitable for crops or pasture. Terraces and other erosion-control measures, for example, have slowed and, in some areas, controlled the rates of runoff and erosion. Some areas along streams are better suited to cultivation than they were in the past because the channels have been straightened and deepened and obstacles to cultivation have been removed. Because applications of commercial fertilizer and lime have counteracted deficiencies in plant nutrients, some soils are more productive than they were in their natural state.

Processes of Horizon Differentiation

Most of the soils in Pocahontas County have weakly expressed horizons. Examples are Canisteo, Storden, and Webster soils. Kossuth soils have moderately expressed horizons. Rolfe soils have strongly expressed horizons. Some soils are characterized by a marked difference in texture between the solum and the underlying 2C horizon. Examples are Biscay, Cylinder, Linder, and Wadena soils.

The processes of horizon differentiation include the accumulation of organic matter, the leaching of calcium carbonates and other bases, the formation and translocation of silicate clay minerals, the accumulation of calcium carbonates, and the reduction and transfer of iron (*12*). In most of the soils in the county, two or more of these processes have differentiated horizons.

In most of the soils, some organic matter has accumulated in an A horizon. If the A horizon formed in organic deposits, it has a high content of organic matter. Examples of mineral soils that have a high content of organic matter are Canisteo, Coland, Okoboji, and Webster. These soils have a thick A horizon. Estherville, Salida, and Storden soils have a low content of organic matter and a faint, thin A horizon. Clarion and Wadena soils have a moderate content of organic matter.

Leaching of calcium carbonates and other bases has occurred in many of the soils in the county. It generally occurs before and during the translocation of silicate clay minerals. Many of the soils, including Clarion and Nicollet soils, have been leached of calcium carbonates only in the upper part. Little clay has been moved downward in their profiles. Rolfe soils generally are more strongly leached than those soils and have a distinct accumulation of silicate clay in the B horizon.

The translocation of silicate clay minerals has contributed to the prominent horizonation of Rolfe soils. The B horizon contains more clay than the A horizon and, in many areas, has dark clay coatings on the faces of peds and along root channels. The eluviated E horizon has platy structure, contains less clay than the B horizon, and is lighter colored, especially when dry. In these soils the leaching of bases and the translocation of clay have been more important processes of horizon differentiation than the accumulation of organic matter.

Calcium carbonates have accumulated in the surface layer and subsoil of Canisteo and Harps soils, which have weakly expressed horizons. The calcium carbonate equivalent of Harps soils is 20 to 40 percent.

Gleying, a result of the reduction and transfer of iron, is evident in poorly drained and very poorly drained soils (*11*). Biscay, Canisteo, Harps, Okoboji, and Webster soils have a gleyed Bg horizon. This horizon is grayish. Some soils have reddish brown concretions of iron.

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Glossary

ABC soil. A soil having an A, a B, and a C horizon.

AC soil. A soil having only an A and a C horizon. Commonly such soil formed in recent alluvium or on steep rocky slopes.

Aeration, soil. The exchange of air in soil with air from the atmosphere. The air in a well aerated soil is similar to that in the atmosphere; the air in a poorly aerated soil is considerably higher in carbon dioxide and lower in oxygen.

Aggregate, soil. Many fine particles held in a single mass or cluster. Natural soil aggregates, such as granules, blocks, or prisms, are called peds. Clods are aggregates produced by tillage or logging.

Alluvium. Material, such as sand, silt, or clay, deposited on land by streams.

Area reclaim (in tables). An area difficult to reclaim after the removal of soil for construction and other uses. Revegetation and erosion control are extremely difficult.

Association, soil. A group of soils geographically associated in a characteristic repeating pattern and defined and delineated as a single map unit.

Available water capacity (available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field moisture capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil. The capacity, in inches, in a 60-inch profile or to a limiting layer is expressed as—

	Inches
Very low	0 to 3
Low	3 to 6
Moderate	6 to 9
High	9 to 12
Very high	more than 12

Base saturation. The degree to which material having cation exchange properties is saturated with exchangeable bases (sum of Ca, Mg, Na, K), expressed as a percentage of the total cation exchange capacity.

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

Bench terrace. A raised, level or nearly level strip of earth constructed on or nearly on the contour, supported by a barrier of rocks or similar material, and designed to make the soil suitable for tillage and to prevent accelerated erosion.

Bottom land. The normal flood plain of a stream, subject to flooding.

Calcareous soil. A soil containing enough calcium carbonate (commonly combined with magnesium carbonate) to effervesce visibly when treated with cold, dilute hydrochloric acid.

Capillary water. Water held as a film around soil particles and in tiny spaces between particles. Surface tension is the adhesive force that holds capillary water in the soil.

Catena. A sequence, or "chain," of soils on a landscape that formed in similar kinds of parent material but have different characteristics as a result of differences in relief and drainage.

Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.

Chiseling. Tillage with an implement having one or more soil-penetrating points that shatter or loosen hard compacted layers to a depth below normal plow depth.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Climax vegetation. The stabilized plant community on a particular site. The plant cover reproduces itself and does not change so long as the environment remains the same.

Coarse fragments. If round, mineral or rock particles 2 millimeters to 25 centimeters (10 inches) in diameter; if flat, mineral or rock particles (flagstone) 15 to 38 centimeters (6 to 15 inches) long.

Coarse textured soil. Sand or loamy sand.

Cobblestone (or cobble). A rounded or partly rounded fragment of rock 3 to 10 inches (7.5 to 25 centimeters) in diameter.

Colluvium. Soil material, rock fragments, or both moved by creep, slide, or local wash and deposited at the base of steep slopes.

Complex slope. Irregular or variable slope. Planning or constructing terraces, diversions, and other water-control measures on a complex slope is difficult.

Complex, soil. A map unit of two or more kinds of soil in such an intricate pattern or so small in area that it is not practical to map them separately at the selected scale of mapping. The pattern and proportion of the soils are somewhat similar in all areas.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrated compounds or cemented soil grains. The composition of most concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are common compounds in concretions.

Conservation tillage. A tillage system that does not invert the soil and that leaves a protective amount of crop residue on the surface throughout the year.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material and tends to stretch somewhat and pull apart rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard; little affected by moistening.

Contour stripcropping. Growing crops in strips that follow the contour. Strips of grass or close-growing crops are alternated with strips of clean-tilled crops or summer fallow.

Control section. The part of the soil on which classification is based. The thickness varies among different kinds of soil, but for many it is that part of the soil profile between depths of 10 inches and 40 or 80 inches.

Coprogenous earth (sedimentary peat). Fecal material deposited in water by aquatic organisms.

Corrosive. High risk of corrosion to uncoated steel or deterioration of concrete.

Cover crop. A close-growing crop grown primarily to improve and protect the soil between periods of regular crop production, or a crop grown between trees and vines in orchards and vineyards.

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Deferred grazing. Postponing grazing or resting grazing land for a prescribed period.

Depth to rock (in tables). Bedrock is too near the surface for the specified use.

Drainage class (natural). Refers to the frequency and duration of periods of saturation or partial saturation during soil formation, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven classes of natural soil drainage are recognized:

Excessively drained.—Water is removed from the soil very rapidly. Excessively drained soils are commonly very coarse textured, rocky, or shallow. Some are steep. All are free of the mottling related to wetness.

Somewhat excessively drained.—Water is removed from the soil rapidly. Many somewhat excessively drained soils are sandy and rapidly pervious. Some are shallow. Some are so steep that much of the water they receive is lost as runoff. All are free of the mottling related to wetness.

Well drained.—Water is removed from the soil readily, but not rapidly. It is available to plants throughout most of the growing season, and wetness does not inhibit growth of roots for significant periods during most growing seasons. Well drained soils are commonly medium textured. They are mainly free of mottling.

Moderately well drained.—Water is removed from the soil somewhat slowly during some periods. Moderately well drained soils are wet for only a short time during the growing season, but periodically they are wet long enough that most mesophytic crops are affected. They commonly have a slowly pervious layer within or directly below the solum, or periodically receive high rainfall, or both.

Somewhat poorly drained.—Water is removed slowly enough that the soil is wet for significant periods during the growing season. Wetness markedly restricts the growth of mesophytic crops unless artificial drainage is provided. Somewhat poorly drained soils commonly have a slowly pervious layer, a high water table, additional water from seepage, nearly continuous rainfall, or a combination of these.

Poorly drained.—Water is removed so slowly that the soil is saturated periodically during the growing season or remains wet for long periods. Free water is commonly at or near the surface for long enough during the growing season that most mesophytic crops cannot be grown unless the soil is artificially drained. The soil is not continuously saturated in layers directly below plow depth. Poor drainage results from a high water table, a slowly pervious layer within the profile, seepage, nearly continuous rainfall, or a combination of these.

Very poorly drained.—Water is removed from the soil so slowly that free water remains at or on the surface during most of the growing season. Unless the soil is artificially drained, most mesophytic crops cannot be grown. Very poorly drained soils are commonly level or depressed and are frequently ponded. Yet, where rainfall is high and nearly continuous, they can have moderate or high slope gradients.

Drainage, surface. Runoff, or surface flow of water, from an area.

Eluviation. The movement of material in true solution or colloidal suspension from one place to another within the soil. Soil horizons that have lost material through eluviation are eluvial; those that have received material are illuvial.

Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature, for example, fire, that exposes the surface.

Esker (geology). A narrow, winding ridge of stratified gravelly and sandy drift deposited by a stream flowing in a tunnel beneath a glacier.

Excess fines (in tables). Excess silt and clay in the soil. The soil is not a source of gravel or sand for construction purposes.

Fast intake (in tables). The rapid movement of water into the soil.

Fertility, soil. The quality that enables a soil to provide plant nutrients, in adequate amounts and in proper balance, for the growth of specified plants when light, moisture, temperature, tilth, and other growth factors are favorable.

Fibric soil material (peat). The least decomposed of all organic soil material. Peat contains a large amount of well preserved fiber that is readily identifiable according to botanical origin. Peat has the lowest bulk density and the highest water content at saturation of all organic soil material.

Fine textured soil. Sandy clay, silty clay, and clay.

First bottom. The normal flood plain of a stream, subject to frequent or occasional flooding.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Foot slope. The inclined surface at the base of a hill.

Frost action (in tables). Freezing and thawing of soil moisture. Frost action can damage roads, buildings and other structures, and plant roots.

Genesis, soil. The mode of origin of the soil. Refers especially to the processes or soil-forming factors responsible for the formation of the solum, or true soil, from the unconsolidated parent material.

Glacial drift (geology). Pulverized and other rock material transported by glacial ice and then deposited. Also the sorted and unsorted material deposited by streams flowing from glaciers.

Glacial outwash (geology). Gravel, sand, and silt, commonly stratified, deposited by glacial melt water.

Glacial till (geology). Unsorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Glaciofluvial deposits (geology). Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur as kames, eskers, deltas, and outwash plains.

Glaciolacustrine deposits. Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial melt water. Many deposits are interbedded or laminated.

Gleyed soil. Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors and mottles.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material that is 15 to 50 percent, by volume, rounded or angular rock fragments, not prominently flattened, up to 3 inches (7.6 centimeters) in diameter.

Ground water (geology). Water filling all the unblocked pores of underlying material below the water table.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rainfall. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage.

Hemic soil material (mucky peat). Organic soil material intermediate in degree of decomposition between the less decomposed fibric and the more decomposed sapric material.

Horizon, soil. A layer of soil, approximately parallel to the surface, having distinct characteristics produced by soil-forming processes. In the identification of soil horizons, an uppercase letter represents the major horizons. Numbers or lowercase letters that follow represent subdivisions of the major horizons. The major horizons are as follows:

O horizon.—An organic layer of fresh and decaying plant residue.

A horizon.—The mineral horizon at or near the surface in which an accumulation of humified organic matter is mixed with the mineral material. Also, any plowed or disturbed surface layer.

E horizon.—The mineral horizon in which the main feature is loss of silicate clay, iron, aluminum, or some combination of these.

B horizon.—The mineral horizon below an O, A, or E horizon. The B horizon is in part a layer of transition from the overlying horizon to the underlying C horizon. The B horizon also has distinctive characteristics such as (1) accumulation of clay, sesquioxides, humus, or a combination of these; (2) granular, prismatic, or blocky structure; (3) redder or browner colors than those in the A horizon; or (4) a combination of these.

C horizon.—The mineral horizon or layer, excluding indurated bedrock, that is little affected by soil-forming processes and does not have the properties typical of the overlying horizon. The material of a C horizon may be either like or unlike that in which the solum formed. If the material is known to differ from that in the solum, an Arabic numeral, commonly a 2, precedes the letter C.

Cr horizon.—Soft, consolidated bedrock beneath the soil.

R layer.—Hard, consolidated bedrock beneath the soil. The bedrock commonly underlies a C horizon, but can be directly below an A or a B horizon.

Humus. The well decomposed, more or less stable part of the organic matter in mineral soils.

Hydrologic soil groups. Refers to soils grouped according to their runoff-producing characteristics. The chief consideration is the inherent capacity of soil bare of vegetation to permit infiltration. The slope and the kind of plant cover are not considered but are separate factors in predicting runoff. Soils are assigned to four groups. In group A are soils having a high infiltration rate when thoroughly wet and having a low runoff potential. They are mainly deep, well drained, and sandy or gravelly. In group D, at the other extreme, are soils having a very slow infiltration rate and thus a high runoff potential. They have a claypan or clay layer at or near the surface, have a permanent high water table, or are shallow over nearly impervious bedrock or other material. A soil is assigned to two hydrologic groups if part of the acreage is artificially drained and part is undrained.

Illuviation. The movement of soil material from one horizon to another in the soil profile. Generally, material is removed from an upper horizon and deposited in a lower horizon.

Impervious soil. A soil through which water, air, or roots penetrate slowly or not at all. No soil is absolutely impervious to air and water all the time.

Infiltration. The downward entry of water into the immediate surface of soil or other material, as contrasted with percolation, which is movement of water through soil layers or material.

Infiltration capacity. The maximum rate at which water can infiltrate into a soil under a given set of conditions.

