United States Department of Agriculture

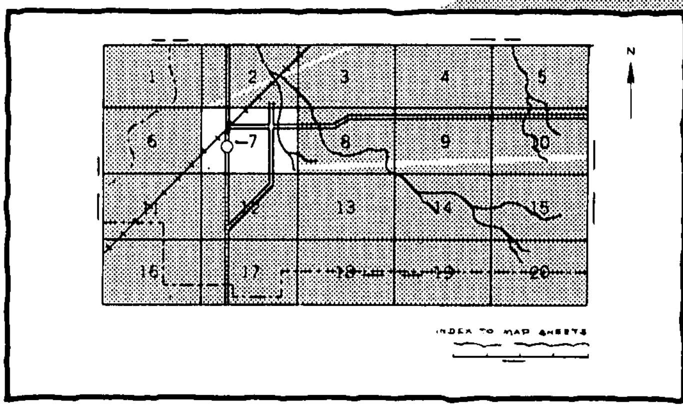
Soil Conservation Service

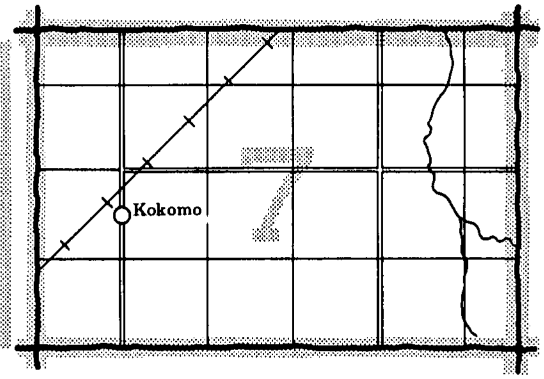
In cooperation with Iowa Agriculture and Home Economics Experiment Station; Cooperative Extension Service, Iowa State University; and Department of Soil Conservation, State of Iowa

Soil Survey of Winnebago County, Iowa

HOW TO USE

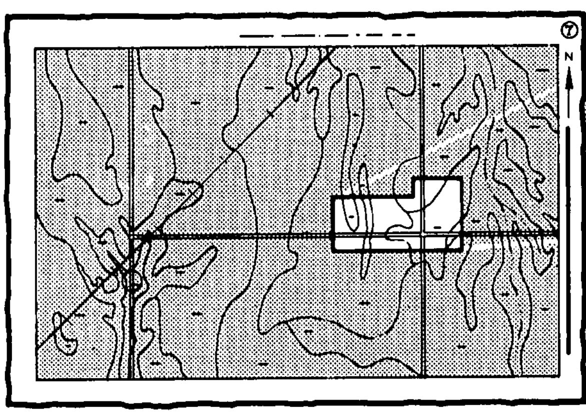
1. Locate your area of interest on the "Index to Map Sheets."

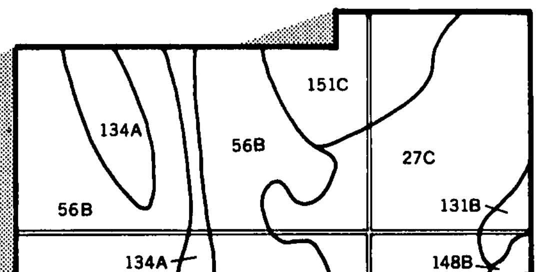




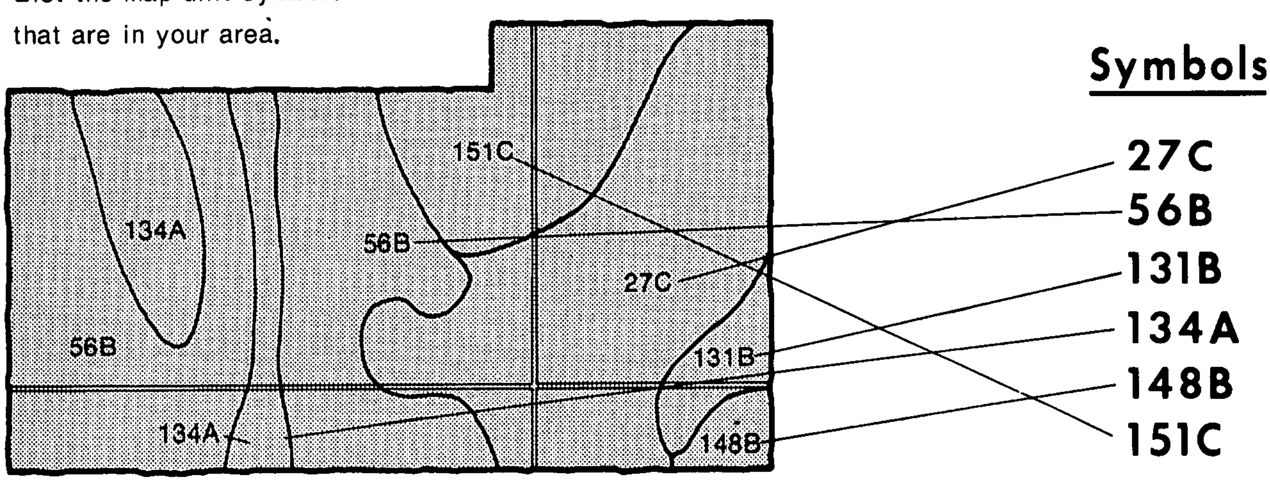
2. Note the number of the map sheet and turn to that sheet.

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



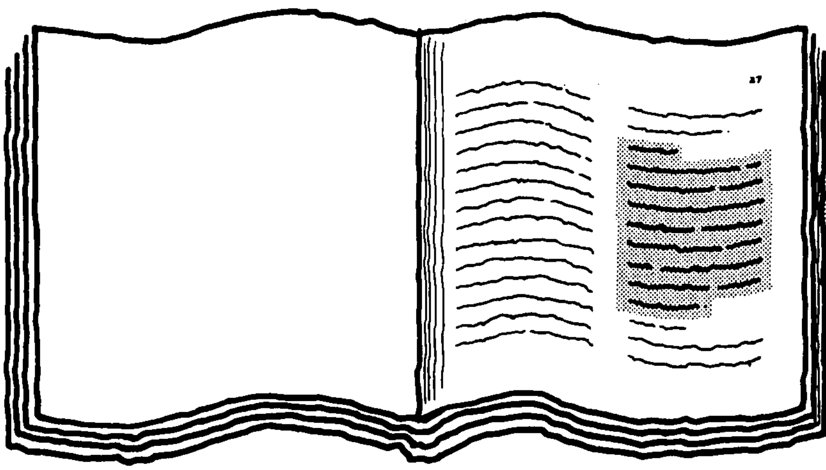


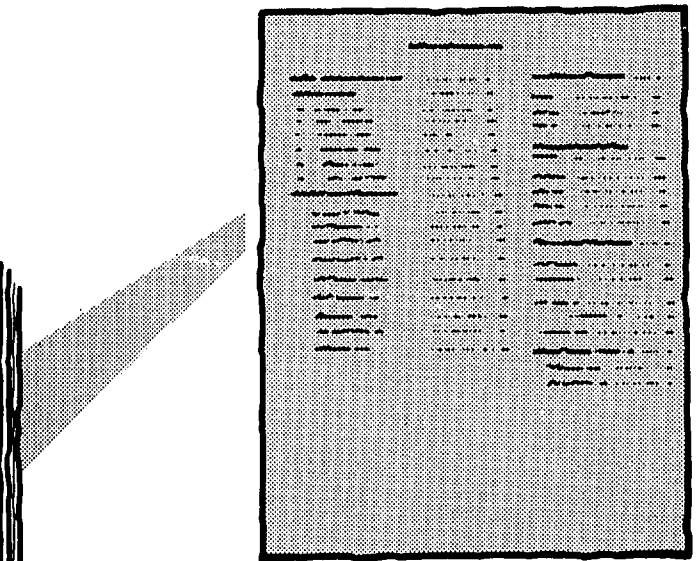
4. List the map unit symbols that are in your area.



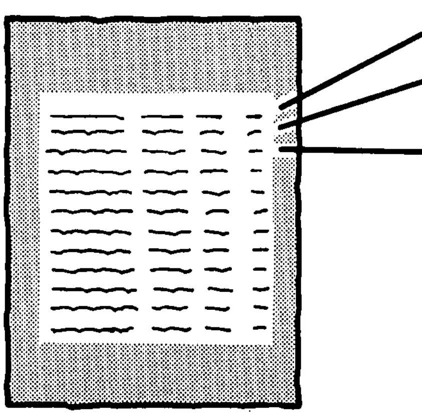
THIS SOIL SURVEY

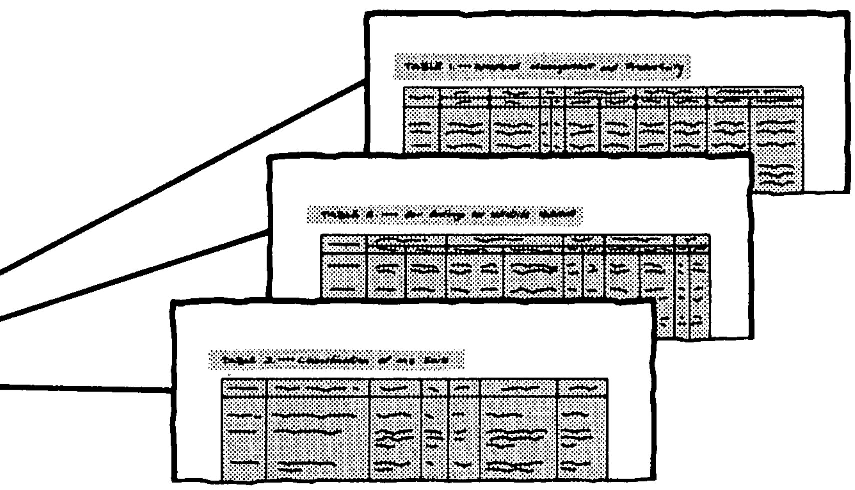
5. Turn to ''Index to Soil Map Units'' which lists the name of each map unit and the page where that map unit is described.





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





7. Consult ''Contents'' for parts of the publication that will meet your specific needs. This survey contains useful information for farmers or ranchers, foresters or agronomists; for planners, community decision makers, engineers, developers, builders, or homebuyers; for conservationists, recreationists, teachers, or students; 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 1978-83. Soil names and descriptions were approved in 1984. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1984. 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 Winnebago County Soil Conservation District. Funds appropriated by Winnebago County were used to defray part of the cost of the 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: Corn and soybeans on Nicollet loam, 1 to 3 percent slopes.

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Soil Series

Issued August 1987

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Summary of Tables

Preface

This soil survey contains information that can be used in land-planning programs in Winnebago 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 ensure 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 Winnebago County, Iowa

By Robert G. Jones, Soil Conservation Service

Fieldwork by Patrick L. Abel, Ronald J. Kuehl, Robert G. Jones, Richard A. Lensch, Daniel Selky, Robert Vobora, Robert W. Wilson, and Allan Younk, 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

WINNEBAGO COUNTY is in the north-central part of Iowa (fig. 1). It has a total of 256,704 acres, or 401 square miles. Forest City, the county seat, is in the south-central part of the county.

The county is chiefly agricultural. The principal crops are corn and soybeans, but oats and hay are also grown. Beef cattle and hogs are other important sources of income.

The landscape varies greatly throughout the county. It consists of wide plains; precipitous hills, some of which enclose lakes; alternating marshes and knobby hills; and valleys that have gently flowing streams bordered by rounded, sloping hillsides (*14*). Elevation ranges from about 1,120 to 1,380 feet above sea level.

This survey updates the soil survey of Winnebago County published in 1921 (*28*). It provides additional information and larger maps, which show the soils in greater detail.

General Nature of the County

The paragraphs that follow provide general information about Winnebago County. They describe history and development, transportation facilities, business and industry, relief and drainage, natural resources, farming, and climate.