Infiltration rate. The rate at which water penetrates the surface of the soil at any given instant, usually expressed in inches per hour. The rate can be limited by the infiltration capacity of the soil or the rate at which water is applied at the surface.

Intake rate. The average rate of water entering the soil under irrigation. Most soils have a fast initial rate; the rate decreases with application time. Therefore, intake rate for design purposes is not a constant but is a variable depending on the net irrigation application. The rate of water intake in inches per hour is expressed as follows:

Less than 0.2	very low
0.2 to 0.4	low
0.4 to 0.75	moderately low
0.75 to 1.25	moderate
1.25 to 1.75	moderately high
1.75 to 2.5	high
More than 2.5	very high

Kame (geology). An irregular, short ridge or hill of stratified glacial drift.

Lacustrine deposit (geology). Material deposited in lake water and exposed when the water level is lowered or the elevation of the land is raised.

Large stones (in tables). Rock fragments 3 inches (7.6 centimeters) or more across. Large stones adversely affect the specified use of the soil.

Leaching. The removal of soluble material from soil or other material by percolating water.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Low strength. The soil is not strong enough to support loads.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Minimum tillage. Only the tillage essential to crop production and prevention of soil damage.

Moderately coarse textured soil. Coarse sandy loam, sandy loam, and fine sandy loam.

Moderately fine textured soil. Clay loam, sandy clay loam, and silty clay loam.

Moraine (geology). An accumulation of earth, stones, and other debris deposited by a glacier. Some types are terminal, lateral, medial, and ground.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical, mineral, and biological properties of the various horizons, and the thickness and arrangement of those horizons in the soil profile.

Mottling, soil. Irregular spots of different colors that vary in number and size. Mottling generally indicates poor aeration and impeded drainage. Descriptive terms are as follows: abundance—*few, common,* and *many*; size—*fine, medium,* and *coarse*; and contrast—*faint, distinct,* and *prominent*. The size measurements are of the diameter along the greatest dimension. *Fine* indicates less than 5 millimeters (about 0.2 inch); *medium*, from 5 to 15 millimeters (about 0.2 to 0.6 inch); and *coarse*, more than 15 millimeters (about 0.6 inch).

Munsell notation. A designation of color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

Neutral soil. A soil having a pH value between 6.6 and 7.3. (See Reaction, soil.)

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter. Plant and animal residue in the soil in various stages of decomposition.

Outwash, glacial. Stratified sand and gravel produced by glaciers and carried, sorted, and deposited by glacial melt water.

Outwash plain. A landform of mainly sandy or coarse textured material of glaciofluvial origin. An outwash plain is commonly smooth; where pitted, it is generally low in relief.

Parent material. The unconsolidated organic and mineral material in which soil forms.

Peat. Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil adversely affecting the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated soil. Terms describing permeability are:

Very slow	less than 0.06 inch
Slow	0.06 to 0.2 inch
Moderately slow	0.2 to 0.6 inch
Moderate	0.6 inch to 2.0 inches
Moderately rapid	2.0 to 6.0 inches
Rapid	6.0 to 20 inches
Very rapid	more than 20 inches

Phase, soil. A subdivision of a soil series based on features that affect its use and management. For example, slope, stoniness, and thickness.

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Piping (in tables). Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from semisolid to plastic.

Ponding. Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

Poorly graded. Refers to a coarse grained soil or soil material consisting mainly of particles of nearly the same size. Because there is little difference in size of the particles, density can be increased only slightly by compaction.

Poor filter (in tables). Because of rapid permeability the soil may not adequately filter effluent from a waste disposal system.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH
Extremely acid	below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

Relief. The elevations or inequalities of a land surface, considered collectively.

Residuum (residual soil material). Unconsolidated, weathered, or partly weathered mineral material that accumulated as consolidated rock disintegrated in place.

Rill. A steep sided channel resulting from accelerated erosion. A rill is generally a few inches deep and not wide enough to be an obstacle to farm machinery.

Rooting depth (in tables). Shallow root zone. The soil is shallow over a layer that greatly restricts roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

Sapric soil material (muck). The most highly decomposed of all organic soil material. Muck has the least amount of plant fiber, the highest bulk density, and the lowest water content at saturation of all organic soil material.

Sedimentary rock. Rock made up of particles deposited from suspension in water. The chief kinds of sedimentary rock are conglomerate, formed from gravel; sandstone, formed from sand; shale, formed from clay; and limestone, formed from soft masses of calcium carbonate. There are many intermediate types. Some wind-deposited sand is consolidated into sandstone.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

Sequum. A sequence consisting of an illuvial horizon and the overlying eluvial horizon. (See Eluviation.)

Series, soil. A group of soils that have profiles that are almost alike, except for differences in texture of the surface layer or of the substratum. All the soils of a series have horizons that are similar in composition, thickness, and arrangement.

Sheet erosion. The removal of a fairly uniform layer of soil material from the land surface by the action of rainfall and surface runoff.

Shrink-swell. The shrinking of soil when dry and the swelling when wet. Shrinking and swelling can damage roads, dams, building foundations, and other structures. It can also damage plant roots.

Silica. A combination of silicon and oxygen. The mineral form is called quartz.

Silica-sesquioxide ratio. The ratio of the number of molecules of silica to the number of molecules of alumina and iron oxide. The more highly weathered soils or their clay fractions in warm-temperate, humid regions, and especially those in the tropics, generally have a low ratio.

Silt. As a soil separate, individual mineral particles that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). As a soil textural class, soil that is 80 percent or more silt and less than 12 percent clay.

Slippage (in tables). Soil mass susceptible to movement downslope when loaded, excavated, or wet.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slope (in tables). Slope is great enough that special practices are required to insure satisfactory performance of the soil for a specific use.

Small stones (in tables). Rock fragments less than 3 inches (7.6 centimeters) in diameter. Small stones adversely affect the specified use of the soil.

Soil. A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows:

	Millimeters
Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and plant and animal activities are largely confined to the solum.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter if rounded and 6 to 15 inches (15 to 38 centimeters) in length if flat.

Stony. Refers to a soil containing stones in numbers that interfere with or prevent tillage.

Stripcropping. Growing crops in a systematic arrangement of strips or bands which provide vegetative barriers to wind and water erosion.

Structure, soil. The arrangement of primary soil particles into compound particles or aggregates. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are either *single grain* (each grain by itself, as in dune sand) or *massive* (the particles adhering without any regular cleavage, as in many hardpans).

Stubble mulch. Stubble or other crop residue left on the soil or partly worked into the soil. It protects the soil from soil blowing and water erosion after harvest, during preparation of a seedbed for the next crop, and during the early growing period of the new crop.

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Subsoiling. Breaking up a compact subsoil by pulling a special chisel through the soil.

Substratum. The part of the soil below the solum.

Subsurface layer. Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Surface soil. The A, E, AB, and EB horizons. Includes all subdivisions of these horizons.

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior.

Terminal moraine. A belt of thick glacial drift that generally marks the termination of important glacial advances.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Thin layer (in tables). Otherwise suitable soil material too thin for the specified use.

Till plain. An extensive flat to undulating area underlain by glacial till.

Tilth, soil. The physical condition of the soil as related to tillage, seedbed preparation, seedling emergence, and root penetration.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Trace elements. Chemical elements, for example, zinc, cobalt, manganese, copper, and iron, are in soils in extremely small amounts. They are essential to plant growth.

Variegation. Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

Varve. A sedimentary layer or a lamina or sequence of laminae deposited in a body of still water within a year. Specifically, a thin pair of graded glaciolacustrine layers seasonally deposited, usually by melt water streams, in a glacial lake or other body of still water in front of a glacier.

Water table (seasonal high). The highest level of a saturated zone in the soil in most years. An *apparent* water table is a thick zone of free water in the soil. It is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil.

Weathering. All physical and chemical changes produced in rocks or other deposits at or near the earth's surface by atmospheric agents. These changes result in disintegration and decomposition of the material.

Well graded. Refers to soil material consisting of coarse grained particles that are well disturbed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wilting point (or permanent wilting point). The moisture content of soil, on a ovendry basis, at which a plant (specifically sunflower) wilts so much that it does not recover when placed in a humid, dark chamber.

Tables

TABLE 1.--TEMPERATURE AND PRECIPITATION

[Data were recorded in the period 1951-79 at Pocahontas, Iowa]

Month	Temperature						Precipitation				
	Average daily maximum	Average daily minimum	Average daily	2 years in 10 will have-- Maximum temperature higher than--	2 years in 10 will have-- Minimum temperature lower than--	Average number of growing degree days*	Average	2 years in 10 will have-- Less than--	2 years in 10 will have-- More than--	Average number of days with 0.10 inch or more	Average snowfall
	°F	°F	°F	°F	°F	Units	In	In	In		In
January----	24.3	4.8	14.6	49	-23	0	0.62	0.20	0.96	2	5.9
February---	31.0	11.3	21.2	53	-20	0	.84	.20	1.35	3	6.8
March------	41.2	22.1	31.7	75	-7	25	2.01	.85	2.98	5	7.5
April------	59.5	36.3	47.9	87	16	86	2.87	1.62	3.97	6	1.2
May--------	72.5	47.8	60.2	92	28	330	3.73	2.46	4.88	7	.0
June-------	81.5	57.9	69.7	98	41	591	4.44	2.35	6.27	7	.0
July-------	85.1	61.9	73.5	100	47	729	3.83	1.75	5.61	7	.0
August-----	82.8	59.3	71.1	97	44	654	3.96	1.95	5.69	6	.0
September--	74.7	49.8	62.3	93	30	369	3.03	.95	4.71	6	.0
October----	63.9	38.9	51.4	88	19	155	2.01	.71	3.09	4	.1
November---	45.3	25.3	35.3	71	-1	8	1.30	.28	2.11	3	3.0
December---	31.0	13.1	22.1	58	-18	0	.82	.33	1.23	2	6.5
Yearly:											
Average--	57.7	35.7	46.8	---	---	---	---	---	---	---	---
Extreme--	---	---	---	100	-23	---	---	---	---	---	---
Total----	---	---	---	---	---	2,947	29.46	22.77	35.09	58	31.0

* A growing degree day is a unit of heat available for plant growth. It can be calculated by adding the maximum and minimum daily temperatures, dividing the sum by 2, and subtracting the temperature below which growth is minimal for the principal crops in the area (50° F).

TABLE 2.--FREEZE DATES IN SPRING AND FALL

[Data were recorded in the period 1951-79 at Pocahontas, Iowa]

Probability	Temperature		
	24° F or lower	28° F or lower	32° F or lower
Last freezing temperature in spring:			
1 year in 10 later than--	April 23	May 8	May 14
2 years in 10 later than--	April 19	May 3	May 9
5 years in 10 later than--	April 12	April 23	April 30
First freezing temperature in fall:			
1 year in 10 earlier than--	October 14	October 3	September 22
2 years in 10 earlier than--	October 18	October 7	September 26
5 years in 10 earlier than--	October 26	October 16	October 4

TABLE 3.--GROWING SEASON

[Data were recorded in the period 1951-79 at Pocahontas, Iowa]

Probability	Daily minimum temperature during growing season		
	Higher than 24° F	Higher than 28° F	Higher than 32° F
	Days	Days	Days
9 years in 10	180	156	138
8 years in 10	186	163	144
5 years in 10	197	175	156
2 years in 10	207	188	168
1 year in 10	213	194	175

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Acres	Percent
4	Knoke silty clay loam, 0 to 1 percent slopes	6,780	1.8
6	Okoboji silty clay loam, 0 to 1 percent slopes	17,280	4.6
27B	Terril loam, 2 to 5 percent slopes	250	0.1
34	Estherville sandy loam, 0 to 2 percent slopes	430	0.1
34B	Estherville sandy loam, 2 to 5 percent slopes	1,350	0.4
34C2	Estherville sandy loam, 5 to 9 percent slopes, moderately eroded	260	0.1
41B	Sparta loamy fine sand, 2 to 5 percent slopes	120	*
48	Knoke mucky silt loam, 0 to 1 percent slopes	3,480	0.9
55	Nicollet clay loam, 1 to 3 percent slopes	51,640	13.9
62C2	Storden loam, 5 to 9 percent slopes, moderately eroded	2,790	0.7
62D2	Storden loam, 9 to 14 percent slopes, moderately eroded	1,820	0.5
62E	Storden loam, 14 to 18 percent slopes	430	0.1
62F	Storden loam, 18 to 25 percent slopes	400	0.1
62G	Storden loam, 25 to 40 percent slopes	330	0.1
90	Okoboji mucky silty clay loam, 0 to 1 percent slopes	7,020	1.9
95	Harps clay loam, 0 to 2 percent slopes	9,350	2.5
107	Webster clay loam, 0 to 2 percent slopes	86,300	23.2
108	Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	460	0.1
108B	Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes	3,020	0.8
108C2	Wadena loam, 24 to 32 inches to sand and gravel, 5 to 9 percent slopes, moderately eroded	370	0.1
135	Coland clay loam, 0 to 2 percent slopes	8,140	2.2
135B	Coland clay loam, 2 to 4 percent slopes	540	0.1
138B	Clarion loam, 2 to 5 percent slopes	56,610	15.2
138C	Clarion loam, 5 to 9 percent slopes	360	0.1
138C2	Clarion loam, 5 to 9 percent slopes, moderately eroded	10,880	2.9
138D2	Clarion loam, 9 to 14 percent slopes, moderately eroded	740	0.2
141	Watseka loamy sand, 0 to 2 percent slopes	270	0.1
150	Hanska loam, 0 to 2 percent slopes	230	0.1
202	Cylinder clay loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	1,430	0.4
203	Cylinder clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	910	0.2
224	Linder loam, 0 to 2 percent slopes	200	0.1
259	Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	4,810	1.3
274	Rolfe silt loam, 0 to 1 percent slopes	150	*
308B	Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes	490	0.1
330	Kingston silty clay loam, 0 to 3 percent slopes	110	*
338	Garmore, loam 0 to 2 percent slopes	340	0.1
338B	Garmore loam, 2 to 5 percent slopes	240	0.1
339B	Truman silt loam, 2 to 6 percent slopes	280	0.1
388	Kossuth silty clay loam, 0 to 2 percent slopes	1,840	0.5
485	Spillville loam, 0 to 2 percent slopes	170	*
485B	Spillville loam, 2 to 5 percent slopes	450	0.1
506	Wacousta silty clay loam, 0 to 1 percent slopes	1,940	0.5
507	Canisteo clay loam, 0 to 2 percent slopes	70,250	18.9
508	Calcousta silty clay loam, 0 to 1 percent slopes	610	0.2
511	Blue Earth mucky silty clay loam, 0 to 1 percent slopes	1,000	0.3
541C	Estherville-Salida complex, 5 to 10 percent slopes	310	0.1
559	Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	4,710	1.3
651	Faxon silt loam, 0 to 2 percent slopes	170	*
655	Crippin loam, 1 to 3 percent slopes	1,070	0.3
735	Havelock clay loam, 0 to 2 percent slopes	5,570	1.5
1048	Knoke mucky silt loam, ponded, 0 to 1 percent slopes	540	0.1
1585B	Coland-Spillville complex, channeled, 2 to 5 percent slopes	230	0.1
1735	Havelock clay loam, channeled, 0 to 2 percent slopes	1,420	0.4
5010	Pits, gravel	340	0.1
5030	Pits, limestone	390	0.1
5040	Orthents, loamy	360	0.1
	Water	500	0.1
	Total	372,480	100.0

* Less than 0.1 percent.

TABLE 5.--PRIME FARMLAND

[Only the soils considered prime farmland are listed. Urban or built-up areas of the soils listed are not considered prime farmland. If a soil is prime farmland only under certain conditions, the conditions are specified in parentheses after the soil name]

Map symbol	Soil name
27B	Terril loam, 2 to 5 percent slopes
55	Nicollet clay loam, 1 to 3 percent slopes
95	Harps clay loam, 0 to 2 percent slopes (where drained)
107	Webster clay loam, 0 to 2 percent slopes (where drained)
108	Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes
108B	Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes
135	Coland clay loam, 0 to 2 percent slopes (where drained)
135B	Coland clay loam, 2 to 4 percent slopes (where drained)
138B	Clarion loam, 2 to 5 percent slopes
150	Hanska loam, 0 to 2 percent slopes (where drained)
202	Cylinder clay loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes
203	Cylinder clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes
259	Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes (where drained)
308B	Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes
330	Kingston silty clay loam, 0 to 3 percent slopes
338	Garmore loam, 0 to 2 percent slopes
338B	Garmore loam, 2 to 5 percent slopes
339B	Truman silt loam, 2 to 6 percent slopes
388	Kossuth silty clay loam, 0 to 2 percent slopes (where drained)
485	Spillville loam, 0 to 2 percent slopes
485B	Spillville loam, 2 to 5 percent slopes
507	Canisteo clay loam, 0 to 2 percent slopes (where drained)
559	Talcot clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes (where drained)
655	Crippin loam, 1 to 3 percent slopes
735	Havelock clay loam, 0 to 2 percent slopes (where drained)

TABLE 6.--YIELDS PER ACRE OF CROPS AND PASTURE

[Yields are those that can be expected under a high level of management. Absence of a yield indicates that the soil is not suited to the crop or the crop generally is not grown on the soil]

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
	Bu	Bu	Bu	Tons	AUM*	AUM*	AUM*
4------------------------ Knoke	82	31	65	3.3	3.3	4.3	5.5
6------------------------ Okoboji	84	32	67	3.4	3.3	4.3	7.3
27B---------------------- Terril	118	45	94	5.0	4.2	7.0	8.3
34----------------------- Estherville	50	17	40	2.0	2.0	3.0	3.0
34B---------------------- Estherville	45	15	35	2.0	2.0	3.0	2.5
34C2--------------------- Estherville	27	9	29	1.4	1.2	2.5	2.0
41B---------------------- Sparta	50	23	40	2.5	2.0	3.7	4.3
48----------------------- Knoke	82	31	65	3.3	3.3	4.3	5.5
55----------------------- Nicollet	120	40	80	4.5	3.5	7.0	6.5
62C2--------------------- Storden	88	33	71	3.5	3.0	5.5	5.0
62D2--------------------- Storden	79	23	65	3.4	2.8	5.2	4.8
62E---------------------- Storden	60	---	40	3.0	2.5	4.0	4.5
62F---------------------- Storden	---	---	---	2.5	2.0	3.5	3.7
62G---------------------- Storden	---	---	---	---	1.5	---	---
90----------------------- Okoboji	84	32	67	3.4	3.3	4.3	7.3
95----------------------- Harps	95	36	76	4.0	3.3	5.0	6.6
107---------------------- Webster	110	42	88	4.4	4.2	6.6	7.3
108---------------------- Wadena	72	27	60	2.7	2.7	4.3	4.8
108B--------------------- Wadena	70	27	60	2.8	2.7	4.3	4.7
108C2-------------------- Wadena	62	24	53	2.5	2.3	3.7	4.2
135---------------------- Coland	110	42	83	4.6	4.1	6.0	7.6

See footnote at end of table.

TABLE 6.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
	Bu	Bu	Bu	Tons	AUM*	AUM*	AUM*
135B----------------------- Coland	108	41	81	4.5	4.0	5.9	7.5
138B----------------------- Clarion	110	42	88	4.6	4.2	6.7	7.6
138C----------------------- Clarion	105	40	84	4.4	3.8	6.3	7.3
138C2---------------------- Clarion	102	39	82	4.3	3.8	6.2	7.1
138D2---------------------- Clarion	93	35	74	3.9	3.7	5.5	6.5
141------------------------ Watseka	61	23	45	2.3	2.1	3.2	3.2
150------------------------ Hanska	75	28	60	3.5	3.7	6.0	5.2
202------------------------ Cylinder	88	33	70	3.7	3.3	5.3	6.1
203------------------------ Cylinder	103	39	82	4.3	3.8	6.2	7.1
224------------------------ Linder	61	23	42	2.5	2.3	3.7	4.1
259------------------------ Biscay	85	32	60	3.5	3.5	6.2	5.2
274------------------------ Rolfe	86	33	69	3.0	3.3	4.5	5.0
308B----------------------- Wadena	90	34	72	3.6	3.7	5.3	6.0
330------------------------ Kingston	116	38	80	4.5	3.5	7.1	6.7
338------------------------ Garmore	115	44	92	4.8	3.8	6.7	8.0
338B----------------------- Garmore	112	42	85	4.7	3.7	6.5	7.8
339B----------------------- Truman	110	36	75	4.5	4.0	6.7	7.1
388------------------------ Kossuth	98	37	83	4.2	4.0	5.9	7.3
485------------------------ Spillville	122	46	98	5.1	4.2	7.3	8.6
485B----------------------- Spillville	120	45	96	5.0	4.1	7.2	8.5
506------------------------ Wacousta	90	38	80	4.0	2.0	7.0	6.6
507------------------------ Canisteo	110	36	75	3.5	3.0	4.1	5.2

See footnote at end of table.

TABLE 6.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
	Bu	Bu	Bu	Tons	AUM*	AUM*	AUM*
508 Calcousta	75	29	62	4.0	2.0	4.0	5.0
511 Blue Earth	75	30	---	3.0	---	3.8	---
541C Estherville-Salida	---	---	29	1.7	1.3	2.9	2.5
559 Talcot	95	36	76	4.0	3.3	5.0	6.3
651 Faxon	85	30	65	3.0	3.0	4.0	3.5
655 Crippin	113	39	84	4.3	4.2	6.5	7.1
735 Havelock	110	42	83	4.6	4.1	6.0	7.6
1048. Knoke							
1585B Coland-Spillville	---	---	---	---	3.1	---	---
1735 Havelock	---	---	---	---	2.5	---	---
5010**, 5030**. Pits							
5040. Orthents							

* Animal-unit-month: The amount of forage or feed required to feed one animal unit (one cow, one horse, one mule, five sheep, or five goats) for 30 days.

** See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 7.--CAPABILITY CLASSES AND SUBCLASSES

[Miscellaneous areas are excluded. Absence of an entry indicates no acreage]

Class	Total acreage	Major management concerns (Subclass)		
		Erosion (e)	Wetness (w)	Soil problem (s)
		Acres	Acres	Acres
I	53,160	---	---	---
II	256,250	61,880	191,370	3,000
III	55,620	15,140	38,430	2,050
IV	2,630	2,250	---	380
V	1,650	---	1,650	---
VI	710	400	---	310
VII	870	330	540	---
VIII	---	---	---	---

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS

[The symbol < means less than; > means more than. Absence of an entry indicates that trees generally do not grow to the given height on that soil]

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
4----------------- Knoke	---	Siberian peashrub, Tatarian honeysuckle, lilac, northern white-cedar.	White spruce, bur oak, hackberry.	Honeylocust, golden willow, green ash.	Eastern cottonwood.
6----------------- Okoboji	---	Northern white-cedar, Siberian peashrub, lilac, Tatarian honeysuckle.	Hackberry, bur oak, white spruce.	Honeylocust, golden willow, green ash.	Eastern cottonwood.
27B--------------- Terril	---	Gray dogwood, Siberian peashrub, lilac, redosier dogwood.	Eastern redcedar, Russian-olive, Amur maple, honeylocust, blue spruce, northern white-cedar.	Eastern white pine, green ash.	---
34, 34B, 34C2----- Estherville	Siberian peashrub	Eastern redcedar, lilac, Tatarian honeysuckle.	Austrian pine, honeylocust, red pine, Russian-olive, jack pine, green ash, Siberian elm.	Eastern white pine	---
41B--------------- Sparta	Manyflower cotoneaster.	Siberian peashrub, Russian-olive.	Hackberry----------	Red pine, eastern white pine, jack pine.	---
48---------------- Knoke	---	Siberian peashrub, Tatarian honeysuckle, lilac, northern white-cedar.	White spruce, bur oak, eastern redcedar, hackberry.	Honeylocust, golden willow, green ash.	Eastern cottonwood.
55---------------- Nicollet	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, blue spruce, Amur maple.	Austrian pine, eastern white pine, green ash, hackberry.	Silver maple.
62C2, 62D2, 62E, 62F, 62G--------- Storden	American plum-----	Eastern redcedar, hackberry, Tatarian honeysuckle, Siberian peashrub.	Honeylocust, green ash, Russian-olive.	Siberian elm------	---
90---------------- Okoboji	---	Northern white-cedar, Siberian peashrub, lilac, Tatarian honeysuckle.	Hackberry, eastern redcedar, bur oak, white spruce.	Honeylocust, golden willow, green ash.	Eastern cottonwood.
95---------------- Harps	---	Tatarian honeysuckle, northern white-cedar, Siberian peashrub, lilac.	Hackberry, white spruce, eastern redcedar, bur oak.	Golden willow, honeylocust, green ash.	Eastern cottonwood.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
107---------------- Webster	---	Redosier dogwood, American plum, Tatarian honeysuckle, silky dogwood.	Hackberry, Amur maple, northern white-cedar, tall purple willow, white spruce.	Golden willow, green ash.	Eastern cottonwood, silver maple.
108, 108B, 108C2-- Wadena	Siberian peashrub, lilac, Tatarian honeysuckle.	Eastern redcedar, Russian-olive, hackberry, Manchurian crabapple.	Jack pine, honeysuckle, bur oak, green ash, eastern white pine.	---	---
135, 135B--------- Coland	---	Redosier dogwood, American plum, Tatarian honey- suckle.	Tall purple willow, hack- berry, Amur maple, white spruce, northern white-cedar.	Green ash, golden willow.	Silver maple, eastern cottonwood.
138B, 138C, 138C2, 138D2------------ Clarion	---	Gray dogwood, redosier dogwood, lilac, Siberian peashrub.	Northern white- cedar, blue spruce, Amur maple, Russian- olive, eastern redcedar, hackberry.	Green ash, eastern white pine.	---
141---------------- Watseka	---	Redosier dogwood, lilac, Tatarian honeysuckle.	White spruce, northern white- cedar, blue spruce, Amur maple.	Eastern white pine, Austrian pine, hackberry, green ash.	Silver maple.
150---------------- Hanska	---	Tatarian honeysuckle, American plum, redosier dogwood.	Northern white- cedar, white spruce, tall purple willow, Amur maple, hackberry.	Golden willow, green ash.	Eastern cottonwood, silver maple.
202, 203. Cylinder					
224---------------- Linder	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Blue spruce, Amur maple, white spruce, northern white-cedar.	Eastern white pine, Austrian pine, green ash, hackberry.	Silver maple.
259. Biscay					
274---------------- Rolfe	---	Redosier dogwood, Tatarian honeysuckle, American plum.	Amur maple, northern white- cedar, hackberry, white spruce, tall purple willow.	Golden willow, green ash.	Silver maple, eastern cottonwood.
308B-------------- Wadena	Siberian peashrub, lilac, Tatarian honeysuckle.	Eastern redcedar, Russian-olive, hackberry, Manchurian crabapple.	Jack pine, honeysuckle, bur oak, green ash, eastern white pine.	---	---

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
330 Kingston	---	Lilac, Tatarian honeysuckle, redosier dogwood.	Northern white-cedar, white spruce, Amur maple, blue spruce.	Austrian pine, eastern white pine, green ash, hackberry.	Silver maple.
338, 338B Garmore	---	Redosier dogwood, gray dogwood, lilac, Siberian peashrub.	Northern white-cedar, eastern redcedar, Russian-olive, blue spruce, Amur maple, hackberry.	Eastern white pine, green ash.	---
339B Truman	---	Gray dogwood, redosier dogwood, Siberian peashrub, lilac.	Northern white-cedar, blue spruce, hackberry, Russian-olive, eastern redcedar, Amur maple.	Eastern white pine, green ash.	---
388 Kossuth	---	Redosier dogwood, American plum, Tatarian honeysuckle.	Tall purple willow, Amur maple, hackberry, white spruce, northern white-cedar.	Golden willow, green ash.	Eastern cottonwood, silver maple.
485, 485B Spillville	---	Lilac, Tatarian honeysuckle, redosier dogwood.	Northern white-cedar, white spruce, blue spruce, Amur maple.	Eastern white pine, hackberry, Austrian pine, green ash.	Silver maple.
506 Wacousta	---	Northern white-cedar, Tatarian honeysuckle, Siberian peashrub, lilac.	Hackberry, eastern redcedar, bur oak, white spruce.	Golden willow, honeylocust, green ash.	Eastern cottonwood.
507 Canisteo	---	Siberian peashrub, Tatarian honeysuckle, lilac, northern white-cedar.	Hackberry, bur oak, white spruce, eastern redcedar.	Golden willow, honeylocust, golden ash.	Eastern cottonwood.
508 Calcousta	---	Northern white-cedar, Tatarian honeysuckle, Siberian peashrub, lilac.	Hackberry, eastern redcedar, bur oak, white spruce.	Honeylocust, golden willow, green ash.	Eastern cottonwood.
511 Blue Earth	Lilac	Siberian peashrub, Tatarian honeysuckle.	Hackberry, ponderosa pine, Russian-olive, blue spruce, eastern redcedar.	Green ash, golden willow, honeylocust.	Eastern cottonwood.
541C*: Estherville	Siberian peashrub	Eastern redcedar, lilac, Tatarian honeysuckle.	Austrian pine, red pine, honeylocust, Russian-olive, jack pine, green ash, Siberian elm.	Eastern white pine.	---
Salida.					