History and Development

Before being designated a county in Iowa, what is now Winnebago County was part of an area declared by the U.S. Government as neutral ground between warring Indian tribes. Many Indian artifacts have been found in the county, chiefly in areas that were formerly wooded, east of the Winnebago River. Prior to 1850, the survey

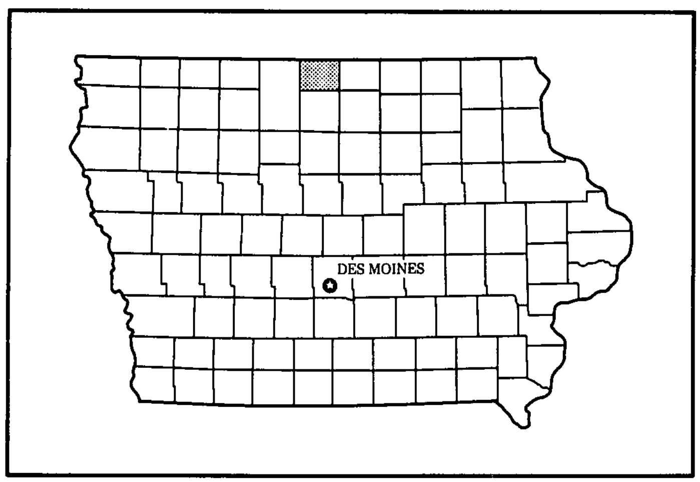

Figure 1.—Location of Winnebago County in Iowa.

area was part of a very large county known as Fayette County. In 1850, the Iowa Legislature established 50 new counties, including Winnebago County. In October of 1857, the first election of county officers was held and the county became a civil unit on its own. One of the first acts of the supervisors was that of dividing the county into two townships. The northern half of the county was called Pleasant Township and the southern half Forest Township. In 1889, the present 12 townships were established. In 1858, Forest City was named as county seat (*17*).

Early settlement was centered in the wooded areas, primarily east of Lime Creek, now called the Winnebago River. Trees in this part of the county provided the material necessary for shelter and fuel. Originally, about one-third to two-thirds of the acreage was timbered, but much of the timber was cut by 1915. The early stands were chiefly oak and walnut (*17*). Only about 1,500 acres currently is wooded, mostly with oak. The woodland is primarily scattered small tracts on steep slopes bordering large depressions and around farmsteads.

The first permanent settlement was on the east side of the Winnebago River, near Forest City. In the late 1800's, railroads were extended into the county, and by the early 1900's, the present towns were established (*17*). Several of the early railroad stations and some early post offices have vanished. In 1860, the population was 168. It was 13,564 in 1915; 13,972 in 1940; 12,990 in 1970; and 13,010 in 1980.

Transportation Facilities

Transportation facilities generally are adequate for the economic enterprises in the county. Every farm is served by a graded and surfaced road. Most of the roads are surfaced with gravel. The main farm-to-market roads are surfaced with bituminous material. Federal and state highways are concrete or concrete surfaced with bituminous material.

U.S. Highway 69 runs generally north and south across the eastern part of the county. U.S. Highway 9 runs generally east and west. It intersects with U.S. Highway 169 in the east-central part of the county. State Highway 254 connects the towns of Buffalo Center and Rake, and state Highway 105 runs east from Lake Mills. State Highway 332, a short spur, connects Highway 9 with Pilot Knob State Park, which is adjacent to the county.

Only two railroads serve the county. One crosses the northwest corner and serves the town of Rake. The other crosses the northeast corner and serves the towns of Lake Mills and Scarville. Buffalo Center, Leland, Thompson, and Forest City are without railroad service.

Bus transportation is available to towns along the U.S. highways. A regional bus system serves the county. Every trading center is served by motor freight lines. A small airport is located in Hancock County, near Forest City.

Business and Industry

Industry provides markets for farm products in the county. Every town has a grain elevator, a feed mill, and a fertilizer plant. Packing plants provide hog-buying stations in most of the towns. An organized livestock auction is in Forest City. Several towns have frozen food locker plants.

Businesses that sell and service farm machinery and supplies operate at several towns in the county. Veterinarian services are readily available. Industry provides several hundred jobs at Forest City. It also provides many jobs at Lake Mills and, to a lesser extent, at Buffalo Center.

Relief and Drainage

The western two-thirds of the county is dominated by a ground moraine characterized by numerous small depressions and potholes. The moraine generally is nearly level to moderately sloping but is steeper in scattered areas. Two large marshes, Myre Slough and Lake Harmon, are in this area. Relief is low to moderate, generally less than about 30 feet.

Except for outwash areas and the flood plains along the Winnebago River and Lime Creek, the eastern third of the county is dominated by a moraine front and a moraine complex. Along the Algona Moraine front is a broad belt of high-relief hummocks and in places a relatively broad series of ridges or hills, which also have high relief. To the east of the Winnebago River and Lime Creek is a moraine complex area that has high relief. Organic soils in large depressions are common in this area. In areas of both the moraine front and the moraine complex, relief approaches 75 feet or more. In the moraine complex, such landscape features as kames, eskers, and kettles are common. Hogsback Ridge, an eskerlike landform, is in this area. Rice Lake, the largest lake in the county, also is in this area.

Generally, the eastern half of the county is drained by Lime Creek and the Winnebago River and its tributaries. The tributaries are Pike Run, Twister Branch, Bear Creek, and several drainage ditches. The southeast corner of the county is drained by Beaver Creek.

The western half of the county is drained by South Buffalo Creek, North Buffalo Creek, the Blue Earth River, and their tributaries, which are drainage ditches. Except for the water in the northwest corner, drainage waters in this part of the county generally flow southwest or west. The Blue Earth River and two of its tributaries generally flow west in this county. In the extreme northwest corner are two drainage ditches that flow north into Minnesota.

The channels of the smaller streams generally have been straightened and deepened. Together with various drainage ditches, they provide outlets for tile drains as well as surface drains. Except for soils in depressions, most of the upland soils are drained adequately for dependable crop production.

Natural Resources

Agricultural land is the primary natural resource in Winnebago County. Other natural resources include water, trees, peat, sand and gravel, and wildlife.

Winnebago County has a good supply of underground water. Wells that are properly drilled rarely fail because of a seasonal lack of water or during periods of drought. Some wells are less than 100 feet deep, but many are as much as 300 feet or more. Shallow wells and sand points are dependable sources of water in a few areas where the substratum is gravelly. Water quality generally is good, but a few wells have higher nitrate levels than is desirable.

A few thousand acres have potential for irrigation. A few shallow wells in an outwash area currently provide water for irrigation on a limited basis. The best potential for irrigation is in small areas adjacent to the Winnebago River, in a glacial outwash area west of Forest City, and in an outwash area in the northern part of the county, near the town of Scarville. These areas have soils that are seasonally droughty.

Myre Slough, Lake Harmon, and marshy areas along the Winnebago River and adjacent to Rice Lake have been developed as wildlife areas. Smaller marshy areas are throughout the county. The marshy areas provide many opportunities for hunting and trapping. A few manmade farm ponds, several gravel pits, the Winnebago River, and Rice Lake provide opportunities for fishing.

State parks are located at Rice Lake and Hogsback Ridge. Other parks have been developed at points along the Winnebago River and at some gravel pits. Thorpe Park, in the south-central part of the county, is developed around a small natural lake and a small manmade lake. The parks generally provide facilities for camping, fishing, and picnicking.

Native oak and other trees are harvested on a limited basis in the county. Peat is mined and processed for potting soil and horticultural uses in marshy areas near Lake Mills. A few sand and gravel pits are mined in areas adjacent to the Winnebago River and in glacial outwash areas. The sand and gravel are used extensively as road-surfacing material and as concrete aggregate.

Opportunities for hunting, fishing, and trapping are available throughout the county. Migratory waterfowl, deer, rabbit, squirrel, pheasant, and partridge are commonly hunted. Muskrat, raccoon, and mink are among the species commonly trapped.

Farming

In 1983, Winnebago County had 246,000 acres of farmland (*8*). Of this land, 221,130 acres was used for row crops, small grain, or hay. The rest was used for permanent pasture, woods, lots, buildings, or roads or was idle land. Corn was planted on 121,000 acres. It yielded an average of 125.6 bushels per acre. Soybeans were planted on 93,500 acres. They yielded an average of 36.4 bushels per acre. Oats was grown on 4,700 acres. It yielded an average of 61.7 bushels per acre. About 4,400 acres was used for hay of all types.

Beef cattle and hogs are the most extensively raised livestock in the county. In 1982, about 5,000 grain-fed cattle and 160,000 hogs were sold. In the same year, 16,100 sows were farrowed. Beef cows totaled 3,700 and milk cows 1,500. The county had a few sheep and lambs and 27,000 laying hens.

In recent years the number of people living on farms and the number of farms have declined. Farm size has increased. In 1982, the county had 870 farms, which averaged 283 acres in size. In 1980, about 8,740 people lived on the farms (*9*).

Most farms are cash-grain enterprises. Farmers derive most of their income from the sale of corn and soybeans. Many, however, derive a large part of their income from the sale of livestock, especially hogs and beef cattle.

Dairying is a major enterprise on a few farms. The number of dairy farms has been decreasing in recent years, but the size of the herds has increased. Some poultry is raised in the county. A recent trend has been toward fewer but larger poultry enterprises, mainly those that raise laying hens. Commercial broiler and turkey production is minimal. Sheep are raised on a few farms, but the numbers have declined in recent years. In 1982, the number was 3,000 head.

Climate

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

Table 1 gives data on temperature and precipitation for the survey area as recorded at Forest City 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 17 degrees F, and the average daily minimum temperature is 8 degrees. The lowest temperature on record, which occurred at Forest City on January 21, 1970, is -30 degrees. In summer the average temperature is 71 degrees, and the average daily maximum temperature is 82 degrees. The highest recorded temperature, which occurred at Forest City on July 31, 1955, is 101 degrees.

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

The total annual precipitation is about 31.4 inches. Of this, 23 inches, or about 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 19 inches. The heaviest 1-day rainfall during the period of record was 7.51 inches at Forest City on August 31, 1962. Thunderstorms occur on about 40 days each year, and most occur in spring. Tornadoes and severe thunderstorms strike occasionally. These storms are local in extent and of short duration. They result in sparse damage in narrow belts. Hailstorms occur during the warmer part of the year in scattered small areas.

The average seasonal snowfall is 42.9 inches. The greatest snow depth at any one time during the period of record was 25 inches. On the average, 35 days of the year have at least 1 inch of snow 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 85 percent. The sun shines 70 percent of the time possible in summer and 50 percent in winter. The prevailing wind is from the northwest. Average windspeed is highest, 13 miles per hour, in spring.

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-Canisteo-Nicollet Association

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

This association consists of soils in nearly level to gently rolling areas on ground moraines characterized by swales and rises. Differences in elevation between the swales and rises are about 5 to 20 feet. A few steeper areas are around some of the many scattered potholes or are along some small streams and drainageways. A branch of the Blue Earth River and several small creeks originate in this association. In most places the channels of these streams have been straightened and deepened and are good outlets for tile drains. Most of the flood plains along the streams are narrow and indistinct and are no longer subject to flooding. Slopes range from 0 to 9 percent.

This association makes up about 53 percent of the county. It is about 25 percent Clarion soils, 25 percent Canisteo soils, 20 percent Nicollet soils, and 30 percent soils of minor extent (fig. 2).

The well drained, gently sloping and moderately sloping Clarion soils are on the higher convex slopes and on low, irregularly shaped ridges above the Canisteo and Nicollet soils. The ridges have short slopes. The somewhat poorly drained, very gently sloping Nicollet soils are on low, slightly convex rises on broad flats. They also are at intermediate levels between the well drained Clarion soils and the poorly drained Canisteo soils. The poorly drained, nearly level Canisteo soils are on low, broad flats and in swales. They commonly surround depressional areas. The natural drainage pattern is not well defined, and runoff is slow.

Typically, the surface layer of the Clarion soils is black loam about 10 inches thick. The subsurface layer is black and very dark grayish brown, friable loam about 7 inches thick. The subsoil is friable loam about 13 inches thick. The upper part is dark brown and dark yellowish brown, and the lower part is dark yellowish brown and brown. The substratum to a depth of about 60 inches is dark yellowish brown and yellowish brown, friable, mottled, calcareous loam.

Typically, the surface layer of the Canisteo soils is black clay loam about 8 inches thick. The subsurface layer is black and very dark gray clay loam about 13 inches thick. The subsoil is olive gray, mottled clay loam about 25 inches thick. The substratum to a depth of about 60 inches is olive gray, mottled loam. The soils are calcareous throughout.

Typically, the surface layer of the Nicollet soils is black loam about 7 inches thick. The subsurface layer is black, very dark brown, and very dark grayish brown loam about 12 inches thick. The subsoil is dark grayish brown, friable loam about 28 inches thick. It is mottled and calcareous in the lower part. The substratum to a depth of about 60 inches is light olive brown, mottled, calcareous loam.

The minor soils in this association are the Harps, Okoboji, Palms, Storden, and Webster soils in the uplands and the Coland soils along stream bottoms. The nearly level, highly calcareous, poorly drained Harps soils are mainly on the rims around depressions. When dry, their surface soil is distinctly lighter in color than that of the major soils. The very poorly drained Okoboji and Palms soils are in depressions. They are often ponded in spring or after heavy rains. The gently sloping to strongly sloping, well drained, calcareous Storden soils are on convex slopes and ridge crests. They border drainageways and are adjacent to the Clarion soils. The poorly drained Coland soils are in areas along streams.