See footnote at end of table.

TABLE 8.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
559. Talcot	---	Siberian peashrub, Tatarian honeysuckle, lilac, northern white-cedar.	Hackberry, white spruce, bur oak, eastern redcedar.	Green ash, golden willow, honeylocust.	Eastern cottonwood.
651. Faxon	---	Amur privet, Amur honeysuckle, American cranberrybush, silky dogwood.	Norway spruce, Austrian pine, northern white-cedar, blue spruce, white fir, Washington hawthorn.	Eastern white pine	Pin oak.
655. Crippin	---	Northern white-cedar, Tatarian honeysuckle, Siberian peashrub, lilac.	Hackberry, white spruce, eastern redcedar, bur oak.	Golden willow, green ash, honeylocust.	Eastern cottonwood.
735. Havelock	---	Tatarian honeysuckle, northern white-cedar, Siberian peashrub, lilac.	White spruce, hackberry, eastern redcedar, bur oak.	Golden willow, honeylocust, green ash.	Eastern cottonwood.
1048. Knoke					
1585B*:					
Coland	---	Redosier dogwood, American plum, Tatarian honeysuckle.	Tall purple willow, hackberry, Amur maple, white spruce, northern white-cedar.	Green ash, golden willow.	Silver maple, eastern cottonwood.
Spillville	---	Lilac, Tatarian honeysuckle, redosier dogwood.	Northern white-cedar, white spruce, blue spruce, Amur maple.	Eastern white pine, hackberry, Austrian pine, green ash.	Silver maple.
1735. Havelock					
5010*, 5030*. Pits					
5040. Orthents					

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 9.--RECREATIONAL DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
4 Knoke	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
6 Okoboji	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
27B Terril	Slight	Slight	Moderate: slope.	Slight	Slight.
34 Estherville	Slight	Slight	Moderate: small stones.	Slight	Moderate: droughty.
34B Estherville	Slight	Slight	Moderate: slope, small stones.	Slight	Moderate: droughty.
34C2 Estherville	Slight	Slight	Severe: slope.	Slight	Moderate: droughty.
41B Sparta	Slight	Slight	Moderate: slope, small stones.	Slight	Moderate: droughty.
48 Knoke	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
55 Nicollet	Slight	Slight	Moderate: slope.	Slight	Slight.
62C2 Storden	Slight	Slight	Severe: slope.	Slight	Slight.
62D2 Storden	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
62E, 62F Storden	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
62G Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
90 Okoboji	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
95 Harps	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
107 Webster	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
108 Wadena	Slight	Slight	Moderate: small stones.	Slight	Slight.
108B Wadena	Slight	Slight	Moderate: slope, small stones.	Slight	Slight.
108C2 Wadena	Slight	Slight	Severe: slope.	Slight	Slight.
135 Coland	Severe: flooding, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, flooding.

TABLE 9.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
135B------------------ Coland	Severe: flooding, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, flooding.
138B------------------ Clarion	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
138C, 138C2----------- Clarion	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
138D2----------------- Clarion	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: slope.
141------------------- Watseka	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, droughty.
150------------------- Hanska	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
202, 203-------------- Cylinder	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Slight----------	Slight.
224------------------- Linder	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Slight----------	Slight.
259------------------- Biscay	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
274------------------- Rolfe	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding.
308B------------------ Wadena	Slight----------	Slight----------	Moderate: slope, small stones.	Slight----------	Slight.
330------------------- Kingston	Slight----------	Slight----------	Slight----------	Slight----------	Slight.
338------------------- Garmore	Slight----------	Slight----------	Slight----------	Slight----------	Slight.
338B------------------ Garmore	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
339B------------------ Truman	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
388------------------- Kossuth	Severe: wetness.	Moderate: wetness, percs slowly.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
485------------------- Spillville	Severe: flooding.	Slight----------	Moderate: flooding.	Slight----------	Moderate: flooding.
485B------------------ Spillville	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
506------------------- Wacousta	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
507------------------- Canisteo	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
508------------------- Calcousta	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.

TABLE 9.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
511 Blue Earth	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding.
541C*:					
Estherville	Slight	Slight	Severe: slope.	Slight	Moderate: droughty.
Salida	Moderate: small stones.	Moderate: small stones.	Severe: slope, small stones.	Slight	Severe: droughty.
559 Talcot	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
651 Faxon	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.
655 Crippin	Moderate: wetness.	Moderate: wetness.	Moderate: slope, wetness.	Slight	Slight.
735 Havelock	Severe: flooding, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, flooding.
1048 Knoke	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
1585B*:					
Coland	Severe: flooding, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, flooding.
Spillville	Slight	Slight	Moderate: slope.	Slight	Slight.
1735 Havelock	Severe: flooding, wetness.	Moderate: flooding, wetness.	Severe: wetness, flooding.	Moderate: wetness, flooding.	Severe: flooding.
5010*, 5030*. Pits					
5040. Orthents					

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 10.--WILDLIFE HABITAT POTENTIALS

[See text for definitions of "good," "fair," "poor," and "very poor." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
4 Knoke	Fair	Fair	Fair	Poor	Very poor.	Good	Good	Fair	Poor	Good.
6 Okoboji	Fair	Fair	Fair	Fair	Very poor.	Good	Good	Fair	Fair	Good.
27B Terril	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
34, 34B, 34C2 Estherville	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
41B Sparta	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
48 Knoke	Fair	Fair	Fair	Poor	Very poor.	Good	Good	Fair	Poor	Good.
55 Nicollet	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
62C2, 62D2, 62E Storden	Fair	Good	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
62F, 62G Storden	Poor	Fair	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
90 Okoboji	Fair	Fair	Fair	Fair	Very poor.	Good	Good	Fair	Fair	Good.
95 Harps	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
107 Webster	Good	Good	Good	Fair	Poor	Good	Good	Good	Fair	Good.
108, 108B Wadena	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
108C2 Wadena	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
135, 135B Coland	Good	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.
138B Clarion	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
138C, 138C2, 138D2 Clarion	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
141 Watseka	Fair	Fair	Good	Good	Good	Fair	Poor	Fair	Good	Poor.
150 Hanska	Fair	Fair	Fair	Fair	Fair	Good	Good	Fair	Fair	Good.
202, 203 Cylinder	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.

TABLE 10.--WILDLIFE HABITAT POTENTIALS--Continued

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
224----------------- Linder	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
259----------------- Biscay	Good	Good	Good	Good	Fair	Good	Good	Good	Fair	Good.
274----------------- Rolfe	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
308B---------------- Wadena	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
330----------------- Kingston	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
338, 338B----------- Garmore	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
339B---------------- Truman	Good	Good	Good	Good	Fair	Poor	Very poor.	Good	Good	Very poor.
388----------------- Kossuth	Good	Good	Good	Fair	Poor	Good	Good	Good	Fair	Good.
485----------------- Spillville	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
485B---------------- Spillville	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
506----------------- Wacousta	Good	Good	Fair	Good	Good	Poor	Poor	Good	Good	Poor.
507----------------- Canisteo	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
508----------------- Calcousta	Good	Good	Fair	Good	Good	Poor	Poor	Good	Good	Poor.
511----------------- Blue Earth	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Poor	Good.
541C*:										
Estherville--------	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
Salida-------------	Poor	Poor	Poor	Poor	Poor	Very poor.	Very poor.	Poor	Poor	Very poor.
559----------------- Talcot	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
651----------------- Faxon	Fair	Fair	Fair	Poor	Poor	Good	Fair	Fair	Poor	Fair.
655----------------- Crippin	Good	Good	Good	Good	Fair	Fair	Poor	Good	Good	Poor.
735----------------- Havelock	Good	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.
1048---------------- Knoke	Fair	Fair	Fair	Poor	Very poor.	Good	Good	Fair	Poor	Good.
1585B*:										
Coland-------------	Good	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.

See footnote at end of table.

TABLE 10.--WILDLIFE HABITAT POTENTIALS--Continued

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herba- ceous plants	Hardwood trees	Conif- erous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
1585B*:										
Spillville	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
1735 Havelock	Poor	Fair	Fair	Poor	Poor	Good	Good	Poor	Poor	Good.
5010*, 5030*. Pits										
5040. Orthents										

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 11.--BUILDING SITE DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
4 Knoke	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, low strength, shrink-swell.	Severe: ponding.
6 Okoboji	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.
27B Terril	Slight	Slight	Slight	Slight	Severe: low strength.	Slight.
34, 34B Estherville	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Moderate: droughty.
34C2 Estherville	Severe: cutbanks cave.	Slight	Slight	Moderate: slope.	Slight	Moderate: droughty.
41B Sparta	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Moderate: droughty.
48 Knoke	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, low strength, shrink-swell.	Severe: ponding.
55 Nicollet	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
62C2 Storden	Slight	Slight	Slight	Moderate: slope.	Moderate: frost action.	Slight.
62D2 Storden	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
62E, 62F, 62G Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
90 Okoboji	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.
95 Harps	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
107 Webster	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
108, 108B Wadena	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Slight.
108C2 Wadena	Severe: cutbanks cave.	Slight	Slight	Moderate: slope.	Slight	Slight.
135 Coland	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: low strength, flooding, frost action.	Moderate: wetness, flooding.

TABLE 11.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
135B: Coland	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: low strength, flooding, frost action.	Moderate: wetness, flooding.
138B: Clarion	Slight	Slight	Slight	Slight	Moderate: frost action.	Slight.
138C, 138C2: Clarion	Slight	Slight	Slight	Moderate: slope.	Moderate: frost action.	Slight.
138D2: Clarion	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
141: Watseka	Severe: wetness, cutbanks cave.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Moderate: wetness, frost action.	Moderate: wetness, droughty.
150: Hanska	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action.	Moderate: wetness.
202, 203: Cylinder	Severe: cutbanks cave, wetness.	Moderate: shrink-swell, wetness.	Severe: wetness.	Moderate: shrink-swell, wetness.	Severe: frost action.	Slight.
224: Linder	Severe: cutbanks cave, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Severe: frost action.	Slight.
259: Biscay	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
274: Rolfe	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.
308B: Wadena	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Slight.
330: Kingston	Moderate: wetness.	Slight	Moderate: wetness.	Slight	Severe: frost action.	Slight.
338, 338B: Garmore	Moderate: wetness.	Slight	Moderate: wetness.	Slight	Severe: frost action.	Slight.
339B: Truman	Slight	Slight	Slight	Moderate: slope.	Severe: low strength, frost action.	Slight.
388: Kossuth	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: low strength, frost action, shrink-swell.	Moderate: wetness.
485: Spillville	Moderate: flooding, wetness.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding.	Moderate: flooding.
485B: Spillville	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness, shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Slight.
506: Wacousta	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.

TABLE 11.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
507---------------- Canisteo	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
508---------------- Calcousta	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: low strength, ponding, frost action.	Severe: ponding.
511---------------- Blue Earth	Severe: excess humus, ponding.	Severe: low strength, ponding.	Severe: low strength, ponding.	Severe: low strength, ponding.	Severe: low strength, ponding, frost action.	Severe: ponding.
541C*:						
Estherville------	Severe: cutbanks cave.	Slight---------	Slight---------	Moderate: slope.	Slight---------	Moderate: droughty.
Salida-----------	Severe: cutbanks cave.	Slight---------	Slight---------	Moderate: slope.	Slight---------	Severe: droughty.
559---------------- Talcot	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
651---------------- Faxon	Severe: depth to rock, wetness.	Severe: wetness.	Severe: depth to rock, wetness.	Severe: wetness.	Severe: low strength, wetness.	Severe: wetness.
655---------------- Crippin	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Severe: frost action, low strength.	Slight.
735---------------- Havelock	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: low strength, flooding, frost action.	Moderate: wetness, flooding.
1048--------------- Knoke	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, low strength, shrink-swell.	Severe: ponding.
1585B*:						
Coland-----------	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: low strength, flooding, frost action.	Moderate: wetness, flooding.
Spillville-------	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness, shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Slight.
1735--------------- Havelock	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: low strength, flooding, frost action.	Severe: flooding.
5010*, 5030*. Pits						
5040. Orthents						

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 12.--SANITARY FACILITIES

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," "good," "fair," and other terms. Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
4------------------ Knoke	Severe: percs slowly, ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
6------------------ Okoboji	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: hard to pack, ponding.
27B---------------- Terril	Slight-----------	Moderate: seepage, slope.	Moderate: too clayey.	Slight-----------	Fair: too clayey.
34, 34B------------ Estherville	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
34C2--------------- Estherville	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
41B---------------- Sparta	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
48----------------- Knoke	Severe: percs slowly, ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
55----------------- Nicollet	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
62C2--------------- Storden	Slight-----------	Severe: slope.	Slight-----------	Slight-----------	Good.
62D2--------------- Storden	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
62E, 62F, 62G------- Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
90----------------- Okoboji	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: hard to pack, ponding.
95----------------- Harps	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: hard to pack, wetness.
107---------------- Webster	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
108, 108B----------- Wadena	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
108C2-------------- Wadena	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.