Most of this association is cultivated and is well suited to cultivated crops. The moderately sloping and strongly sloping areas, however, are only moderately suited or

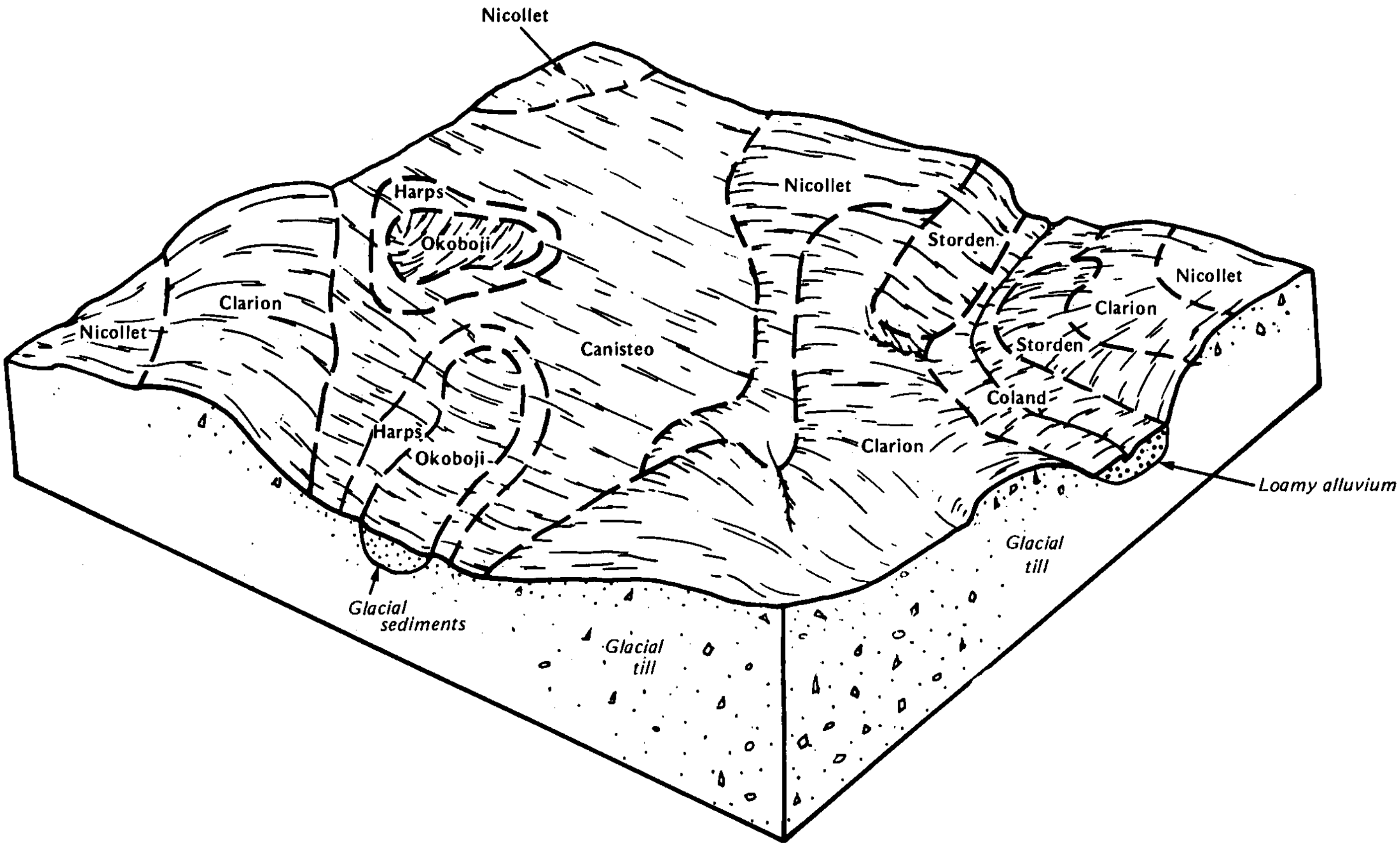

Figure 2.—Pattern of soils and parent material in the Clarion-Canisteo-Nic(

are poorly suited. Corn and soybeans are the main crops. Some areas are used for oats or for rotation hay and pasture, including alfalfa and alfalfa-grass mixtures. A few areas, mostly along streams and around farmsteads, are used as permanent pasture. The content of organic matter generally is moderate or high in the surface layer, and available water capacity is high. Crops respond well to applications of fertilizer, and yields are high.

Measures that control water erosion are needed on the more sloping soils. Because of the irregular pattern of slopes, farming on the contour and terracing are somewhat difficult in places. Soil blowing is a hazard in large areas where the surface is bare after fall plowing. The nearly level, poorly drained soils and the very poorly drained soils in depressions are generally tile drained. Measures that improve drainage are needed in some areas. Maintaining fertility and tilth also is an important management concern. Herbicide carry-over is a concern on the Canisteo soils. Herbicide carry-over and low fertility are concerns on the minor Harps and Storden soils.

2. Canisteo-Nicollet Association

Nearly level and very gently sloping, poorly drained and somewhat poorly drained soils formed in glacial till or glacial till sediments; on uplands

This association consists of soils in nearly level and gently undulating areas on ground moraines characterized by swales and rises. Differences in elevation between the swales and rises are about 5 to 10 feet. A few steeper areas are around the many scattered potholes or are along drainageways. Tributaries of creeks flow through areas of this association. They are good outlets for tile drains. Most have been straightened and deepened. Areas along the tributaries are former flood plains, which are narrow and indistinct. They are subject to rare flooding. Slopes generally are short. They range from 0 to 3 percent.

This association makes up about 6 percent of the county. It is about 36 percent Canisteo and similar soils, 24 percent Nicollet and similar soils, and 40 percent soils of minor extent.

The poorly drained, nearly level Canisteo soils are on broad flats and in swales. They commonly surround depressional areas. The natural drainage pattern is not well defined, and runoff is slow. The somewhat poorly drained, very gently sloping Nicollet soils are on slight rises on the broad flats.

Typically, the surface layer of the Canisteo soils is black clay loam about 8 inches thick. The subsurface layer is black and very dark gray clay loam about 13 inches thick. The subsoil is olive gray and dark gray, mottled clay loam about 25 inches thick. The substratum to a depth of about 60 inches is olive gray, mottled loam. The soils are calcareous throughout.

Typically, the surface layer of the Nicollet soils is black loam about 7 inches thick. The subsurface layer is black, very dark brown, and very dark grayish brown loam about 12 inches thick. The subsoil is dark grayish brown, friable loam about 28 inches thick. It is mottled and calcareous in the lower part. The substratum to a depth of about 60 inches is light olive brown, mottled, calcareous loam.

The minor soils in this association are the Clarion, Harps, Okoboji, Palms, and Storden soils. Clarion soils are well drained and are on knobs, hills, and side slopes. Harps soils are highly calcareous and poorly drained and border areas of Okoboji and Palms soils. When dry, their surface layer is distinctly lighter in color than that of the major soils. Okoboji and Palms soils are very poorly drained and are in depressions. Palms soils have a thick surface soil that is very high in content of organic matter. Storden soils are well drained and calcareous. They are generally adjacent to the Clarion soils.

Most of this association is cultivated and is well suited to cultivated crops. Corn and soybeans are the main crops. Some areas are used for oats or for rotation hay and pasture, including alfalfa and alfalfa-grass mixtures. The content of organic matter in the surface layer generally is high, but it is moderate in the surface layer of the Clarion soils. Available water capacity is high. Crops respond well to applications of fertilizer, and yields are among the highest in the county.

The main concerns of management are improving drainage and maintaining tilth and fertility. Herbicide carry-over is a concern on the Canisteo soils. Most areas of the poorly drained soils are tile drained, but additional tile is needed in places. Soil blowing is a hazard in large areas where the surface is bare after fall plowing.

3. Clarion-Storden Association

Gently sloping to moderately steep, well drained soils formed in glacial till; on uplands

This association consists of soils that are gently sloping and moderately sloping on ridgetops and strongly sloping and moderately steep on side slopes. It is generally on the northward extension of the Algona Moraine. It is dissected by upland drainageways. Several small tributaries of the Winnebago River also flow across this association. Slopes range from 2 to 20 percent.

This association makes up about 13 percent of the county. It is about 40 percent Clarion soils, 20 percent Storden soils, and 40 percent soils of minor extent.

Clarion soils are on the high parts of the uplands, mostly in gently sloping and moderately sloping areas at or near the borders of the association. A few steeper areas are adjacent to drainageways that cut back into the uplands. Storden soils are mainly in strongly sloping and moderately steep areas on side slopes adjacent to bottom land. They also are in steep areas on side slopes adjacent to drainageways that cut back into the uplands.

Typically, the surface layer of the Clarion soils is very dark brown, friable loam about 8 inches thick. Plowing has mixed streaks and pockets of brown subsoil material into the surface layer. The subsoil is friable loam about 16 inches thick. The upper part is dark brown and dark yellowish brown, and the lower part is brown and yellowish brown. The substratum to a depth of about 60 inches is yellowish brown, calcareous loam.

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

The minor soils in this association are the Coland, Nicollet, Spillville, and Webster soils. Coland and Spillville soils are in narrow stream channels and drainageways. Coland soils are poorly drained and border the stream channels. Spillville soils are somewhat poorly drained and moderately well drained and are on foot slopes bordering the Coland soils. Nicollet soils are somewhat poorly drained and nearly level and commonly are adjacent to the Clarion soils. Webster soils are poorly drained and nearly level. In this association they are commonly in swales between areas of the Clarion or Storden soils. In many areas, however, they are bordered by Nicollet soils.

This association is used for general farming. The suitability for cultivated crops ranges from good to poor. Corn and soybeans are the main crops. The steeper areas commonly are used for oats or for rotation hay and pasture. The content of organic matter is moderate in the Clarion soils and low in the Storden soils. Both soils have a high available water capacity. In some of the steeper areas of Storden soils, however, the amount of available water is reduced because of rapid runoff. Many of these areas are better suited to hay and pasture than to row crops. The minor soils have a high content of organic matter and a high available water capacity.

The main management need is controlling erosion on the more sloping soils. Measures that improve drainage are needed in some areas of the minor soils. Intensively row cropping the steeper soils results in serious erosion. Much of the soil that is washed off the slopes is deposited on the concave foot slopes, but some is carried into the depressions. Large quantities are carried into the drainageways and small streams that empty into the Winnebago River. As a result, much filling or siltation has occurred in and along the channels. Soil blowing also is a serious hazard, especially on the higher crests and nose slopes that are plowed in the fall or at other times when the surface is bare. Terraces, contour farming, grassed waterways, and reduced tillage methods are needed to control erosion. Terracing and farming on the contour are difficult in some areas, however, because of the irregular pattern of slopes.

The potential for upland wildlife habitat is good on these soils. The habitat can be improved by measures that control erosion, such as grassed-backslope terraces, grassed waterways, a system of reduced tillage that leaves crop residue on the surface, and a cropping sequence that includes more grass and hay crops.

4. Kilkenny-Lester-Waldorf Association

Nearly level to very steep, well drained and poorly drained soils formed in glacial till and glacial lacustrine sediments; on uplands

This association consists of soils on hummocks or ridges and in swales. The parent material of these soils occurs as a complex pattern of glacial lacustrine sediments intermingled with glacial till or till-like material. The fine grained glacial lacustrine sediments are in many of the nearly level areas on rounded or circular knobs or in the lower areas between the knobs. Large depressions are common. Differences in elevation range from about 20 to 50 feet. Scattered small areas of native oak trees grow on some of the steeper slopes and around many farmsteads. Slopes range from 0 to 35 percent.

This association makes up about 11 percent of the county. It is about 30 percent Kilkenny soils, 20 percent Lester soils, 10 percent Waldorf soils, and 40 percent soils of minor extent (fig. 3).

The well drained Kilkenny soils are moderately sloping on ridges or knobs and some side slopes and strongly sloping to very steep on other side slopes. Most of the very steep areas are wooded. Hogsback State Park, a landmark in this association, is on a long, convex, eskerlike ridge in an area of these soils. The well drained Lester soils are gently sloping on knobs and ridges and moderately sloping to steep on side slopes. The poorly drained, nearly level Waldorf soils are mainly in swales between the knobs and ridges.

Typically, the surface layer of the Kilkenny soils is very dark grayish brown clay loam about 8 inches thick. Plowing has mixed some streaks and pockets of brown subsoil material into the surface layer. The subsoil is clay loam about 49 inches thick. The upper part is brown, the next part is olive brown, and the lower part is olive brown and light olive brown. The substratum to a depth of about 60 inches is light olive brown, mottled clay loam.