TABLE 12.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
135, 135B----------- Coland	Severe: flooding, wetness.	Severe: seepage, flooding, wetness.	Severe: flooding, seepage, wetness.	Severe: flooding, wetness.	Poor: hard to pack, wetness.
138B---------------- Clarion	Slight-----------	Moderate: slope, seepage.	Slight-----------	Slight-----------	Good.
138C, 138C2--------- Clarion	Slight-----------	Severe: slope.	Slight-----------	Slight-----------	Good.
138D2--------------- Clarion	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
141----------------- Watseka	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: wetness, seepage, too sandy.	Severe: seepage, wetness.	Poor: too sandy, wetness, seepage.
150----------------- Hanska	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, wetness.
202, 203------------ Cylinder	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: too sandy, seepage.
224----------------- Linder	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, small stones, too sandy.
259----------------- Biscay	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, small stones.
274----------------- Rolfe	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
308B---------------- Wadena	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
330----------------- Kingston	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness, too clayey.
338----------------- Garmore	Moderate: wetness, percs slowly.	Moderate: seepage, wetness.	Severe: wetness.	Moderate: wetness.	Fair: too clayey.
338B---------------- Garmore	Moderate: wetness, percs slowly.	Moderate: seepage, slope, wetness.	Severe: wetness.	Moderate: wetness.	Fair: too clayey.
339B---------------- Truman	Slight-----------	Moderate: seepage, slope.	Slight-----------	Slight-----------	Good.
388----------------- Kossuth	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.

TABLE 12.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
485 Spillville	Severe: wetness, flooding.	Severe: wetness, seepage, flooding.	Severe: wetness, seepage, flooding.	Severe: wetness, flooding.	Fair: wetness.
485B Spillville	Severe: wetness.	Severe: seepage, wetness.	Severe: seepage, wetness.	Severe: wetness.	Fair: wetness.
506 Wacousta	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
507 Canisteo	Severe: wetness.	Severe: seepage, wetness.	Severe: wetness.	Severe: seepage, wetness.	Poor: wetness.
508 Calcousta	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
511 Blue Earth	Severe: ponding.	Severe: ponding.	Severe: ponding, excess humus.	Severe: ponding.	Poor: hard to pack, ponding.
541C*:					
Estherville	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
Salida	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
559 Talcot	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, wetness.
651 Faxon	Severe: depth to rock, wetness.	Severe: depth to rock, wetness.	Severe: depth to rock, wetness.	Severe: depth to rock, wetness.	Poor: area reclaim, wetness.
655 Crippin	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
735 Havelock	Severe: flooding, wetness.	Severe: seepage, flooding, wetness.	Severe: flooding, seepage, wetness.	Severe: flooding, wetness.	Poor: hard to pack, wetness.
1048 Knoke	Severe: percs slowly, ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
1585B*:					
Coland	Severe: flooding, wetness.	Severe: seepage, flooding, wetness.	Severe: flooding, seepage, wetness.	Severe: flooding, wetness.	Poor: hard to pack, wetness.
Spillville	Severe: wetness.	Severe: seepage, wetness.	Severe: seepage, wetness.	Severe: wetness.	Fair: wetness.

See footnote at end of table.

TABLE 12.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
1735----------------- Havelock	Severe: flooding, wetness.	Severe: seepage, flooding, wetness.	Severe: flooding, seepage, wetness.	Severe: flooding, wetness.	Poor: hard to pack, wetness.
5010*, 5030*. Pits					
5040. Orthents					

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 13.--CONSTRUCTION MATERIALS

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," "poor," "probable," and "improbable." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
4 Knoke	Poor: wetness, low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
6 Okoboji	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
27B Terril	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
34, 34B, 34C2 Estherville	Good	Probable	Probable	Poor: small stones, area reclaim.
41B Sparta	Good	Probable	Improbable: too sandy.	Fair: too sandy.
48 Knoke	Poor: wetness, low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
55 Nicollet	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
62C2 Storden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
62D2 Storden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones, slope.
62E, 62F Storden	Fair: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
62G Storden	Poor: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
90 Okoboji	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
95 Harps	Fair: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: large stones.
107 Webster	Fair: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Good.
108, 108B, 108C2 Wadena	Good	Probable	Probable	Poor: small stones, area reclaim.
135, 135B Coland	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
138B, 138C, 138C2 Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Good.

TABLE 13.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
138D2: Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: slope.
141: Watseka	Fair: wetness.	Probable	Improbable: too sandy.	Fair: too sandy.
150: Hanska	Fair: wetness.	Probable	Improbable: too sandy.	Fair: small stones, thin layer.
202, 203: Cylinder	Fair: wetness.	Probable	Improbable: too sandy.	Fair: area reclaim, small stones, thin layer.
224: Linder	Fair: wetness.	Probable	Improbable: too sandy.	Poor: small stones, area reclaim.
259: Biscay	Fair: wetness.	Probable	Probable	Poor: area reclaim.
274: Rolfe	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer, wetness.
308B: Wadena	Good	Probable	Probable	Poor: small stones, area reclaim.
330: Kingston	Fair: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
338, 338B: Garmore	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
339B: Truman	Fair: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
388: Kossuth	Fair: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
485, 485B: Spillville	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
506: Wacousta	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
507: Canisteo	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
508: Calcousta	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
511: Blue Earth	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
541C*:				
Estherville	Good	Probable	Probable	Poor: small stones, area reclaim.

See footnote at end of table.

TABLE 13.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
541C*:				
Salida	Good	Probable	Probable	Poor: small stones, area reclaim, too sandy.
559 Talcot	Fair: wetness.	Probable	Probable	Fair: small stones, area reclaim, thin layer.
651 Faxon	Poor: area reclaim, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: small stones, wetness.
655 Crippin	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
735 Havelock	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
1048 Knoke	Poor: wetness, low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
1585B*:				
Coland	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
Spillville	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
1735 Havelock	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
5010*, 5030*. Pits				
5040. Orthents				

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 14.--WATER MANAGEMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not evaluated]

Soil name and map symbol	Limitations for--		Features affecting--			
	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
4----------------- Knoke	Slight----------	Severe: hard to pack, ponding.	Ponding, frost action.	Ponding---------	Ponding, erodes easily.	Wetness, erodes easily.
6----------------- Okoboji	Moderate: seepage.	Severe: ponding.	Ponding, frost action.	Ponding---------	Not needed------	Not needed.
27B--------------- Terril	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Slope-----------	Favorable-------	Favorable.
34---------------- Estherville	Severe: seepage.	Severe: seepage.	Deep to water	Droughty, soil blowing.	Too sandy, soil blowing.	Droughty.
34B, 34C2--------- Estherville	Severe: seepage.	Severe: seepage.	Deep to water	Droughty, soil blowing, slope.	Too sandy, soil blowing.	Droughty.
41B--------------- Sparta	Severe: seepage.	Severe: seepage, piping.	Deep to water	Droughty, fast intake, soil blowing.	Too sandy, soil blowing.	Droughty.
48---------------- Knoke	Slight----------	Severe: hard to pack, ponding.	Ponding, frost action.	Ponding---------	Ponding, erodes easily.	Wetness, erodes easily.
55---------------- Nicollet	Moderate: seepage.	Severe: piping.	Frost action---	Wetness---------	Wetness---------	Favorable.
62C2-------------- Storden	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Slope-----------	Erodes easily	Erodes easily.
62D2, 62E, 62F, 62G-------------- Storden	Severe: slope.	Moderate: piping.	Deep to water	Slope-----------	Slope, erodes easily.	Slope, erodes easily.
90---------------- Okoboji	Moderate: seepage.	Severe: ponding.	Ponding, frost action.	Ponding---------	Not needed------	Not needed.
95---------------- Harps	Moderate: seepage.	Severe: wetness.	Frost action---	Wetness---------	Wetness---------	Wetness.
107--------------- Webster	Moderate: seepage.	Severe: wetness.	Frost action---	Wetness---------	Wetness---------	Wetness.
108--------------- Wadena	Severe: seepage.	Severe: seepage, piping.	Deep to water	Favorable-------	Too sandy-------	Favorable.
108B, 108C2------- Wadena	Severe: seepage.	Severe: seepage, piping.	Deep to water	Slope-----------	Too sandy-------	Favorable.
135--------------- Coland	Moderate: seepage.	Severe: wetness.	Flooding, frost action.	Wetness, flooding.	Wetness---------	Wetness.
135B-------------- Coland	Moderate: seepage, slope.	Severe: wetness.	Flooding, frost action, slope.	Wetness, slope, flooding.	Wetness---------	Wetness.
138B, 138C, 138C2- Clarion	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope-----------	Erodes easily	Erodes easily.
138D2------------- Clarion	Severe: slope.	Severe: piping.	Deep to water	Slope-----------	Slope, erodes easily.	Slope, erodes easily.

TABLE 14.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for--		Features affecting--			
	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
141---------------- Watseka	Severe: seepage.	Severe: piping, seepage, wetness.	Cutbanks cave	Wetness, droughty, fast intake.	Wetness, too sandy, soil blowing.	Wetness, droughty.
150---------------- Hanska	Severe: seepage.	Severe: seepage, wetness.	Frost action, cutbanks cave.	Wetness---------	Wetness, too sandy.	Wetness.
202, 203----------- Cylinder	Severe: seepage.	Severe: seepage, piping.	Frost action, cutbanks cave.	Wetness---------	Wetness, too sandy.	Favorable.
224---------------- Linder	Severe: seepage.	Severe: seepage, piping.	Frost action, cutbanks cave.	Wetness, droughty.	Wetness, too sandy.	Droughty.
259---------------- Biscay	Severe: seepage.	Severe: seepage, wetness.	Frost action, cutbanks cave.	Wetness---------	Wetness, too sandy.	Wetness.
274---------------- Rolfe	Moderate: seepage.	Severe: ponding.	Ponding, percs slowly, frost action.	Ponding, percs slowly.	Ponding---------	Wetness, percs slowly.
308B--------------- Wadena	Severe: seepage.	Severe: seepage, piping.	Deep to water	Slope-----------	Too sandy-------	Favorable.
330---------------- Kingston	Moderate: seepage.	Severe: piping.	Frost action---	Wetness---------	Erodes easily, wetness.	Erodes easily.
338---------------- Garmore	Moderate: seepage.	Moderate: piping.	Deep to water	Favorable-------	Erodes easily	Erodes easily.
338B--------------- Garmore	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Slope-----------	Erodes easily	Erodes easily.
339B--------------- Truman	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope-----------	Erodes easily	Erodes easily.
388---------------- Kossuth	Moderate: seepage.	Severe: wetness.	Frost action---	Wetness, rooting depth.	Wetness---------	Wetness, rooting depth.
485---------------- Spillville	Moderate: seepage.	Moderate: piping, wetness.	Deep to water	Flooding--------	Favorable-------	Favorable.
485B--------------- Spillville	Moderate: seepage, slope.	Moderate: thin layer, piping, wetness.	Deep to water	Slope-----------	Favorable-------	Favorable.
506---------------- Wacousta	Moderate: seepage.	Severe: piping, ponding.	Ponding, frost action.	Ponding---------	Not needed------	Not needed.
507---------------- Canisteo	Severe: seepage.	Severe: wetness.	Frost action---	Wetness---------	Wetness---------	Wetness.
508---------------- Calcousta	Moderate: seepage.	Severe: piping, ponding.	Ponding, frost action.	Ponding---------	Erodes easily, ponding.	Wetness, erodes easily.
511---------------- Blue Earth	Moderate: seepage.	Severe: piping, excess humus, ponding.	Ponding, frost action.	Ponding---------	Ponding---------	Wetness.

TABLE 14.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for--		Features affecting--			
	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
541C*:						
Estherville	Severe: seepage.	Severe: seepage.	Deep to water	Droughty, soil blowing, slope.	Too sandy, soil blowing.	Droughty.
Salida	Severe: seepage.	Severe: seepage.	Deep to water	Droughty, fast intake, slope.	Too sandy	Droughty.
559 Talcot	Severe: seepage.	Severe: seepage, wetness.	Frost action, cutbanks cave.	Wetness	Wetness, too sandy.	Wetness.
651 Faxon	Moderate: seepage, depth to rock.	Severe: piping, wetness.	Depth to rock, frost action.	Depth to rock, wetness.	Depth to rock, wetness.	Wetness, depth to rock.
655 Crippin	Moderate: seepage.	Moderate: wetness, piping.	Frost action	Wetness	Wetness, erodes easily.	Erodes easily.
735 Havelock	Moderate: seepage.	Severe: wetness.	Flooding, frost action.	Wetness, flooding.	Wetness	Wetness.
1048 Knoke	Slight	Severe: hard to pack, ponding.	Ponding, frost action.	Ponding	Ponding, erodes easily.	Wetness, erodes easily.
1585B*:						
Coland	Moderate: seepage, slope.	Severe: wetness.	Flooding, frost action, slope.	Wetness, slope, flooding.	Wetness	Wetness.
Spillville	Moderate: seepage, slope.	Moderate: thin layer, piping, wetness.	Deep to water	Slope	Favorable	Favorable.
1735 Havelock	Moderate: seepage.	Severe: wetness.	Flooding, frost action.	Wetness, flooding.	Wetness	Wetness.
5010*, 5030*. Pits						
5040. Orthents						

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 15.--ENGINEERING INDEX PROPERTIES

[The symbol < means less than; > means more than. Absence of an entry indicates that data were not estimated]