Typically, the surface layer of the Lester soils is very dark grayish brown, friable loam about 7 inches thick. The subsoil is about 27 inches thick. It is mottled and friable. The upper part is dark yellowish brown clay loam, and the lower part is dark yellowish brown and yellowish brown loam. The substratum to a depth of about 60 inches is light olive brown, mottled, calcareous loam.

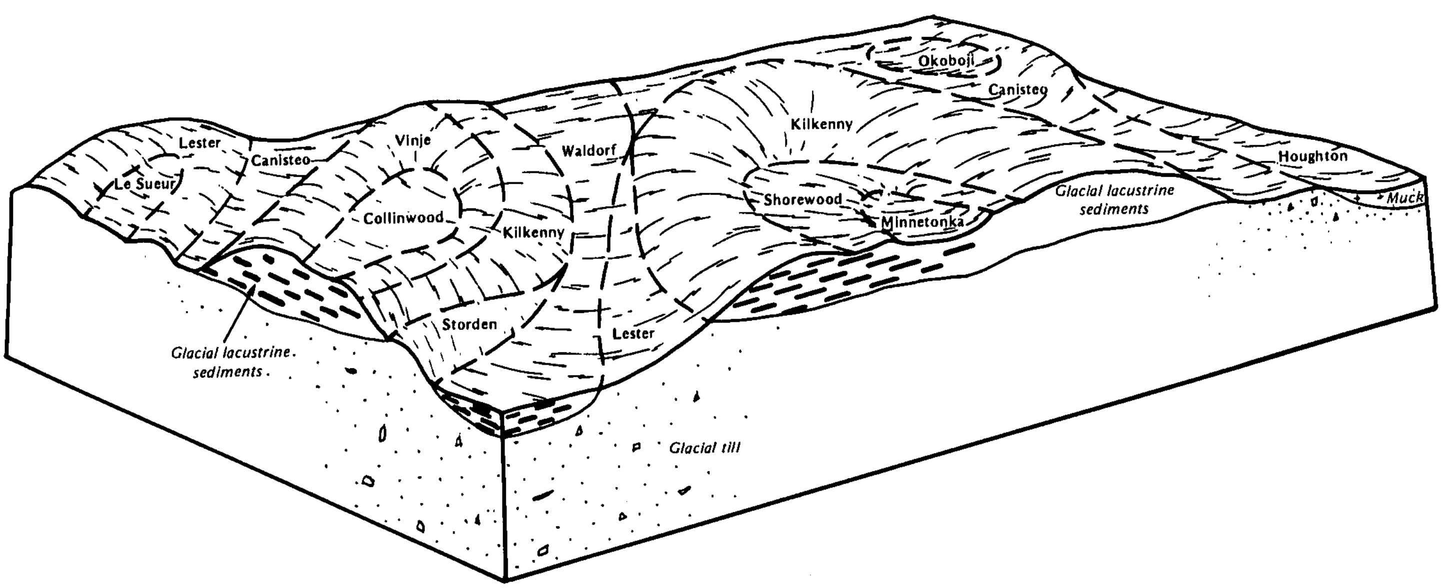

Figure 3.—Pattern of soils and parent material in the Kilkenny-Lester-Waldorf association.

Typically, the surface layer of the Waldorf soils is black silty clay loam about 7 inches thick. The subsurface layer is black silty clay about 12 inches thick. The subsoil is dark gray and olive gray, mottled silty clay about 25 inches thick. The substratum to a depth of about 60 inches is olive gray, mottled, calcareous silty clay loam.

The minor soils in this association are the Canisteo, Collinwood, Houghton, Le Sueur, Minnetonka, Okoboji, Shorewood, Storden, and Vinje soils. The poorly drained, calcareous Canisteo soils formed in glacial till or glacial till sediments. In places they are adjacent to the Waldorf soils and are lower on the landscape. The somewhat poorly drained, nearly level Collinwood soils formed in fine textured lacustrine sediments. The very poorly drained Houghton soils formed in thick deposits of organic material in large depressions and on former lake bottoms. The somewhat poorly drained, nearly level Le Sueur soils formed in glacial till on slightly concave to slightly convex slopes. The poorly drained, nearly level Minnetonka soils formed in fine textured glaciolacustrine sediments. The very poorly drained Okoboji soils are in depressions. The somewhat poorly drained Shorewood soils formed in fine textured lacustrine sediments. The well drained, calcareous Storden soils are in strongly sloping to moderately steep areas. The well drained Vinje soils formed in glaciolacustrine sediments over loamy glacial till.

This association is used mainly for general farming. Its suitability for cultivated crops is mainly dependent on the slope. The nearly level soils, except for Houghton and Okoboji soils, and the gently sloping soils are well suited to cultivated crops. The Houghton and Okoboji soils are only moderately suited. Most of the remaining soils are moderately suited or poorly suited. The steepest soils, however, are generally unsuited. They support grass or mixed grass and trees. Corn and soybeans are the main crops, but oats and hay and pasture are grown in many areas. Trees, chiefly oak, grow in most of the steeper areas of the Lester and Kilkenny soils and in some less sloping areas. The content of organic matter is moderate in the Kilkenny and Lester soils, is high in the Waldorf soils, and ranges from low to very high in the minor soils. Most of the major and minor soils have a high available water capacity.

The main management needs are controlling erosion, improving drainage, and maintaining tilth. Erosion is a serious hazard. Because of the slope and a restricted infiltration rate in the finer textured soils, the rate of runoff increases the susceptibility to erosion.

Terraces, contour farming, grassed waterways, and a system of conservation tillage that leaves crop residue on the surface can slow runoff and increase the infiltration rate. In places, however, terracing and farming on the contour are difficult because many slopes are short and complex or are too steep. Maintaining tilth is a problem, especially if the finer textured soils are tilled when wet. Although most naturally wet areas have been drained, internal drainage generally is slow. Measures that improve drainage are needed in some areas. Suitable outlets for tile drains are available in most areas, except for a few depressions. In some years when rainfall is abnormally high, crops are not grown in some depressions where drainage is inadequate.

Some upland and wetland wildlife species are plentiful in this association. The potential for improving the habitat for both species is good.

5. Lester-Hayden-Cordova Association

Nearly level to very steep, well drained and poorly drained soils formed in glacial till; on uplands

This association consists of soils on ridges and knobs and in interspersed drainageways and depressions. These soils are nearly level to moderately sloping on the crests of the ridges and knobs and strongly sloping to steep on the side slopes. In a few places they are very steep. The native vegetation was trees or mixed trees and grasses. Scattered native oaks grow on some of the knobs and on the steeper slopes around depressions or along drainageways. Slopes range from 0 to 30 percent.

This association makes up about 6 percent of the county. It is about 25 percent Lester soils, 16 percent Hayden soils, 12 percent Cordova soils, and 47 percent soils of minor extent (fig. 4).

The well drained Lester and Hayden soils are in gently sloping and moderately sloping areas on ridgetops and in strongly sloping to very steep areas on side slopes. The poorly drained, nearly level Cordova soils are in swales or upland drainageways and on broad flats on ridgetops.

Typically, the surface layer of the Lester soils is very dark grayish brown loam about 7 inches thick. The subsoil is about 27 inches thick. It is mottled and friable. The upper part is dark yellowish brown clay loam, and the lower part is dark yellowish brown and yellowish brown loam. The substratum to a depth of about 60 inches is light olive brown, mottled, calcareous loam.

Typically, the surface layer of the Hayden soils is dark grayish brown and grayish brown, friable loam about 8 inches thick. The subsoil is clay loam about 29 inches thick. The upper part is brown and dark yellowish brown and is friable and firm. The lower part is yellowish brown and dark yellowish brown and is firm. The substratum to a depth of about 60 inches is yellowish brown and light olive brown, mottled, calcareous loam.

Typically, the surface layer of the Cordova soils is black loam about 6 inches thick. The subsurface layer is black and very dark gray clay loam about 15 inches thick. The subsoil is mottled clay loam about 27 inches thick. The upper part is dark grayish brown, and the lower part is olive gray. The substratum to a depth of about 60 inches is olive gray loam.

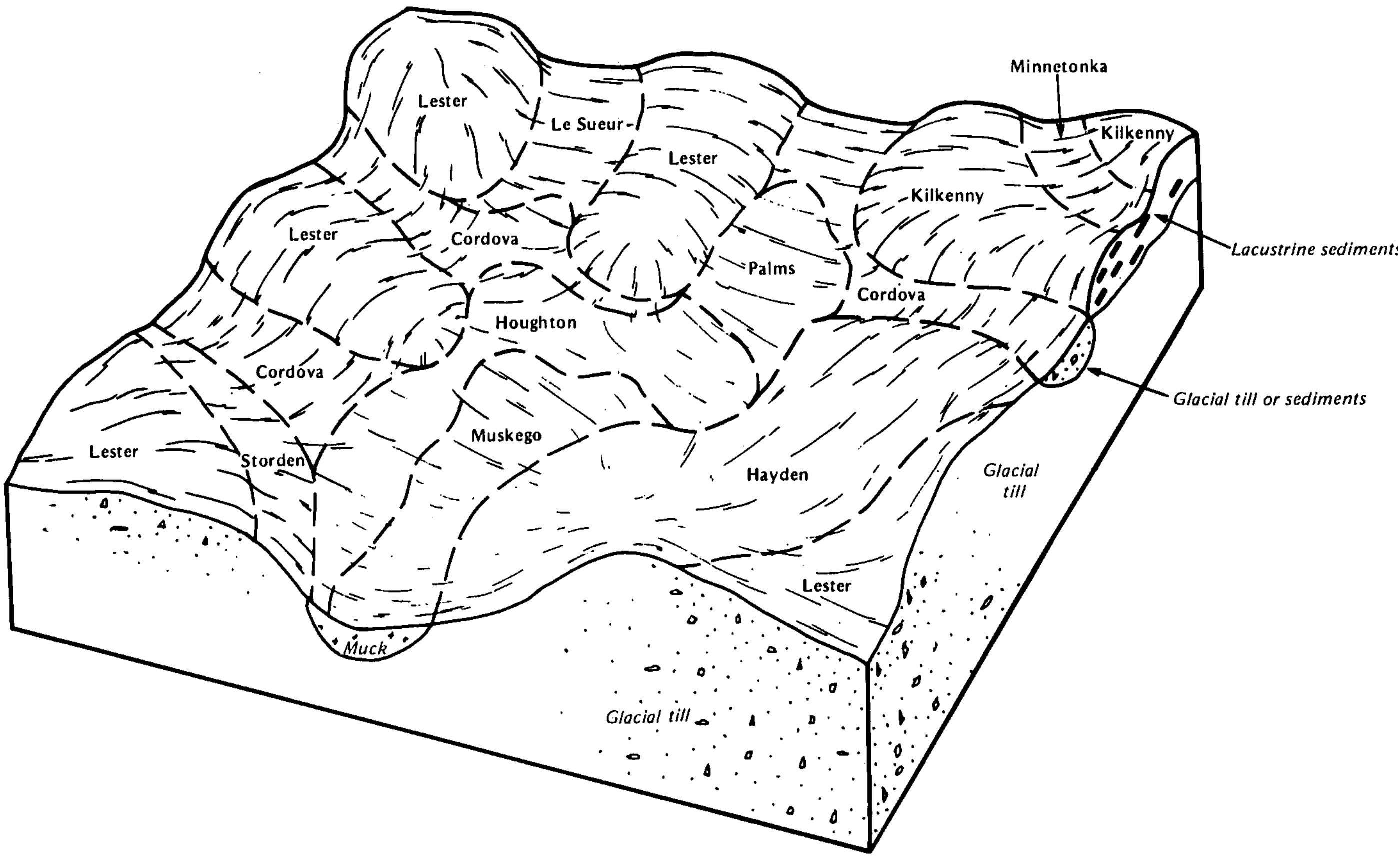

Figure 4.—Pattern of soils and parent material in the Lester-Hayden-Cordova association.

The minor soils in this association are the Houghton, Kilkenny, Le Sueur, Minnetonka, Muskego, Palms, and Storden soils. The very poorly drained Houghton, Muskego, and Palms soils formed in organic deposits in depressions and on former lake bottoms. The well drained Kilkenny soils formed in glaciolacustrine sediments over loamy glacial till. The somewhat poorly drained, very gently sloping Le Sueur soils formed in glacial till on slightly concave to slightly convex slopes. The poorly drained, nearly level Minnetonka soils formed in fine textured glaciolacustrine sediments. The calcareous, well drained Storden soils formed in glacial till. They are mainly in strongly sloping to steep areas.