Soil name and map symbol	Depth	USDA texture	Classification: Unified	Classification: AASHTO	Fragments > 3 inches	Percentage passing sieve number--: 4	10	40	200	Liquid limit	Plasticity index
	In				Pct					Pct	
4----------------- Knoke	0-9	Silty clay loam	MH, OH	A-7	0	100	100	90-100	80-95	55-90	15-40
	9-40	Silty clay loam, mucky silty clay loam.	MH, OH	A-7	0	100	100	90-100	80-95	55-90	15-40
	40-60	Silty clay loam, silt loam, loam.	CL, CH	A-7	0	95-100	95-100	90-100	80-95	30-55	15-40
6----------------- Okoboji	0-8	Silty clay loam	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	8-36	Silty clay loam, silty clay.	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	36-60	Silty clay loam, silty clay.	CH	A-7	0	95-100	95-100	90-100	80-95	55-65	30-40
27B--------------- Terril	0-32	Loam--------------	CL	A-6	0-5	100	95-100	70-90	60-80	30-40	10-20
	32-60	Clay loam, loam	CL	A-6	0-5	100	100	85-95	65-85	25-40	10-20
34, 34B----------- Estherville	0-13	Sandy loam--------	SM, SM-SC, SC	A-2, A-4	0-5	90-100	80-100	50-75	25-50	20-30	2-10
	13-18	Sandy loam, loam, coarse sandy loam.	SM, SM-SC, SC	A-2, A-4, A-1	0-5	85-100	80-95	40-75	15-45	20-30	2-8
	18-60	Coarse sand, gravelly coarse sand, loamy coarse sand.	SP, SP-SM, SM	A-1	0-10	55-90	50-85	10-40	2-25	---	NP
34C2-------------- Estherville	0-7	Sandy loam--------	SM, SM-SC, SC	A-2, A-4	0-5	90-100	80-100	50-75	25-50	20-30	2-10
	7-12	Sandy loam, loam, coarse sandy loam.	SM, SM-SC, SC	A-2, A-4, A-1	0-5	85-100	80-95	40-75	15-45	20-30	2-8
	12-60	Coarse sand, gravelly coarse sand, loamy coarse sand.	SP, SP-SM, SM	A-1	0-10	55-90	50-85	10-40	2-25	---	NP
41B--------------- Sparta	0-13	Loamy fine sand	SM	A-2, A-4	0	85-100	85-100	50-95	15-50	---	NP
	13-31	Loamy fine sand, fine sand, sand.	SP-SM, SM	A-2, A-3, A-4	0	85-100	85-100	50-95	5-50	---	NP
	31-60	Sand, fine sand	SP-SM, SM, SP	A-2, A-3	0	85-100	85-100	50-95	2-30	---	NP
48---------------- Knoke	0-12	Mucky silt loam	OH, MH	A-7	0	100	100	95-100	90-95	60-90	10-30
	12-16	Silty clay loam, mucky silty clay loam.	MH, OH	A-7	0	100	100	90-100	80-95	55-90	15-40
	16-60	Silty clay loam, silt loam, loam.	CL, CH	A-7	0	95-100	95-100	90-100	80-95	30-55	15-40
55---------------- Nicollet	0-22	Clay loam---------	OL, ML, CL	A-6, A-7	0	95-100	90-100	85-98	55-85	35-50	10-25
	22-31	Clay loam, loam	CL	A-6, A-7	0-5	95-100	90-100	80-95	55-80	35-50	15-25
	31-60	Loam, clay loam	CL	A-6, A-4	0-5	95-100	90-100	75-90	50-75	30-40	15-25
62C2, 62D2-------- Storden	0-8	Loam--------------	ML, CL, CL-ML	A-4, A-6	0-5	95-100	95-100	70-85	55-70	30-40	5-15
	8-60	Loam, clay loam	CL-ML, CL, ML	A-4, A-6	0-5	95-100	85-97	70-85	55-70	20-40	5-15
62E, 62F, 62G----- Storden	0-5	Loam--------------	ML, CL, CL-ML	A-4, A-6	0-5	95-100	95-100	70-85	55-70	30-40	5-15
	5-60	Loam, clay loam	CL-ML, CL, ML	A-4, A-6	0-5	95-100	85-97	70-85	55-70	20-40	5-15

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag- ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
90---------------- Okoboji	0-15	Mucky silty clay loam.	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	15-40	Silty clay loam, silty clay.	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	40-60	Silty clay loam, silty clay.	CH	A-7	0	95-100	95-100	90-100	80-95	55-65	30-40
95---------------- Harps	0-19	Clay loam--------	CL, CH	A-6, A-7	0-5	100	95-100	80-90	65-80	30-55	15-35
	19-41	Loam, clay loam, sandy clay loam.	CL, CH	A-6, A-7	0-5	95-100	95-100	80-90	65-80	30-60	15-35
	41-60	Loam, sandy clay loam.	CL	A-6	0-5	95-100	90-100	70-80	50-75	25-40	10-25
107--------------- Webster	0-20	Clay loam--------	CL, CH	A-7, A-6	0-5	100	95-100	85-95	70-90	35-60	15-30
	20-36	Clay loam, silty clay loam, loam.	CL	A-6, A-7	0-5	95-100	95-100	85-95	60-80	35-50	15-30
	36-60	Loam, sandy loam, clay loam.	CL	A-6	0-5	95-100	90-100	75-85	50-75	30-40	10-20
108, 108B--------- Wadena	0-14	Loam-------------	ML	A-4	0	95-100	80-100	75-95	50-65	25-40	2-10
	14-26	Loam, sandy loam, sandy clay loam.	SM, ML, Cl-ML, SM-SC	A-4, A-6	0	95-100	80-100	75-95	40-60	25-40	5-12
	26-60	Stratified gravelly coarse sand to gravelly sand.	SP, SP-SM, GP, GP-GM	A-1, A-3, A-2	0-5	45-100	40-95	10-80	2-10	---	NP
108C2------------- Wadena	0-7	Loam-------------	ML	A-4	0	95-100	80-100	75-95	50-65	25-40	2-10
	7-24	Loam, sandy loam, sandy clay loam.	SM, ML, CL-ML, SM-SC	A-4, A-6	0	95-100	80-100	75-95	40-60	25-40	5-12
	24-60	Stratified gravelly coarse sand to gravelly sand.	SP, SP-SM, GP, GP-GM	A-1, A-3, A-2	0-5	45-100	40-95	10-80	2-10	---	NP
135, 135B--------- Coland	0-7	Clay loam--------	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	7-37	Clay loam, silty clay loam.	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	37-60	Loam, sandy loam, sandy clay loam.	CL, SC, CL-ML, SM-SC	A-4, A-6	0	100	90-100	60-70	40-60	20-40	5-15
138B, 138C-------- Clarion	0-16	Loam-------------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	16-41	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	41-60	Loam, sandy loam	CL, CL-ML, SC, SM-SC	A-4, A-6	0-5	90-100	85-100	75-90	45-70	25-40	5-15
138C2, 138D2------ Clarion	0-7	Loam-------------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	7-27	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	27-60	Loam, sandy loam	CL, CL-ML, SC, SM-SC	A-4, A-6	0-5	90-100	85-100	75-90	45-70	25-40	5-15
141--------------- Watseka	0-21	Loamy sand-------	SM, SM-SC	A-2	0	100	95-100	80-100	17-35	<25	NP-5
	21-60	Fine sand, sand, loamy fine sand.	SP, SM, SP-SM	A-3, A-2	0	90-100	90-100	60-80	3-25	<20	NP-4
150--------------- Hanska	0-21	Loam-------------	ML, CL, CL-ML	A-4	0	98-100	95-100	80-95	50-65	<25	2-10
	21-30	Sandy loam, coarse sandy loam, loam.	SM, SM-SC, SC	A-4	0	98-100	95-100	65-80	35-50	<20	2-8
	30-34	Loamy sand, loamy coarse sand.	SP-SM, SM	A-2, A-3	0	95-100	90-100	50-75	5-25	<20	NP
	34-60	Sand, coarse sand	SP-SM	A-3, A-1, A-2	0	95-100	85-100	45-70	5-10	<20	NP

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag- ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
202--------------- Cylinder	0-20	Clay loam, loam	CL	A-6, A-7	0	100	90-100	80-100	50-75	30-50	10-25
	20-30	Loam, clay loam, gravelly loam.	CL, SC	A-6	0	95-100	80-100	80-95	45-70	30-40	10-20
	30-60	Gravelly coarse sand, loamy sand.	SP-SM, SM	A-1, A-2, A-3	0-10	75-95	75-95	20-55	5-25	---	NP
203--------------- Cylinder	0-20	Clay loam, loam	CL	A-6, A-7	0	100	90-100	80-100	50-75	30-50	10-25
	20-36	Loam, clay loam, gravelly loam.	CL, SC	A-6	0	95-100	80-100	80-95	45-70	30-40	10-20
	36-60	Gravelly coarse sand, loamy sand.	SP-SM, SM	A-1, A-2, A-3	0-10	75-95	75-95	20-55	5-25	---	NP
224--------------- Linder	0-11	Loam--------------	CL, SC	A-4, A-6	0	100	95-100	80-95	35-80	25-40	8-15
	11-24	Sandy loam--------	SC, SM-SC	A-2, A-4	0	95-100	80-100	45-75	30-45	20-30	5-10
	24-60	Gravelly sand, sand, loamy coarse sand.	SP, SP-SM	A-1	0-5	75-95	30-95	25-50	2-12	---	NP
259--------------- Biscay	0-19	Clay loam---------	CL, ML	A-7, A-6	0	95-100	95-100	70-95	50-80	35-50	10-25
	19-36	Loam, clay loam, sandy clay loam.	CL, ML	A-6, A-7	0	95-100	90-100	70-90	50-75	30-50	10-20
	36-60	Stratified loamy sand to gravelly coarse sand.	SP, SP-SM, GP, GP-GM	A-1	0-5	45-95	35-95	20-45	2-10	---	NP
274--------------- Rolfe	0-19	Silt loam---------	OL, CL, ML	A-6, A-4	0	100	95-100	90-100	80-95	30-40	5-15
	19-51	Clay, silty clay, clay loam.	CH	A-7	0	100	95-100	90-100	75-95	50-65	25-35
	51-60	Clay loam, loam	CL	A-7, A-6	0	95-100	90-100	80-90	55-75	30-45	10-20
308B-------------- Wadena	0-14	Loam--------------	ML	A-4	0	95-100	80-100	75-95	50-65	25-40	2-10
	14-36	Loam, sandy loam, sandy clay loam.	SM, ML, CL-ML, SM-SC	A-4, A-6	0	95-100	80-100	75-95	40-60	25-40	5-12
	36-60	Stratified gravelly coarse sand to gravelly sand.	SP, SP-SM, GP, GP-GM	A-1, A-3, A-2	0-5	45-100	40-95	10-80	2-10	---	NP
330--------------- Kingston	0-21	Silty clay loam	OL, CL-ML, CL	A-4, A-6	0	100	100	95-100	85-100	25-40	6-20
	21-39	Silty clay loam, silt loam.	ML	A-6, A-7, A-4	0	100	100	95-100	85-100	35-50	6-20
	39-60	Silt loam, silty clay loam.	CL-ML, CL, ML	A-4, A-6	0	100	100	95-100	85-100	25-50	5-15
338, 338B--------- Garmore	0-18	Loam--------------	CL, CL-ML	A-4, A-6	0-5	95-100	90-100	80-95	50-65	25-40	5-20
	18-51	Loam, clay loam	CL	A-6	0-5	95-100	90-100	80-95	50-65	30-40	10-20
	51-60	Loam--------------	CL, CL-ML	A-6, A-4	0-5	95-100	90-100	80-95	50-65	25-40	5-15
339B-------------- Truman	0-15	Silt loam---------	CL-ML, CL	A-4, A-6	0	100	100	95-100	80-100	25-40	5-15
	15-32	Silt loam, silty clay loam.	CL, CL-ML	A-4, A-6, A-7	0	100	100	95-100	80-100	25-45	5-20
	32-60	Silt loam---------	CL, CL-ML	A-4, A-6	0	100	100	95-100	75-95	25-40	5-15
388--------------- Kossuth	0-21	Silty clay loam	CL, CH	A-7	0	95-100	95-100	80-85	75-85	40-60	20-30
	21-44	Silty clay loam, clay loam, clay.	CL, CH	A-7	0	95-100	95-100	80-85	75-85	45-65	25-35
	44-60	Loam--------------	CL	A-4, A-6	0-5	95-100	90-100	70-85	50-70	25-40	8-20

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag- ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
485, 485B-------- Spillville	0-49	Loam-------------	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
	49-60	Sandy clay loam, loam, sandy loam.	CL, CL-ML, SM-SC, SC	A-6, A-4	0	100	95-100	80-90	35-75	20-40	5-15
506-------------- Wacousta	0-15	Silty clay loam	CH, CL	A-7	0	100	100	95-100	95-100	40-65	20-40
	15-60	Silt loam, silty clay loam.	CL, ML	A-6, A-4	0-5	95-100	95-100	85-100	80-90	30-40	5-15
507-------------- Canisteo	0-16	Clay loam--------	OL, CL	A-7	0	98-100	95-100	85-98	60-90	40-50	15-20
	16-24	Clay loam, loam, silty clay loam.	CL	A-6, A-7	0	98-100	90-100	85-95	65-85	38-50	25-35
	24-35	Clay loam, loam, sandy loam.	CL, ML, SM, SC	A-6, A-4	0-5	90-100	80-95	60-90	40-80	30-40	5-15
	35-60	Clay loam, loam, fine sandy loam.	CL	A-6	0-5	95-100	90-98	80-95	50-75	30-40	12-20
508-------------- Calcousta	0-15	Silty clay loam	CH, CL	A-7	0	100	100	95-100	95-100	40-65	20-40
	15-21	Silty clay loam, silt loam.	CH, CL	A-7	0	100	100	90-100	90-100	40-60	20-35
	21-60	Silty clay loam, silt loam.	CL, ML	A-6, A-4	0-5	95-100	95-100	85-100	80-90	30-40	5-15
511-------------- Blue Earth	0-9	Mucky silty clay loam.	OL, ML	A-5	0	95-100	95-100	85-95	80-95	41-50	2-8
	9-60	Mucky silty clay loam, clay loam, mucky silt loam.	OL, ML	A-5	0	95-100	80-100	80-95	80-95	41-50	2-8
541C*: Estherville-----	0-7	Sandy loam-------	SM, SM-SC, SC	A-2, A-4	0-5	90-100	80-100	50-75	25-50	20-30	2-10
	7-12	Sandy loam, loam, coarse sandy loam.	SM, SM-SC, SC	A-2, A-4, A-1	0-5	85-100	80-95	40-75	15-45	20-30	2-8
	12-60	Coarse sand, gravelly coarse sand, loamy coarse sand.	SP, SP-SM, SM	A-1	0-10	55-90	50-85	10-40	2-25	---	NP
Salida----------	0-9	Gravelly sandy loam.	SM, SP-SM	A-2, A-1	0-5	85-95	60-75	30-60	12-20	---	NP
	9-60	Very gravelly coarse sand, very gravelly sand.	SP, SW, GP, GW	A-1	0-5	20-70	10-60	5-30	0-5	---	NP
559-------------- Talcot	0-18	Clay loam--------	CL	A-7	0	100	100	80-90	60-85	40-50	15-25
	18-34	Clay loam, silty clay loam, loam.	CL	A-7	0	95-100	85-100	70-90	60-85	40-50	15-25
	34-60	Stratified loamy sand to gravelly coarse sand.	SP, SP-SM, SW	A-1	0	65-90	50-85	20-50	2-10	---	NP
651-------------- Faxon	0-19	Silt loam, silty clay loam.	ML, CL	A-6, A-4	0-10	95-100	90-100	85-100	50-80	30-40	5-15
	19-37	Silty clay loam, clay, clay loam.	CL, ML, SC, SM	A-7, A-6	0-10	95-100	70-100	65-95	40-85	30-50	10-20
	37	Unweathered bedrock.	---	---	---	---	---	---	---	---	---

See footnote at end of table.

TABLE 15.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Frag- ments > 3 inches	Percentage passing sieve number--				Liquid limit	Plas- ticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
655---------------- Crippin	0-15	Loam---------------	CL	A-6, A-7	0	95-100	95-100	80-90	60-80	30-45	10-20
	15-35	Loam, clay loam	CL	A-6	0-5	95-100	90-100	80-90	60-80	30-40	10-20
	35-60	Loam, clay loam	CL	A-6	2-5	90-100	85-100	75-90	55-80	30-40	10-20
735---------------- Havelock	0-40	Clay loam---------	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	40-60	Loam, sandy loam, sandy clay loam.	CL, SC, CL-ML, SM-SC	A-4, A-6	0	100	90-100	60-70	40-60	20-40	5-15
1048--------------- Knoke	0-10	Mucky silt loam	OH, MH	A-7	0	100	100	95-100	90-95	60-90	10-30
	10-19	Silty clay loam, mucky silty clay loam.	MH, OH	A-7	0	100	100	90-100	80-95	55-90	15-40
	19-60	Silty clay loam, silt loam, loam.	CL, CH	A-7	0	95-100	95-100	90-100	80-95	30-55	15-40
1585B*:											
Coland-----------	0-7	Clay loam---------	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	7-37	Clay loam, silty clay loam.	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	37-60	Loam, sandy loam, sandy clay loam.	CL, SC, CL-ML, SM-SC	A-4, A-6	0	100	90-100	60-70	40-60	20-40	5-15
Spillville-------	0-49	Loam---------------	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
	49-60	Sandy clay loam, loam, sandy loam.	CL, CL-ML, SM-SC, SC	A-6, A-4	0	100	95-100	80-90	35-75	20-40	5-15
1735--------------- Havelock	0-40	Clay loam---------	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	40-60	Loam, sandy loam, sandy clay loam.	CL, SC, CL-ML, SM-SC	A-4, A-6	0	100	90-100	60-70	40-60	20-40	5-15
5010*, 5030*. Pits											
5040. Orthents											

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS

[The symbol < means less than; > means more than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" and "Organic matter" apply only to the surface layer. Absence of an entry indicates that data were not available or were not estimated]

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors		Wind erodibility group	Organic matter
								K	T		
	In	Pct	G/cm3	In/hr	In/in	pH					Pct
4------------------ Knoke	0-9	27-36	1.30-1.40	0.2-0.6	0.21-0.23	7.4-8.4	High----------	0.37	5	7	7-15
	9-40	27-36	1.30-1.40	0.2-0.6	0.21-0.23	7.4-8.4	High----------	0.37			
	40-60	20-40	1.35-1.45	0.2-0.6	0.18-0.20	7.4-8.4	High----------	0.37			
6------------------ Okoboji	0-8	35-42	1.25-1.30	0.2-0.6	0.21-0.23	6.1-7.8	High----------	0.37	5	4	7-15
	8-36	35-42	1.30-1.35	0.2-0.6	0.18-0.20	6.6-7.8	High----------	0.37			
	36-60	35-45	1.35-1.40	0.2-0.6	0.18-0.20	7.4-8.4	High----------	0.37			
27B---------------- Terril	0-32	18-26	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low-----------	0.24	5	6	4-5
	32-60	22-30	1.45-1.70	0.6-2.0	0.16-0.18	6.1-7.8	Low-----------	0.32			
34, 34B------------ Estherville	0-13	5-15	1.25-1.35	2.0-6.0	0.13-0.18	5.6-7.3	Low-----------	0.20	3	3	2-4
	13-18	10-18	1.35-1.60	2.0-6.0	0.09-0.14	5.6-7.3	Low-----------	0.20			
	18-60	0-8	1.50-1.65	>6.0	0.02-0.04	6.6-8.4	Low-----------	0.10			
34C2--------------- Estherville	0-7	5-15	1.25-1.35	2.0-6.0	0.13-0.18	5.6-7.3	Low-----------	0.20	3	3	1-2
	7-12	10-18	1.35-1.60	2.0-6.0	0.09-0.14	5.6-7.3	Low-----------	0.20			
	12-60	0-8	1.50-1.65	>6.0	0.02-0.04	6.6-8.4	Low-----------	0.10			
41B---------------- Sparta	0-13	3-10	1.20-1.40	2.0-6.0	0.09-0.12	5.1-7.3	Low-----------	0.17	5	2	1-2
	13-31	1-8	1.40-1.60	6.0-20	0.05-0.11	5.1-6.5	Low-----------	0.17			
	31-60	0-5	1.50-1.70	6.0-20	0.04-0.07	5.1-6.0	Low-----------	0.17			
48----------------- Knoke	0-12	20-26	1.10-1.20	0.6-2.0	0.24-0.26	7.4-8.4	Moderate------	0.28	5	6	10-15
	12-16	27-36	1.30-1.40	0.2-0.6	0.21-0.23	7.4-8.4	High----------	0.37			
	16-60	20-40	1.35-1.45	0.2-0.6	0.18-0.20	7.4-8.4	High----------	0.37			
55----------------- Nicollet	0-22	24-35	1.15-1.25	0.6-2.0	0.17-0.22	5.6-7.3	Moderate------	0.24	5	6	4-8
	22-31	24-35	1.25-1.35	0.6-2.0	0.15-0.19	5.6-7.8	Moderate------	0.32			
	31-60	22-32	1.35-1.45	0.6-2.0	0.14-0.19	7.4-8.4	Low-----------	0.32			
62C2, 62D2--------- Storden	0-8	18-27	1.35-1.45	0.6-2.0	0.20-0.22	7.4-8.4	Low-----------	0.28	5	4L	1-2
	8-60	18-30	1.35-1.65	0.6-2.0	0.17-0.19	7.4-8.4	Low-----------	0.37			
62E, 62F, 62G------ Storden	0-5	18-27	1.35-1.45	0.6-2.0	0.20-0.22	7.4-8.4	Low-----------	0.28	5	4L	1-2
	5-60	18-30	1.35-1.65	0.6-2.0	0.17-0.19	7.4-8.4	Low-----------	0.37			
90----------------- Okoboji	0-15	35-42	1.25-1.30	0.2-0.6	0.21-0.23	6.1-7.8	High----------	0.37	5	4	10-18
	15-40	35-42	1.30-1.35	0.2-0.6	0.18-0.20	6.6-7.8	High----------	0.37			
	40-60	35-45	1.35-1.40	0.2-0.6	0.18-0.20	7.4-8.4	High----------	0.37			
95----------------- Harps	0-19	25-35	1.35-1.40	0.6-2.0	0.19-0.21	7.9-8.4	Moderate------	0.24	5	4L	4-5
	19-41	18-32	1.40-1.50	0.6-2.0	0.17-0.19	7.9-8.4	Moderate------	0.32			
	41-60	20-26	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Moderate------	0.32			
107---------------- Webster	0-20	26-36	1.35-1.40	0.6-2.0	0.19-0.21	6.6-7.3	Moderate------	0.24	5	6	6-7
	20-36	25-35	1.40-1.50	0.6-2.0	0.16-0.18	6.6-7.8	Moderate------	0.32			
	36-60	18-29	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Moderate------	0.32			
108, 108B---------- Wadena	0-14	18-30	1.30-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Low-----------	0.24	4	5	2-4
	14-26	18-30	1.35-1.50	0.6-2.0	0.14-0.19	5.6-7.3	Low-----------	0.32			
	26-60	1-5	1.55-1.65	>6.0	0.02-0.04	6.6-8.4	Low-----------	0.10			
108C2-------------- Wadena	0-7	18-30	1.30-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Low-----------	0.24	4	5	2-4
	7-24	18-30	1.35-1.50	0.6-2.0	0.14-0.19	5.6-7.3	Low-----------	0.32			
	24-60	1-5	1.55-1.65	>6.0	0.02-0.04	6.6-8.4	Low-----------	0.10			
135, 135B---------- Coland	0-7	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High----------	0.28	5	7	5-7
	7-37	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High----------	0.28			
	37-60	12-26	1.50-1.65	0.6-6.0	0.13-0.17	6.1-7.8	Low-----------	0.28			
138B, 138C--------- Clarion	0-16	18-24	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low-----------	0.28	5	6	3-5
	16-41	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low-----------	0.37			
	41-60	12-22	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Low-----------	0.37			

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	G/cm3	In/hr	In/in	pH					Pct
138C2, 138D2----- Clarion	0-7	18-24	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low-----------	0.28	5	6	2-3
	7-27	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low-----------	0.37			
	27-60	12-22	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Low-----------	0.37			
141--------------- Watseka	0-21	8-13	1.35-1.55	6.0-20	0.10-0.12	6.1-7.3	Low-----------	0.17	5	2	1-3
	21-60	1-10	1.70-2.00	6.0-20	0.05-0.10	5.1-7.3	Low-----------	0.17			
150--------------- Hanska	0-21	6-18	1.30-1.40	2.0-6.0	0.20-0.22	6.1-7.8	Low-----------	0.28	4	5	4-8
	21-30	6-18	1.35-1.50	2.0-6.0	0.10-0.13	6.1-7.3	Low-----------	0.28			
	30-34	2-10	1.50-1.60	6.0-20	0.08-0.10	6.1-7.8	Low-----------	0.17			
	34-60	1-10	1.50-1.60	6.0-20	0.03-0.05	6.6-7.8	Low-----------	0.17			
202--------------- Cylinder	0-20	22-32	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Moderate-----	0.24	4	6	4-5
	20-30	22-30	1.45-1.60	0.6-2.0	0.17-0.19	6.1-7.3	Moderate-----	0.32			
	30-60	2-12	1.60-1.70	>20	0.02-0.04	6.6-8.4	Low-----------	0.10			
203--------------- Cylinder	0-20	22-32	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Moderate-----	0.24	4	6	4-5
	20-36	22-30	1.45-1.60	0.6-2.0	0.17-0.19	6.1-7.3	Moderate-----	0.32			
	36-60	2-12	1.60-1.70	>20	0.02-0.04	6.6-8.4	Low-----------	0.10			
224--------------- Linder	0-11	14-18	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.8	Low-----------	0.24	4	5	3-4
	11-24	10-18	1.45-1.55	2.0-6.0	0.15-0.17	6.1-7.8	Low-----------	0.24			
	24-60	2-8	1.55-1.75	>20	0.02-0.04	7.4-8.4	Low-----------	0.10			
259--------------- Biscay	0-19	18-30	1.20-1.30	0.6-2.0	0.20-0.22	6.1-7.8	Moderate-----	0.28	4	6	4-8
	19-36	18-30	1.25-1.35	0.6-2.0	0.17-0.19	6.6-7.8	Moderate-----	0.28			
	36-60	1-6	1.55-1.65	6.0-20	0.02-0.04	7.4-8.4	Low-----------	0.10			
274--------------- Rolfe	0-19	22-28	1.35-1.40	0.6-2.0	0.22-0.24	5.1-7.3	Moderate-----	0.28	5	6	3-5
	19-51	38-45	1.40-1.50	0.06-0.2	0.11-0.13	6.1-7.3	High----------	0.28			
	51-60	24-35	1.50-1.60	0.2-2.0	0.14-0.16	6.1-8.4	Moderate-----	0.28			
308B-------------- Wadena	0-14	18-30	1.30-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Low-----------	0.24	4	5	3-6
	14-36	18-30	1.35-1.50	0.6-2.0	0.14-0.19	5.6-7.3	Low-----------	0.32			
	36-60	1-5	1.55-1.65	>6.0	0.02-0.04	6.6-8.4	Low-----------	0.10			
330--------------- Kingston	0-21	18-32	1.20-1.30	0.6-2.0	0.18-0.24	5.6-7.3	Low-----------	0.28	5	7	4-8
	21-39	18-32	1.25-1.35	0.6-2.0	0.16-0.20	5.6-7.8	Low-----------	0.37			
	39-60	18-32	1.25-1.35	0.6-2.0	0.16-0.20	7.4-8.4	Low-----------	0.37			
338, 338B--------- Garmore	0-18	22-30	1.40-1.45	0.6-2.0	0.19-0.21	5.1-7.3	Low-----------	0.24	5	6	3-4
	18-51	24-30	1.45-1.70	0.6-2.0	0.16-0.18	5.1-7.8	Low-----------	0.37			
	51-60	22-27	1.45-1.60	0.6-2.0	0.16-0.18	6.6-7.8	Low-----------	0.37			
339B-------------- Truman	0-15	18-32	1.25-1.35	0.6-2.0	0.20-0.23	5.6-7.3	Low-----------	0.32	5	6	4-8
	15-32	18-32	1.30-1.45	0.6-2.0	0.18-0.21	5.6-7.8	Low-----------	0.43			
	32-60	18-32	1.35-1.45	0.6-2.0	0.18-0.20	7.4-8.4	Low-----------	0.43			
388--------------- Kossuth	0-21	32-42	1.35-1.45	0.2-0.6	0.21-0.23	6.1-7.3	High----------	0.28	5	4	6-7
	21-44	35-42	1.45-1.55	0.2-0.6	0.18-0.20	6.1-7.8	High----------	0.28			
	44-60	23-27	1.55-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Moderate-----	0.28			
485, 485B--------- Spillville	0-49	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.28	5	6	4-6
	49-60	14-24	1.55-1.70	0.6-6.0	0.15-0.18	5.6-7.3	Low-----------	0.28			
506--------------- Wacousta	0-15	27-35	1.20-1.25	0.6-2.0	0.21-0.23	6.1-7.8	High----------	0.28	5	7	6-8
	15-60	18-30	1.30-1.40	0.6-2.0	0.20-0.22	7.4-8.4	Moderate-----	0.43			
507--------------- Canisteo	0-16	22-32	1.25-1.35	0.6-2.0	0.18-0.22	7.4-8.4	Moderate-----	0.24	5	4L	4-8
	16-24	20-35	1.35-1.50	0.6-2.0	0.15-0.19	7.4-8.4	Moderate-----	0.32			
	24-35	10-35	1.30-1.50	0.6-6.0	0.12-0.18	7.4-8.4	Low-----------	0.32			
	35-60	22-32	1.45-1.60	0.6-2.0	0.14-0.16	7.4-8.4	Low-----------	0.32			
508--------------- Calcousta	0-15	27-35	1.25-1.30	0.6-2.0	0.21-0.23	7.4-8.4	High----------	0.28	5	7	6-8
	15-21	24-32	1.30-1.40	0.6-2.0	0.18-0.20	7.4-8.4	High----------	0.43			
	21-60	22-30	1.30-1.40	0.6-2.0	0.20-0.22	7.4-8.4	Moderate-----	0.43			