This association is used for general farming. The suitability for cultivated crops ranges from good to poor. Corn and soybeans are the main crops. The strongly sloping and moderately steep areas are used for oats or for rotation hay and pasture. The content of organic matter is moderate in the Lester soils, low in the Hayden soils, and high in the Cordova soils. All of these soils have a high available water capacity. In some of the steeper areas of Hayden and Lester soils, however, the amount of available water is reduced during some years because of rapid runoff. The minor soils have a low to very high content of organic matter and a high or very high available water capacity.

The main management concerns are controlling erosion on the Hayden and Lester soils and maintaining tilth in the Hayden soils. Most areas of the Cordova soils have been drained, but measures that improve drainage are needed in a few areas. Some areas of the minor soils are too wet for dependable crop production. Generally, the soils in this association have a lower content of organic matter than the soils in other associations, have a more complex pattern of slopes, and are more eroded. Timely erosion control is more important on this association than on the other associations. Shifting land use away from cultivated crops helps to control further erosion. Terracing and farming on the contour commonly are difficult because of irregular or steep and very steep slopes. A system of conservation tillage that leaves most of the crop residue on the surface or incorporates it into the surface layer is effective in controlling erosion. It also helps to maintain tilth in the Hayden soils. Grassed waterways are needed and can be easily established in many places. More nitrogen is needed in areas of this association, particularly on the Hayden soils, than in the other associations.

Some areas of the Hayden and Lester soils, particularly the moderately steep to very steep ones, support native vegetation. They provide good habitat for wildlife. The potential for improving the habitat for both upland and wetland species is good. Also, these areas have potential for timber production.

6. Houghton-Muskego-Palms Association

Level, very poorly drained soils formed in organic deposits; in large depressions on uplands

This association consists of organic soils in large upland depressions and on former lake bottoms. The organic deposits range from about 2 to several feet in thickness. Natural drainage is very slow. Relief is low. Most areas are subject to runoff from the strongly sloping and moderately steep adjacent soils. Much of this association is drained by a system of drainage ditches and tile drains. In many places, however, drainage is not adequate for dependable crop production in years of above normal rainfall. Slopes are 0 to 1 percent.

This association makes up about 4 percent of the county. It is about 34 percent Houghton soils, 24 percent Muskego soils, 14 percent Palms soils, and 28 percent soils of minor extent.

Houghton soils generally are on the slightly lower parts of this association. Muskego and Palms soils commonly are on the slightly higher parts.

Typically, the upper 58 inches of the Houghton soils is black, friable muck. The substratum to a depth of about 60 inches is olive gray, calcareous silt loam.

Typically, the upper 26 inches of the Muskego soils is black muck. The substratum to a depth of 60 inches or more is highly calcareous, black and very dark gray mucky silt loam.

Typically, the upper 35 inches of the Palms soils is black muck. The upper part of the substratum is black, mottled mucky silt loam. The lower part to a depth of about 60 inches is olive gray, mottled silt loam.

The minor soils in this association are the Boots, Blue Earth, and Harps soils. Boots soils are very poorly drained and commonly are adjacent to the Houghton soils. They have layers of organic material that are thicker and more fibrous than those of the major soils. Blue Earth soils are very poorly drained, are highly calcareous, and are commonly adjacent to the major soils, generally in the slightly higher landscape positions. Harps soils are highly calcareous and formed in glacial till. They are poorly drained and are generally in the slightly higher areas.

Most areas of this association are used for cultivated crops. Some are used as pasture, some are idle, and a few are commercially mined for peat. Adequately drained areas are moderately suited to cultivated crops. The main management concern is maintaining or improving the drainage system. If these soils are fall plowed, soil blowing readily occurs where the surface is bare. The runoff from the adjacent slopes is a problem in a few areas.

Most areas of this association are drained by a combination of drainage ditches and tile. Because of the low relief and the slow removal of water, however, crops are often damaged by excess water. In many areas they are destroyed when rainfall is heavy. Because these soils warm up and dry out slowly in the spring, planting is delayed. The soils lose heat rapidly in the fall and are in low lying areas. As a result, early frost often damages the crops. Short-season varieties of corn and soybeans should be selected for planting. Small grain tends to lodge badly and thus is of poor quality. Most legumes for hay grow poorly and are winterkilled.

These soils have a very high content of organic matter and a very high available water capacity. They can be easily tilled throughout a wide range in moisture content. Controlling unwanted grass and weeds is difficult. Because of the very high content of organic matter, most herbicides are not as effective on these soils as on other soils.

7. Vinje-Collinwood Association

Nearly level to strongly sloping, well drained and somewhat poorly drained soils formed in glacial lacustrine sediments and in the underlying glacial till; on uplands

This association consists of soils on ridges and hummocks and in swales and upland drainageways between the ridges. These soils are nearly level to gently sloping on the crests of the ridges and hummocks and moderately sloping and strongly sloping on the side slopes. Relief ranges from about 20 to 40 feet. The soils on the ridge crests formed mostly in lacustrine sediments. Those on the side slopes and in the swales formed in lacustrine and till sediments. Slopes range from about 0 to 14 percent.

This association makes up about 2 percent of the county. It is about 40 percent Vinje soils, 20 percent Collinwood soils, and 40 percent soils of minor extent (fig. 5).

The well drained, gently sloping and moderately sloping Vinje soils are on ridgetops and side slopes that are relatively smooth and undissected. In some places they are the highest soils on the landscape, but in other places they are below the Collinwood soils. The somewhat poorly drained, nearly level to gently sloping Collinwood soils are on the ridgetops. They generally are somewhat lower on the landscape than the Vinje soils.

Typically, the surface layer of the Vinje soils is very dark brown silty clay loam about 7 inches thick. The

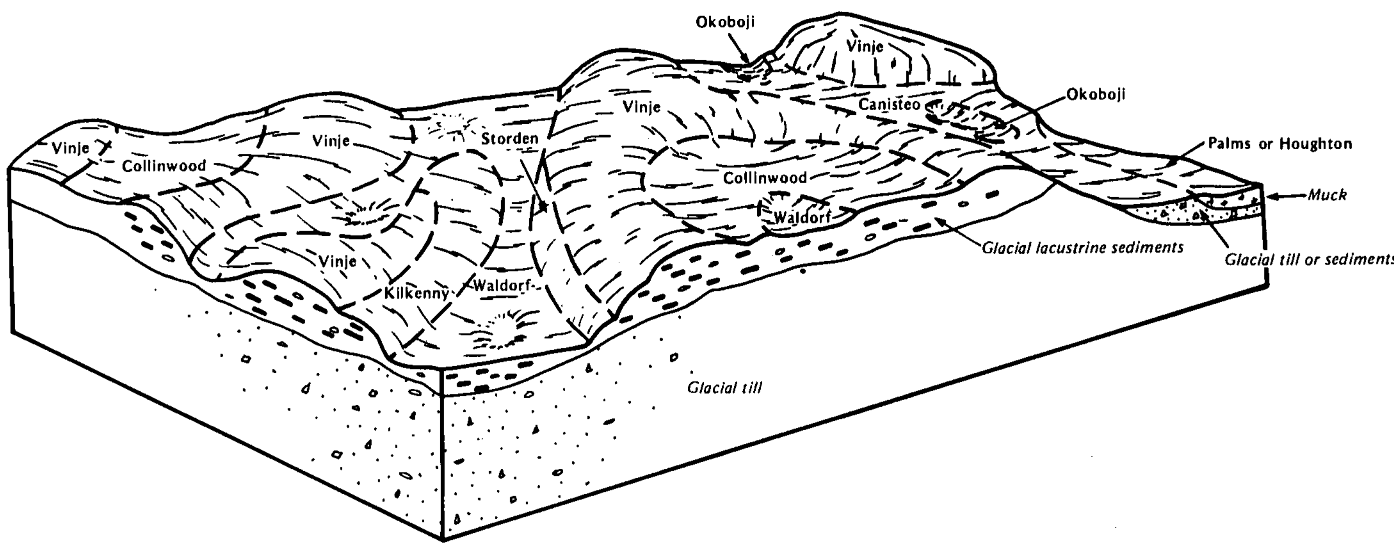

Figure 5.—Pattern of soils and parent material in the Vinje-Collinwood association.

subsurface layer is very dark brown silty clay loam about 6 inches thick. The subsoil is silty clay loam about 28 inches thick. The upper part is dark brown, the next part is dark yellowish brown, and the lower part is grayish brown and olive brown. The upper part of the substratum is grayish brown, mottled silt loam. The lower part to a depth of about 60 inches is grayish brown and yellowish brown, mottled loam.

Typically, the surface layer of the Collinwood soils is black silty clay loam about 8 inches thick. The subsurface layer also is black silty clay loam. It is about 11 inches thick. The subsoil is firm silty clay about 21 inches thick. The upper part is dark grayish brown, and the lower part is dark grayish brown and grayish brown and is mottled. The substratum to a depth of about 60 inches is grayish brown, mottled silty clay loam.

The minor soils in this association are the Canisteo, Houghton, Kilkenny, Okoboji, Palms, Storden, and Waldorf soils. The poorly drained, calcareous Canisteo soils are in swales. They formed in glacial till or till sediments. The very poorly drained Houghton and Palms soils formed in thick or moderately thick organic deposits in depressions. The well drained Kilkenny soils are in positions on the landscape similar to those of the Vinje soils. Their surface layer typically is clay loam. It is lighter colored than that of the major soils. Okoboji soils are in slightly depressional areas within swales. The well drained, calcareous Storden soils are on slopes below or adjacent to Kilkenny and Vinje soils. The poorly drained Waldorf soils are on plane or slightly concave hilltops and in swales or areas between knobs.

This association is used mainly for general farming. The nearly level to gently sloping soils generally are well suited to cultivated crops. The steeper soils are moderately suited or poorly suited. A few areas are too steep for crops. Most of these areas are used for pasture, and some support scattered trees. Corn and soybeans are the main crops. A significant acreage is used for oats or for hay and pasture. The content of organic matter is high in the major soils and ranges from low to very high in the minor soils. Available water capacity is high, but the amount of available water is reduced in some years because of runoff.

The main management concerns are controlling erosion and maintaining tilth. Measures that improve drainage are needed in some areas of the minor soils. Erosion is a serious hazard. Because of the slope and a restricted rate of water infiltration in the fine textured soils, the rate of runoff increases the susceptibility to erosion. Terraces, contour farming, and a system of conservation tillage that leaves crop residue on the surface can slow runoff and increase the rate of infiltration. Farming on the contour and terracing are difficult in some areas, however, because of a complex pattern of slopes.

Because of a higher content of clay, these soils are slower to dry out and more difficult to till than other soils in the county. They should be tilled only at the optimum moisture content. If they are tilled when too wet, they are sticky and become hard and cloddy when dry. If they are tilled when too dry, they are hard and difficult to work.

8. Ridgeport-Mayer-Colo Association

Nearly level to gently sloping, somewhat excessively drained and poorly drained soils formed in glacial outwash and alluvium; on outwash plains, terraces, and bottom land

This association consists of soils on flood plains, stream terraces, and outwash plains. Most areas on the flood plains have a cover of grass. Many support a marsh type of vegetation. A few scattered trees also grow on the flood plains. Many areas are cut by meandering channels and oxbows. Slopes range from 0 to 5 percent.

This association makes up about 5 percent of the county. It is about 35 percent Ridgeport soils, 25 percent Mayer and similar soils, 20 percent Colo soils, and 20 percent soils of minor extent.

The somewhat excessively drained, nearly level to gently sloping Ridgeport soils are on outwash plains and terraces adjacent to streams. The poorly drained, nearly level Mayer soils are on outwash plains and low stream terraces. The poorly drained, nearly level Colo soils border the stream channels.

Typically, the surface layer of the Ridgeport soils is very dark brown sandy loam about 9 inches thick. The subsurface layer is very dark brown sandy loam about 4 inches thick. The subsoil is sandy loam about 25 inches thick. The upper part is very dark grayish brown, dark brown, and brown; the next part is dark brown and brown; and the lower part is dark yellowish brown. The substratum to a depth of about 60 inches is dark yellowish brown, brown, and yellowish brown. It is loamy sand in the upper part and gravelly loamy sand in the lower part.

Typically, the surface layer of the Mayer soils is black, friable loam about 9 inches thick. The subsurface layer is black and very dark gray, friable loam about 13 inches thick. The subsoil is friable loam about 11 inches thick. The upper part is dark grayish brown, and the lower part is dark grayish brown and olive. The substratum to a depth of about 60 inches is olive gray and olive gravelly sand. The soils are calcareous throughout.

Typically, the surface layer of the Colo soils is black silty clay loam about 12 inches thick. The subsurface layer is black and very dark gray silty clay loam about 35 inches thick. The substratum to a depth of about 60 inches is dark gray silty clay loam.

The minor soils in this association are the Coland, Darfur, Dickman, and Palms soils. Coland soils contain more sand than the Colo soils. They are on the flood plains along minor streams. On the flood plains along the Winnebago River, they are commonly adjacent to soils on foot slopes. Darfur soils are poorly drained. They have a lower content of clay and coarse fragments in the substratum than the Mayer soils. The well drained Dickman soils are on uplands. Palms soils formed in organic material and are on the flood plains along the Winnebago River.

Some areas of this association are used for row crops, hay, or pasture. Others are used as permanent pasture or wildlife habitat or are left idle. Most of the soils on the outwash plains are used for corn, soybeans, oats, hay, or rotation pasture. Peas and sweetcorn for canning and a few acres of sunflowers are also grown.

Most areas of the Colo soils are cut by meandering channels. They generally cannot be used for crops because they are flooded too frequently and remain flooded too long. In many areas they are used for pasture. A few small areas are used for cultivated crops. Some areas are so low and so wet that they are managed as wildlife habitat. One old gravel pit has been developed for recreational uses.

The Colo soils and other soils that formed in alluvium on bottom land have a high content of organic matter and a high available water capacity. The soils that formed in outwash generally have a low to moderate content of organic matter and a low or moderate available water capacity. Crop growth and yields vary on these soils, but in most years they are only moderate because of the droughtiness.

The major management concerns are flooding on the soils that formed in alluvium and droughtiness and soil blowing on the soils that formed in outwash. A system of reduced tillage that leaves crop residue on the surface or incorporates it into the surface layer helps to control soil blowing and conserves available moisture.

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

Some map units are made up of two or more major soils. These map units are called soil complexes. A *soil complex* consists of two or more soils, or one or more soils and a miscellaneous area, 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. Clarion-Storden loams, 9 to 14 percent slopes, moderately eroded, 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, sand and 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

6—Okoboji silty clay loam, 0 to 1 percent slopes. This level, very poorly drained soil is in shallow upland depressions or sloughs. It is subject to ponding (fig. 6). Individual areas typically are circular and are about 2 to 6 acres in size, but some are elongated and some are as much as about 12 acres.

Typically, the surface layer is black, friable silty clay loam about 9 inches thick. The subsurface layer is black silty clay loam about 17 inches thick. The subsoil is very dark gray, friable silty clay loam about 22 inches thick. The substratum to a depth of about 60 inches is gray and olive gray, mottled silty clay loam. In places the surface layer is slightly calcareous.

Included with this soil in mapping are a few areas of soils on glacial outwash terraces. These soils have a clay loam surface soil and subsoil and a sandy substratum. They make up about 5 percent of the unit.

Permeability is moderately slow in the Okoboji soil. Runoff is very slow or ponded. A seasonal high water table is about 12 inches below the surface to 12 inches or more above. Available water capacity is high. The content of organic matter in the surface layer is about 9 to 11 percent. The shrink-swell potential is high. The surface layer and subsoil typically are mildly alkaline or neutral. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. Most are drained by tile, and some have surface intakes. A few areas are drained by shallow ditches. In places outlets deep enough for tile drains to function adequately are not readily available. If drained, this soil is moderately suited to cultivated crops.

Figure 6.—Ponding in an area of Okoboji silty clay loam, 0 to 1 percent slopes.

Crop growth varies. In the wetter years water ponds long enough to drown out crops. If the ponding occurs early in the growing season, the crop can be replanted. Even where artificial drainage is adequate for good crop growth, tillage is delayed after heavy rains. The surface layer puddles easily if the soil is worked when wet. In many areas production can be increased by improving the drainage system.

This soil is poorly suited to some legumes, especially alfalfa. Ponding and soil heaving in winter frequently drown out or kill crops. If the soil is used for hay and improved pasture, such grasses as reed canarygrass and legumes that can withstand excessive wetness should be selected for planting. Grazing when the soil is wet causes surface compaction and poor tilth.

Undrained areas generally are used for permanent pasture. Production generally can be increased by improving drainage and planting grasses that can withstand the wetness and the periods of ponding. Some areas are suited to the development of wetland wildlife habitat. This soil generally is managed in conjunction with the adjacent soils.

The land capability classification is IIIw.

28B—Dickman sandy loam, 2 to 7 percent slopes. This gently sloping and moderately sloping, well drained soil is mainly in the uplands and on high terraces near the larger streams. Individual areas are irregularly shaped and range from 2 to 20 acres in size.

Typically, the surface layer is very dark brown and very dark grayish brown sandy loam about 7 inches thick. The subsurface layer is dark brown and very dark grayish brown sandy loam about 5 inches thick. The subsoil is loamy fine sand about 35 inches thick. The upper part is dark yellowish brown, and the lower part is yellowish brown and dark yellowish brown. The substratum to a depth of about 60 inches is yellowish brown and dark yellowish brown fine sand. In places the soil is nearly level. In some areas adjacent to small upland drainageways, the slope is more than 7 percent.

Permeability is moderately rapid in the upper part of the profile and rapid in the lower part. Runoff is slow. Available water capacity is low. The content of organic matter in the surface layer is about 1 to 2 percent. Reaction typically is slightly acid in the upper part of the profile and neutral in the lower part. The subsoil generally has a low supply of available phosphorus and a very low or low supply of available potassium.

Most areas are cultivated along with larger areas of adjacent soils that are better suited to cultivation. This soil is poorly suited to cultivated crops. It is better suited to small grain than to row crops. Soil blowing is a hazard because the surface dries quickly after tillage. Windblown sand damages young plants in some years. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil loss. Applying mechanical erosion-control measures, such as terracing, is difficult because of the instability of the soil. Also, obtaining adequate compaction of the terrace wall is difficult. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to maintain tilth, and improves the available water capacity.

A cover of pasture plants or hay is effective in controlling erosion. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during extremely dry periods help to keep the pasture in good condition.

The land capability classification is IIIe.

55—Nicollet loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is mainly on convex slopes in the uplands. In a few places it is on concave slopes between undulating areas of well drained soils. Individual areas are irregularly shaped. They generally range from 3 to 20 acres in size, but a few are as much as about 100 acres.

Typically, the surface layer is black loam about 7 inches thick. The subsurface layer is black, very dark brown, and very dark grayish brown loam about 12 inches thick. The subsoil is dark grayish brown, friable loam about 28 inches thick. It is mottled and calcareous in the lower part. The substratum to a depth of about 60 inches is olive and light olive brown, mottled, calcareous loam. In places the surface layer and subsoil contain more clay.

Included with this soil in mapping are small areas of the well drained Clarion and Storden soils. These soils are on the highest, most convex part of the slopes. They are not so dark as the Nicollet soil. Also included are small areas of the poorly drained Webster and very poorly drained Okoboji soils on the level or slightly depressional parts of the landscape. Okoboji soils generally are ponded after rains. Included soils make up about 10 percent of the unit.

Permeability is moderate in the Nicollet soil. Runoff is slow. A seasonal high water table is at a depth of about 30 to 60 inches. Available water capacity is high. The content of organic matter in the surface layer is about 4 to 6 percent. Reaction typically is neutral or slightly acid in the upper part of the profile. The subsoil generally has a very low or low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay or pasture. Erosion generally is not a problem. If the soil is plowed in the fall, however, soil blowing may be a problem. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil loss. Good tilth generally can be easily maintained. Returning crop residue to the soil, regularly adding other organic material, and delaying tillage when the soil is wet help to maintain good tilth, improve fertility, and increase the rate of water infiltration. The soil generally is not drained, but in some areas a drainage system would improve the timeliness of tillage.

A cover of pasture plants or hay is effective in controlling soil blowing and in maintaining good tilth. Overgrazing or grazing when the soil is wet causes surface compaction and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is I.

62C2—Storden loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on short, convex side slopes and sharply convex knobs in the uplands. Individual areas are irregularly shaped and are about 5 to 10 acres in size.

Typically, the surface layer is mixed very dark grayish brown and brown loam about 8 inches thick. Plowing has mixed some streaks and pockets of light olive brown substratum material into the surface layer. The substratum to a depth of about 60 inches is light olive brown, mottled, friable, calcareous loam. In places the light colored substratum is exposed. In areas where the soil has not been plowed, the surface layer is darker and is about 10 inches thick.

Included with this soil in mapping are a few small areas of Salida and Dickman soils. These soils are droughty and are more erosive than the Storden soil. They generally are on the higher, more sharply convex slopes. Salida soils contain gravel, and Dickman soils have more sand than the Storden soil. Included soils make up less than 5 percent of the unit.

Permeability is moderate in the Storden soil. Runoff is medium. Available water capacity is high. The content of organic matter in the surface layer generally is about 1 to 2 percent. In severely eroded areas, however, it is less than 1 percent. The soil typically is moderately alkaline throughout. It has a high content of calcium carbonates. The substratum generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. Some are pastured. 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. A system of conservation tillage that leaves crop residue on the surface and grassed waterways help to prevent excessive soil loss. In places applying mechanical erosion-control measures, such as contour farming and terracing, is difficult because of the irregular topography and the short slopes.

The high content of calcium carbonates adversely affects the response of plants to fertilizer and herbicide. The supply of available iron is sometimes deficient, and in places the availability of other minor elements is restricted. Returning crop residue to the soil or regularly adding other organic material increases the organic matter content, improves fertility, and helps to maintain good tilth.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet causes surface compaction and deterioration of tilth 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 in good condition.

The land capability classification is IIIe.

62D2—Storden loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is on short, convex side slopes and sharply convex knobs and ridges in the rolling and hilly uplands throughout the county. Individual areas generally are irregularly shaped and are 5 to 10 acres in size, but some are as large as about 30 acres and some areas on side slopes are long and narrow. Some areas are dissected by shallow waterways.

Typically, the surface layer is very dark grayish brown and brown loam about 8 inches thick. Plowing has mixed some streaks and pockets of light olive brown substratum material into the surface layer. The substratum to a depth of about 60 inches is light olive brown, mottled loam. The soil is calcareous throughout. In places the surface layer is very dark gray or very dark grayish brown and is about 3 to 10 inches thick.

Included with this soil in mapping are a few small areas of Salida and Dickman soils. These soils are mainly on the more sharply convex parts of the slopes. They are more droughty than the Storden soil and are more erosive. They make up less than 10 percent of the unit.

Permeability is moderate in the Storden soil. Runoff is rapid. Available water capacity is high. The content of organic matter in the surface layer is generally about 1 to 2 percent. In severely eroded areas, however, it is less than 1 percent. The soil typically is moderately alkaline throughout. It has a high content of calcium carbonates. The substratum generally has a very low supply of available phosphorus and potassium.

Most areas are used for cultivated crops. Some are frequently pastured. 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 severe hazard. A system of conservation tillage that leaves crop residue on the surface and grassed waterways help to prevent excessive soil loss. In places applying mechanical erosion-control measures, such as contour farming and terracing, is difficult because of the irregular topography and the short slopes.

The high content of calcium carbonates adversely affects the response of plants to fertilizer and herbicide. As a result, large applications of fertilizer are needed. The supply of available iron is sometimes deficient, and in places the availability of other minor elements is restricted. Returning crop residue to the soil or regularly adding other organic material increases the content of organic matter, improves fertility, and helps to maintain good tilth.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet causes surface compaction and deterioration of tilth and increases the runoff rate. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

The land capability classification is IIIe.

62E2—Storden loam, 14 to 20 percent slopes, moderately eroded. This moderately steep, well drained soil is on hills and ridges in the uplands and on side slopes adjacent to drainageways and small streams. Some areas are dissected by shallow drainageways. Individual areas generally are irregularly shaped and are 5 to 10 acres in size, but some are as large as about 30 acres and some areas on side slopes are long and narrow.

Typically, the surface layer is mixed very dark brown, brown, and dark grayish brown loam about 7 inches thick. It has some streaks and pockets of light olive brown substratum material. The substratum to a depth of about 60 inches is yellowish brown and light olive brown, mottled loam. In some areas it is exposed. In places the surface layer is very dark gray and very dark grayish brown, friable, calcareous loam about 3 to 7 inches thick.

Included with this soil in mapping are a few small areas of Clarion, Salida, and Dickman soils. Clarion soils have a surface layer that is thicker and darker than that of the Storden soil. They are leached to a depth of 18 inches or more. Salida and Dickman soils are mainly on the more sharply convex parts of the slopes. They contain more sand than the Storden soil and are more droughty and more erosive. Included soils make up less than 5 percent to 10 percent of the unit.