TABLE 16.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodi-bility group	Organic matter
	In	Pct	G/cm^3	In/hr	In/in	pH					Pct
511---------------- Blue Earth	0-9	18-32	0.20-0.80	0.6-2.0	0.18-0.24	7.4-8.4	Moderate-----	0.28	5	4L	10-25
	9-60	18-32	0.20-0.80	0.6-2.0	0.18-0.24	7.4-8.4	Low----------	0.28			
541C*:											
Estherville-----	0-7	5-15	1.25-1.35	2.0-6.0	0.13-0.18	5.6-7.3	Low----------	0.20	3	3	1-4
	7-12	10-18	1.35-1.60	2.0-6.0	0.09-0.14	5.6-7.3	Low----------	0.20			
	12-60	0-8	1.50-1.65	>6.0	0.02-0.04	6.6-8.4	Low----------	0.10			
Salida----------	0-9	5-15	1.35-1.45	2.0-6.0	0.10-0.12	6.1-8.4	Low----------	0.10	3	8	.5-1
	9-60	0-5	1.50-1.65	>20	0.02-0.04	7.4-8.4	Low----------	0.10			
559---------------- Talcot	0-18	27-35	1.20-1.30	0.6-2.0	0.18-0.22	7.4-8.4	Moderate-----	0.28	4	7	4-8
	18-34	25-35	1.25-1.35	0.6-2.0	0.17-0.20	7.4-8.4	Moderate-----	0.28			
	34-60	1-6	1.55-1.65	6.0-20	0.02-0.04	7.4-8.4	Low----------	0.15			
651---------------- Faxon	0-19	18-35	1.30-1.45	0.6-2.0	0.20-0.24	6.6-7.8	Low----------	0.28	4	6	5-8
	19-37	18-35	1.40-1.60	0.6-2.0	0.12-0.19	6.6-7.8	Moderate-----	0.28			
	37	---	---	---	---	---	-------------	----			
655---------------- Crippin	0-15	22-28	1.35-1.40	0.6-2.0	0.20-0.22	6.6-8.4	Low----------	0.28	5	6	5-6
	15-35	24-30	1.40-1.55	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.28			
	35-60	22-28	1.55-1.75	0.6-2.0	0.17-0.19	7.9-8.4	Low----------	0.37			
735---------------- Havelock	0-40	27-35	1.40-1.50	0.6-2.0	0.20-0.22	7.4-8.4	High---------	0.28	5	7	5-7
	40-60	12-26	1.50-1.65	2.0-6.0	0.13-0.17	7.4-8.4	Low----------	0.28			
1048--------------- Knoke	0-10	20-26	1.10-1.20	0.6-2.0	0.24-0.26	7.4-8.4	Moderate-----	0.28	5	6	10-18
	10-19	27-36	1.30-1.40	0.2-0.6	0.21-0.23	7.4-8.4	High---------	0.37			
	19-60	20-40	1.35-1.45	0.2-0.6	0.18-0.20	7.4-8.4	High---------	0.37			
1585B*:											
Coland----------	0-7	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28	5	7	5-7
	7-37	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28			
	37-60	12-26	1.50-1.65	0.6-6.0	0.13-0.17	6.1-7.8	Low----------	0.28			
Spillville------	0-49	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.28	5	6	4-6
	49-60	14-24	1.55-1.70	0.6-6.0	0.15-0.18	5.6-7.3	Low----------	0.28			
1735--------------- Havelock	0-40	27-35	1.40-1.50	0.6-2.0	0.20-0.22	7.4-8.4	High---------	0.28	5	7	5-7
	40-60	12-26	1.50-1.65	2.0-6.0	0.13-0.17	7.4-8.4	Low----------	0.28			
5010*, 5030*. Pits											
5040. Orthents											

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 17.--SOIL AND WATER FEATURES

["Flooding" and "water table" and terms such as "occasional," "brief," and "apparent" are explained in the text. The symbol < means less than; > means more than. Absence of an entry indicates that the feature is not a concern]

Soil name and map symbol	Hydrologic group	Flooding: Frequency	Flooding: Duration	Flooding: Months	High water table: Depth	High water table: Kind	High water table: Months	Bedrock: Depth	Bedrock: Hardness	Potential frost action	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete
					Ft			In				
4 Knoke	B/D	None	---	---	+1-1.0	Apparent	Nov-Jul	>60	---	High	High	Low.
6 Okoboji	B/D	None	---	---	+1-1.0	Apparent	Nov-Jul	>60	---	High	High	Low.
27B Terril	B	None	---	---	>6.0	---	---	>60	---	Moderate	Moderate	Low.
34, 34B, 34C2 Estherville	B	None	---	---	>6.0	---	---	>60	---	Low	Low	Low.
41B Sparta	A	None	---	---	>6.0	---	---	>60	---	Low	Low	Moderate.
48 Knoke	B/D	None	---	---	+1-1.0	Apparent	Nov-Jul	>60	---	High	High	Low.
55 Nicollet	B	None	---	---	2.5-5.0	Apparent	Apr-May	>60	---	High	High	Low.
62C2, 62D2, 62E, 62F, 62G Storden	B	None	---	---	>6.0	---	---	>60	---	Moderate	Low	Low.
90 Okoboji	B/D	None	---	---	+1-1.0	Apparent	Nov-Jul	>60	---	High	High	Low.
95 Harps	B/D	None	---	---	1.0-3.0	Apparent	Nov-Jun	>60	---	High	High	Low.
107 Webster	B/D	None	---	---	1.0-2.0	Apparent	Nov-Jul	>60	---	High	High	Low.
108, 108B, 108C2 Wadena	B	None	---	---	>6.0	---	---	>60	---	Low	Low	Low.
135 Coland	B/D	Occasional	Brief	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	>60	---	High	High	Low.
135B Coland	B/D	Occasional	Brief	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	>60	---	High	High	Low.
138B, 138C, 138C2, 138D2 Clarion	B	None	---	---	>6.0	---	---	>60	---	Moderate	Low	Low.
141 Watseka	B	None	---	---	1.0-3.0	Apparent	Feb-May	>60	---	Moderate	Low	High.
150 Hanska	C	None	---	---	1.0-3.0	Apparent	Nov-Jun	>60	---	High	High	Low.

TABLE 17.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding: Frequency	Flooding: Duration	Flooding: Months	High water table: Depth	High water table: Kind	High water table: Months	Bedrock: Depth	Bedrock: Hardness	Potential frost action	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete
					Ft			In				
202, 203 Cylinder	B	None	---	---	2.0-4.0	Apparent	Nov-Jul	>60	---	High	Moderate	Low.
224 Linder	B	None	---	---	2.0-4.0	Apparent	Nov-Jul	>60	---	High	Moderate	Low.
259 Biscay	B/D	None	---	---	1.0-3.0	Apparent	Nov-Jun	>60	---	High	Moderate	Low.
274 Rolfe	C	None	---	---	+1-1.0	Apparent	Nov-Jul	>60	---	High	High	Moderate.
308B Wadena	B	None	---	---	>6.0	---	---	>60	---	Low	Low	Low.
330 Kingston	B	None	---	---	2.5-5.0	Apparent	Apr-May	>60	---	High	High	Low.
338, 338B Garmore	B	None	---	---	4.0-6.0	Apparent	Nov-Jun	>60	---	High	Moderate	Moderate.
339B Truman	B	None	---	---	>6.0	---	---	>60	---	High	Low	Low.
388 Kossuth	B/D	None	---	---	1.0-2.0	Apparent	Nov-Jul	>60	---	High	High	Low.
485 Spillville	B	Occasional	Very brief	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	>60	---	Moderate	High	Moderate.
485B Spillville	B	None	---	---	3.0-5.0	Apparent	Nov-Jul	>60	---	Moderate	High	Moderate.
506 Wacousta	B/D	None	---	---	+1-1.0	Apparent	Nov-Jul	>60	---	High	High	Low.
507 Canisteo	B/D	None	---	---	1.0-3.0	Apparent	Oct-Jul	>60	---	High	High	Low.
508 Calcousta	B/D	None	---	---	+1-1.0	Apparent	Nov-Jul	>60	---	High	High	Low.
511 Blue Earth	B/D	None	---	---	+2-1.0	Apparent	Jan-Dec	>60	---	High	High	Low.
541C*:												
Estherville	B	None	---	---	>6.0	---	---	>60	---	Low	Low	Low.
Salida	A	None	---	---	>6.0	---	---	>60	---	Low	Low	Low.
559 Talcot	B/D	None	---	---	1.0-2.5	Apparent	Apr-Jul	>60	---	High	High	Low.

See footnote at end of table.

TABLE 17.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Bedrock		Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months	Depth	Hardness		Uncoated steel	Concrete
					Ft			In				
651----------------- Faxon	B/D	None---------	---	---	0-1.0	Apparent	Nov-May	20-40	Hard	High------	High------	Low.
655----------------- Crippin	B	None---------	---	---	2.0-4.0	Apparent	Nov-Jun	>60	---	High------	High------	Low.
735----------------- Havelock	B/D	Occasional	Brief------	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	>60	---	High------	High------	Low.
1048---------------- Knoke	B/D	None---------	---	---	+1-1.0	Apparent	Nov-Jul	>60	---	High------	High------	Low.
1585B*:												
Coland------------	B/D	Frequent----	Brief------	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	>60	---	High------	High------	Low.
Spillville--------	B	None---------	---	---	3.0-5.0	Apparent	Nov-Jul	>60	---	Moderate	High------	Moderate.
1735---------------- Havelock	B/D	Frequent----	Brief------	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	>60	---	High------	High------	Low.
5010*, 5030*. Pits												
5040. Orthents												

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 18.--CLASSIFICATION OF THE SOILS

Soil name	Family or higher taxonomic class
Biscay	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Haplaquolls
Blue Earth	Fine-silty, mixed (calcareous), mesic Mollic Fluvaquents
Calcousta	Fine-silty, mixed (calcareous), mesic Typic Haplaquolls
Canisteo	Fine-loamy, mixed (calcareous), mesic Typic Haplaquolls
Clarion	Fine-loamy, mixed, mesic Typic Hapludolls
Coland	Fine-loamy, mixed, mesic Cumulic Haplaquolls
Crippin	Fine-loamy, mixed, mesic Aquic Hapludolls
Cylinder	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Aquic Hapludolls
Estherville	Sandy, mixed, mesic Typic Hapludolls
Faxon	Fine-loamy, mixed, mesic Typic Haplaquolls
Garmore	Fine-loamy, mixed, mesic Typic Hapludolls
Hanska	Coarse-loamy, mixed, mesic Typic Haplaquolls
Harps	Fine-loamy, mesic Typic Calciaquolls
Havelock	Fine-loamy, mixed (calcareous), mesic Cumulic Haplaquolls
Kingston	Fine-silty, mixed, mesic Aquic Hapludolls
Knoke	Fine, montmorillonitic (calcareous), mesic Cumulic Haplaquolls
Kossuth	Fine-loamy, mixed, mesic Typic Haplaquolls
Linder	Coarse-loamy, mixed, mesic Aquic Hapludolls
Nicollet	Fine-loamy, mixed, mesic Aquic Hapludolls
Okoboji	Fine, montmorillonitic, mesic Cumulic Haplaquolls
Orthents	Loamy, mixed, mesic Typic Udorthents
Rolfe	Fine, montmorillonitic, mesic Typic Argialbolls
Salida	Sandy-skeletal, mixed, mesic Entic Hapludolls
Sparta	Sandy, mixed, mesic Entic Hapludolls
Spillville	Fine-loamy, mixed, mesic Cumulic Hapludolls
Storden	Fine-loamy, mixed (calcareous), mesic Typic Udorthents
Talcot	Fine-loamy over sandy or sandy-skeletal, mixed (calcareous), mesic Typic Haplaquolls
Terril	Fine-loamy, mixed, mesic Cumulic Hapludolls
Truman	Fine-silty, mixed, mesic Typic Hapludolls
Wacousta	Fine-silty, mixed, mesic Typic Haplaquolls
Wadena	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Hapludolls
Watseka	Sandy, mixed, mesic Aquic Hapludolls
Webster	Fine-loamy, mixed, mesic Typic Haplaquolls

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