Permeability is moderate in the Storden soil. Runoff is very rapid. Available water capacity is high, but this capacity commonly is not reached because of the very rapid runoff and a restricted rate of water infiltration. The content of organic matter in the surface layer generally is about 1 to 2 percent. In severely eroded areas, however, it is less than 1 percent. The soil typically is moderately alkaline throughout. It has a high content of calcium carbonates. The substratum generally has a very low supply of available phosphorus and potassium.

Most areas are used for cultivated crops along with adjacent soils that are better suited to cultivation. Many areas that border drainageways and streams are pastured. This soil is poorly suited to corn and soybeans. It is better suited to small grain and to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a severe hazard. Measures that control runoff and allow more water to enter the soil help to prevent excessive soil loss and improve pasture and crop growth. A system of conservation tillage that leaves crop residue on the surface and grassed waterways are examples. Applying mechanical erosion-control measures, such as contour farming and terracing, is difficult because of the irregular topography and the short slopes.

The high content of calcium carbonates adversely affects the response of plants to fertilizer and herbicide. The supply of available iron is sometimes deficient, and in places the availability of other minor elements is restricted. Returning crop residue to the soil or regularly adding other organic material increases the content of organic matter, improves fertility, and helps to maintain good tilth.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet causes surface compaction and deterioration of tilth 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 in good condition.

The land capability classification is IVe.

73B—Salida gravelly sandy loam, 2 to 7 percent slopes. This gently sloping and moderately sloping, excessively drained soil is on upland knolls and outwash plains. Slopes generally are short and convex. Individual areas generally are small and irregularly shaped and are about 2 to 6 acres in size. Small rocks and pebbles are commonly on the surface.

Typically, the surface layer is very dark grayish brown, calcareous gravelly sandy loam about 9 inches thick. The subsoil is dark brown and brown, calcareous gravelly loamy sand about 6 inches thick. The substratum to a depth of about 60 inches is brown, dark yellowish brown, yellowish brown, and pale brown. It is very gravelly sand in the upper part and gravelly sand in the lower part. It is calcareous throughout. In severely eroded areas the subsoil is mixed with the surface layer.

Permeability is very rapid, and runoff is slow. Available water capacity is very low. The content of organic matter in the surface layer is about 1 to 2 percent. Reaction typically is mildly alkaline in the surface layer and moderately alkaline in the subsoil and substratum. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated along with adjacent soils that are well suited to row crops. This soil is poorly suited to corn, soybeans, and small grain. Crop growth generally is poor because of low fertility and the limited amount of available water. When tilled, the surface layer dries rapidly. Also, the tilled areas are highly susceptible to soil blowing, which often damages young seedlings. A system of conservation tillage that leaves crop residue on the surface and regular additions of other organic material conserve moisture, improve fertility, and help to control soil blowing.

This soil is better suited to a permanent cover of grasses than to cultivated crops. Most areas are small, however, and are adjacent to soils that are well suited to cultivated crops. As a result, managing this soil separately is difficult. A few areas in cultivated fields support grass, which is grazed in the fall along with crop residue. These areas provide habitat for wildlife. They can be improved by planting better suited warm-season species of grass. If the soil is undisturbed, native bluestems eventually become established in many areas.

The land capability classification is IVs.

73E—Salida gravelly sandy loam, 9 to 18 percent slopes. This strongly sloping and moderately steep, excessively drained soil is on knobs and hills in the uplands. It is commonly on kames or eskers. Individual areas generally are long and somewhat narrow and range from 6 to 12 acres in size. Small rocks and pebbles are commonly on the surface.

Typically, the surface layer is very dark grayish brown and dark brown, calcareous gravelly sandy loam about 9 inches thick. The subsoil is dark brown and brown, calcareous gravelly loamy sand about 4 inches thick. It has tongues of very dark grayish brown material. The substratum to a depth of about 60 inches is brown, yellowish brown, dark yellowish brown, and pale brown. It is very gravelly sand in the upper part and gravelly sand in the lower part. It is calcareous throughout. In severely eroded areas plowing has mixed subsoil material and sand and gravel from the substratum into the surface layer. In some small areas the soil is sandy and is leached of carbonates to a depth of about 2 feet. In a few areas the slope is more than 18 percent.

Permeability is very rapid in the Salida soil. Runoff is slow. Available water capacity is very low. The content of organic matter in the surface layer is less than 0.5 percent. Reaction typically is mildly alkaline in the surface layer and moderately alkaline in the subsoil and substratum. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are used for hay and pasture. Some support native grasses. A few are cultivated. This soil generally is unsuited to cultivated crops because of the slope and the hazard of erosion. When plowed or tilled, the surface layer dries rapidly and commonly is subject to soil blowing. Windblown sand damages or destroys young seedlings.

This soil is better suited to grassland and hayland than to cropland. The major management problems are the hazard of soil blowing, low fertility, and the very low available water capacity. Management that maintains an adequate vegetative cover helps to prevent excessive soil loss and increases the supply of available water by reducing the runoff rate and the rate of drying. Additions of fertilizer can improve plant growth if the fertilizer is applied in the fall or very early in spring, before a lack of sufficient water limits plant growth. Proper stocking rates, timely deferment of grazing, and rotation grazing help to maintain the desirable plant species and keep the vegetation and the soil in good condition.

If properly managed, this soil can provide habitat for openland wildlife. It can be managed so that native bluestems eventually become established. Establishing other warm-season grasses, such as indiangrass and switchgrass, can greatly improve the suitability for wildlife habitat, especially if the area is used as a nesting site by pheasants.

The land capability classification is VIe.

90—Okoboji mucky silt loam, 0 to 1 percent slopes. This level, very poorly drained soil is in shallow upland depressions or sloughs. It is subject to ponding. Individual areas are circular. They generally range from about 5 to 12 acres in size, but a few are as much as about 20 acres.

Typically, the surface layer is black mucky silt loam about 18 inches thick. The subsurface layer is black silty clay loam about 18 inches thick. The subsoil to a depth of about 60 inches is very dark gray, mottled silty clay loam. In places the mucky surface layer extends to a depth of about 22 inches.

Permeability is moderately slow, and runoff is very slow or ponded. A seasonal high water table is about 12 inches below the surface to 12 inches or more above. Available water capacity is high. The content of organic matter in the surface layer is about 12 to 18 percent. Reaction typically is neutral in the surface layer and neutral or mildly alkaline in the subsurface layer and subsoil. The subsoil generally has a very low supply of available phosphorus and a low or very low supply of available potassium.

Most areas are cultivated. This soil is moderately suited to corn, soybeans, and small grain and to grasses for hay and pasture. Most of the acreage is drained or partly drained. Surface intakes, shallow ditches, and tile drains are used. Improving the drainage system can increase productivity. In places outlets deep enough for tile drains to function adequately are not readily available. Many areas are ponded in spring and after heavy rains. In some years water ponds long enough to drown out crops. If the ponding occurs early in the growing season, the soil can be tilled and the crop replanted. Even where artificial drainage is adequate for good crop growth, tillage is delayed after heavy rains.

Because it is in low lying areas and has a very high organic matter content, this soil warms up slowly in spring and loses heat rapidly from the surface. As a result, crops are subject to frost damage late in spring and early in fall. In areas that are large enough to be managed separately, planting early maturing varieties helps to prevent excessive crop losses. Tilth is excellent in the surface layer. The soil can be easily tilled throughout a wide range of moisture content. The surface layer is less dense and compacted than that of other Okoboji soils. As a result, preparing a desirable seedbed is easier. Large areas should not be plowed in the fall because soil blowing is a hazard unless the surface is protected. The application rate for some herbicides should be higher than the rate on surrounding soils and on other Okoboji soils because the higher organic matter content of this soil limits the effectiveness of the herbicides.

This soil is poorly suited to some legumes, especially alfalfa. Soil heaving in winter and ponding frequently kill the plants. If the soil is used for hay and improved pasture, the grasses and legumes that can withstand the wetness should be grown. Grazing when the soil is wet damages the plant cover. Undrained areas are generally used for permanent pasture or are left idle, depending on the depth and duration of ponding. Productivity generally can be increased by improving drainage and planting the more desirable grasses that can withstand the wetness and the periods of ponding. Some undrained areas provide habitat for wetland wildlife. This soil generally is managed in conjunction with the adjacent soils, but some areas are managed separately.

The land capability classification is IIIw.

95—Harps loam, 1 to 3 percent slopes. This very gently sloping, highly calcareous, poorly drained soil is on convex rims that border depressions in the uplands. When dry, it has a surface layer that is distinctly grayer than that of the adjacent soils (fig. 7). Individual areas are irregularly shaped and range from 5 to 15 acres in size.

Figure 7.—An area of light colored Harps loam, 1 to 3 percent slopes. Okoboji soils are in the darker areas.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is about 15 inches of black and very dark gray loam and clay loam. The subsoil is gray and olive gray, mottled clay loam about 17 inches thick. The substratum to a depth of about 60 inches is gray and olive gray, mottled loam. In places very fine sand is below a depth of 30 inches.

Included with this soil in mapping are some small areas of the very poorly drained Okoboji soils in slight depressions. These soils generally are ponded after rains. They make up about 5 percent of the unit.

Permeability is moderate in the Harps soil. Runoff is slow. The soil has a seasonal high water table. Available water capacity is high. The content of organic matter in the surface layer is about 4.5 to 5.5 percent. Reaction typically is moderately alkaline throughout the profile. The subsoil generally has a very low supply of available phosphorus and is seriously deficient in available potassium and iron. Some minor elements are likely to be in short supply.

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, a drainage system is needed to reduce the wetness and provide proper aeration for the plants that require a deep root zone. In years of excessive rainfall, crops can be drowned by ponded water from the adjacent Palms and Okoboji soils. Subsurface drains generally work well, but in some areas adequate outlets are not readily available.

The high content of calcium carbonates in this soil reduces the effectiveness of fertilizer. As a result, a special fertilization program may be needed. The content of carbonates also affects the response of plants to some herbicides. The carry-over effect of the herbicides can restrict the growth of subsequent crops. Some crops, particularly soybeans, show dramatic symptoms of iron deficiency. Excessive tillage readily destroys the weak structure of this soil. Also, the soil is subject to soil blowing if the surface is bare when it dries. A system of conservation tillage that leaves crop residue on the surface and regular additions of other organic material improve soil structure and help to control soil blowing.

If this soil is used for pasture, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods are needed. They help to keep the pasture in good condition. Because most areas of this soil are small, they are managed along with the adjacent Canisteo, Palms, and Okoboji soils.

The land capability classification is IIw.

107—Webster clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is in swales and draws on undulating till plains. Individual areas are irregularly shaped and range from 5 to 30 acres in size.

Typically, the surface layer is black clay loam about 9 inches thick. The subsurface layer is black, mottled clay loam about 14 inches thick. The subsoil is about 23 inches thick. The upper part is olive gray and dark gray, mottled clay loam, and the lower part is olive gray, mottled clay loam and loam. The substratum to a depth of about 60 inches is light olive gray, mottled, calcareous loam. In some places the soil has a thinner subsoil and is much shallower to lime. In other places the surface layer is silty clay loam.

Included with this soil in mapping are some small areas of the very poorly drained Okoboji soils in small depressions. These soils generally are ponded after rains. Also included are a few small areas of Harps soils, which are calcareous throughout and are distinctly lighter in color when dry than the Webster soil. Included soils make up less than 10 percent of the unit.

Permeability is moderate in the Webster soil. Runoff is slow. The soil has a seasonal high water table. Available water capacity is high. The content of organic matter in the surface layer is about 6 to 7 percent. Reaction typically is neutral in the surface soil and the upper part of the subsoil. It is neutral to moderately alkaline in the lower part of the subsoil. The subsoil generally has a very low or low supply of available phosphorus and potassium.

Most areas are cultivated. A few small undrained areas are pastured. If drained, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. A drainage system can improve productivity. Drainage can be improved by the installation of tile drains. These drains function well. If the soil is plowed when wet, the surface layer puddles easily and becomes cloddy and hard to work when it dries. When large areas are fall plowed, soil blowing is a hazard unless the surface is protected. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil blowing. Runoff from the steeper adjacent soils concentrates in some concave areas of this soil, causing crop damage, erosion, and siltation. Terraces, contour farming, conservation tillage, or a combination of these on the adjacent soils and grassed waterways in areas where runoff concentrates help to prevent excessive crop damage and erosion.

Most areas that are not drained sufficiently for dependable row crop production are used for pasture. Overgrazing or grazing when the soil is too wet causes surface compaction and poor tilth and reduces the rate of water infiltration. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is IIw.

135—Coland clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is mainly on the flood plains or former flood plains along streams throughout the county. It is occasionally flooded. Some areas have old meander channels, which are somewhat lower than the surrounding soil. In a few areas where these channels are shallow, water ponds for short periods early in spring and after heavy rainfall. Most areas are long and narrow and parallel both sides of the streams. The channels generally have been straightened and deepened and thus provide drainage outlets. A few areas along the larger streams are irregularly shaped. Most areas range from 15 to 35 acres in size, but a few are as large as about 80 acres.

Typically, the surface layer is black clay loam about 9 inches thick. The subsurface layer also is black clay loam. It is about 39 inches thick. The substratum to a depth of about 60 inches is mixed black, very dark gray, and gray clay loam that has strata of sandy loam.

Included with this soil in mapping are areas of soils that are calcareous throughout. These soils are mainly adjacent to the old meander channels. They commonly are loam at a depth of about 30 inches. They make up about 10 percent of the unit. Also included are areas of soils that have contrasting sand and gravel at a depth of 36 to 45 inches. These soils are in the same landscape positions as the Coland soil. They have an available water capacity that is somewhat lower than that of the Coland soil. They make up about 5 percent of the unit.

Permeability is moderate in the Coland soil. Runoff is slow. The soil has a seasonal high water table at a depth of 12 to 36 inches. Available water capacity is high. The content of organic matter in the surface layer is about 5 to 7 percent. The shrink-swell potential is high. Reaction typically is neutral throughout the soil. The subsurface layer generally has a low supply of available phosphorus and potassium.

Most areas are cultivated. A few small areas near farmsteads are used for permanent pasture consisting mostly of bluegrass. Because the stream channels generally have been straightened and deepened, flooding is a problem only in a few areas. An adequate tile drainage system is needed. Tile drains function well, and good outlets are readily available. Where drainage is adequate, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture.

If this soil is used for pasture, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted grazing during wet periods are needed. They help to keep the pasture in good condition.

The land capability classification is IIw.

135B—Coland clay loam, 2 to 5 percent slopes. This gently sloping, somewhat poorly drained soil is on low, concave foot slopes and alluvial fans. Individual areas are long and narrow and are about 3 to 6 acres in size.

Typically, the surface layer is black clay loam about 7 inches thick. The subsurface layer also is black clay loam. It is about 29 inches thick. The subsoil to a depth of about 60 inches is dark grayish brown clay loam. In areas upslope from organic soils in depressions, organic material is in the substratum. In places the subsoil is silty clay and clay.

Permeability is moderate, and runoff is slow. This soil has a seasonal high water table at a depth of 24 to 60 inches. Available water capacity is high. The content of organic matter in the surface layer is about 4 to 6 percent. Reaction typically is neutral to a depth of about 3 feet and neutral or mildly alkaline below that depth. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is moderately well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Erosion is a hazard if cultivated crops are grown. Water from the adjacent slopes runs across this soil. In some areas small gullies form, and in places the deeper waterways cut through areas of this soil. Constructing terraces in some areas upslope from this soil helps to control runoff. Gullies can be shaped, seeded, and used as grassed waterways. A system of conservation tillage that leaves crop residue on the surface helps to slow runoff, control erosion, and improve tilth. Most areas of this soil are managed along with the adjacent soils.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet causes surface compaction and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted grazing during wet periods help to keep the pasture in good condition.

The land capability classification is IIe.

138B—Clarion loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on knolls and ridgetops. Slopes are complex and are short and irregular. Individual areas typically are 10 to 25 acres in size but range from 4 to more than 40 acres.

Typically, the surface layer is black loam about 10 inches thick. The subsurface layer is black and very dark grayish brown, friable loam about 7 inches thick. It is mixed with some dark brown material in the lower part. The subsoil is friable loam about 13 inches thick. The upper part is dark brown and dark yellowish brown, and the lower part is dark yellowish brown and brown. The substratum to a depth of about 60 inches is yellowish brown and dark yellowish brown, friable, calcareous loam. In a few places the surface layer is less than 7 inches thick and is mixed with dark brown subsoil material.

Included with this soil in mapping are a few small areas of Storden, Salida, and Dickman soils. These areas are commonly on the highest, most convex parts of the slopes. They are about 1 acre or less in size. The included soils are lower in content of organic matter than the Clarion soil and are less fertile. Also, Dickman and Salida soils have more sand throughout and are droughty. Gravel in the surface layer of Salida soils can hinder tillage. Included soils make up about 5 percent of the unit.

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

Most areas are cultivated. 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 system of conservation tillage that leaves crop residue on the surface, terraces, and contour farming help to prevent excessive soil loss (fig. 8). In some areas applying mechanical erosion-control measures, such as contour farming and terracing, is difficult because of the irregular topography and the short slopes. In many areas, however, these measures are suitable. 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, reduces the likelihood of crusting, helps to maintain good tilth, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing, however, causes surface compaction, increases the runoff rate, results in poor tilth, and reduces forage production. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

This soil is well suited to windbreaks. Seedlings survive and grow well if competing vegetation is controlled or removed. Site preparation that disturbs the surface increases the erosion hazard.

The land capability classification is IIe.

138C—Clarion loam, 5 to 9 percent slopes. This moderately sloping, well drained soil is on knolls and convex side slopes. Slopes typically are short. Individual areas are irregularly shaped and range from 2 to 15 acres in size.

Typically, the surface layer is black and very dark grayish brown, friable loam about 12 inches thick. The subsoil is friable loam about 16 inches thick. The upper part is dark brown and brown, and the lower part is dark yellowish brown and yellowish brown. The substratum to a depth of about 60 inches is yellowish brown and dark yellowish brown, friable, calcareous loam. In a few places the surface layer is less than 7 inches thick and is mixed with brown subsoil material.

Permeability is moderate, and runoff is medium. Available water capacity is high. The content of organic matter in the surface layer is about 3 to 4 percent. The surface layer and the upper part of the subsoil typically

Figure 8.—A crop planted into crop residue on Clarion loam, 2 to 5 percent slopes.

are slightly acid or neutral. The subsoil generally has a very low or low supply of available potassium.

Most areas are pastured or used as farmsteads. A few are cultivated. This soil is moderately 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 system of conservation tillage that leaves crop residue on the surface, winter cover crops, and grassed waterways help to prevent excessive soil loss. In some areas applying mechanical erosion-control measures, such as contour farming and terracing, is difficult because of the irregular topography and the short slopes. In most areas, however, these measures are suitable. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material helps to maintain fertility and good tilth.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and deterioration of tilth 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 in good condition.

This soil is well suited to the trees and shrubs grown as windbreaks, ornamental plantings, or plantings that enhance wildlife habitat. Seedlings survive and grow well if competing vegetation is controlled or removed. Erosion is a hazard. Site preparation that disturbs the surface increases the hazard. Limited site preparation, applications of herbicide, and a mulch cover help to control runoff and erosion.

The land capability classification is IIIe.

138C2—Clarion loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on knolls and convex side slopes. Slopes typically are short and commonly are irregular. Individual areas are irregularly shaped and range from 2 to 20 acres in size.

Typically, the surface layer is very dark brown, friable loam about 8 inches thick. Plowing has mixed streaks and pockets of brown subsoil material into the surface layer. The subsoil is friable loam about 16 inches thick. The upper part is dark brown and dark yellowish brown, and the lower part is brown and yellowish brown. The substratum to a depth of about 60 inches is yellowish brown, calcareous loam. In places the soil has a lower content of clay and a higher content of sand.

Included with this soil in mapping are a few small areas of Storden, Salida, and Dickman soils. These soils are less fertile than the Clarion soil, are lower in organic matter content, and are droughty. They are mainly on the steepest parts of the slopes. They make up less than 5 percent of the unit.

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

Most areas are cultivated. This soil is moderately well suited to corn, soybeans, and small grain and is well suited to grasses and legumes for hay and pasture. If cultivated crops are grown, further erosion is a hazard. A system of conservation tillage that leaves crop residue on the surface, grassed waterways, and terraces help to prevent excessive soil loss (fig. 9). In places applying mechanical erosion-control measures, such as contour farming and terracing, is difficult because of the irregular topography and the short slopes. In many areas, however, these measures are suitable. Tilth generally is fair in the surface layer. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to prevent excessive crusting, and increases the rate of water infiltration. More nitrogen generally is needed on this soil than on less eroded Clarion soils. Also, more intensive management is needed to maintain productivity and to maintain or improve tilth.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

This soil is well suited to the trees and shrubs grown as ornamental plantings or plantings that enhance wildlife habitat. Seedlings survive and grow well if competing vegetation is controlled or removed. Erosion is a hazard if site preparation disturbs the surface.

Figure 9.—Parallel, grassed back-slope terraces on Clarion loam, 5 to 9 percent slopes, moderately eroded.

Limited site preparation, applications of herbicide, and a mulch cover are effective in controlling runoff and erosion.

The land capability classification is IIIe.

138D2—Clarion loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is on knolls and convex side slopes. Slopes typically are short. Individual areas are irregularly shaped and range from 3 to 25 acres in size.

Typically, the surface layer is very dark grayish brown loam about 8 inches thick. Plowing has mixed streaks and pockets of dark yellowish brown subsoil material into the surface layer. The subsoil is dark yellowish brown, friable loam about 10 inches thick. The substratum to a depth of about 60 inches is yellowish brown, friable, calcareous loam. In places the surface layer consists mainly of yellowish brown subsoil material.

Included with this soil in mapping are a few small areas of Storden, Dickman, and Salida soils. These soils are less fertile than the Clarion soil and are lower in organic matter content. Storden soils are mainly on the steepest parts of the slopes, and Dickman and Salida soils are on the highest parts. Included soils make up about 5 percent of the unit.

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

Most areas are cultivated. Because of the slope, this soil is only moderately well suited to corn, soybeans, and small grain. It is well suited to grasses and legumes for hay or pasture. If cultivated crops are grown, further erosion is a hazard. A system of conservation tillage that leaves crop residue on the surface and grassed waterways help to prevent excessive soil loss. In places applying mechanical erosion-control measures, such as contour farming and terracing, is difficult because of the small size and irregular shape of the areas and the irregular slopes. In many areas, however, these measures are suitable. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to prevent excessive crusting, and increases the rate of water infiltration. More nitrogen generally is needed on this soil than on less eroded Clarion soils. Also, more intensive management is needed to maintain productivity and to maintain or improve tilth.

A cover of pasture plants or hay is very effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

This soil is suited to the trees and shrubs grown as windbreaks, ornamental plantings, or plantings that enhance wildlife habitat. Seedlings survive and grow well if competing vegetation is controlled or removed. Erosion is a severe hazard if large areas are disturbed during site preparation. Limited site preparation, applications of herbicide, and a mulch cover help to control runoff and erosion.

The land capability classification is IIIe.

150—Hanska loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is mainly on outwash plains. In some areas, however, it is on stream terraces. Slopes are slightly concave to slightly convex. Individual areas are irregularly shaped. They typically are 3 to 15 acres in size, but a few are as much as about 40 acres.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is loam about 9 inches thick. The upper part is black, and the lower part is very dark gray and very dark grayish brown. The subsoil is mottled sandy loam about 21 inches thick. The upper part is dark grayish brown, and the lower part is olive gray. The substratum to a depth of about 60 inches is olive gray and olive loamy sand in which the content of gravel is about 10 percent. In places the surface layer is sandy loam.

Included with this soil in mapping are a few small areas of the somewhat poorly drained Linder soils on low rises. These soils make up about 10 percent of the unit.

Permeability is moderately rapid in the upper part of the Hanska soil and rapid in the substratum. Runoff is slow. A seasonal high water table is at a depth of 12 to 36 inches. Available water capacity is medium. The content of organic matter in the surface layer is about 4 to 5 percent. 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. This soil is moderately well suited to corn and soybeans. In undrained or inadequately drained areas, the high water table restricts the root zone. Installing a drainage system can result in dependable crop production. When drained, however, this soil is moderately droughty and crops are adversely affected by a lack of sufficient water, especially if rainfall is below average or is not timely. Because the substratum is unstable, installation of drains is difficult. Suitable outlets are not available in some areas. If the surface is bare when soil is plowed in the fall, soil blowing is a serious hazard. A system of conservation tillage that leaves crop residue on the surface and additions of other organic material improve fertility, help to control soil blowing, and conserve moisture.

Because of the limited amount of available water during critical parts of the growing season, this soil is better suited to small grain and to grasses and legumes for hay and pasture than to corn and soybeans. Small grain and grasses and legumes generally mature early in the growing season, before the lack of sufficient water limits growth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted grazing during wet periods help to keep pastures in good condition.

The land capability classification is IIw.

168B—Hayden loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on undulating ridgetops and convex side slopes. Individual areas are irregularly shaped and range from 5 to 15 acres in size.

Typically, the surface layer is dark grayish brown and grayish brown, friable loam about 8 inches thick. The subsoil is firm clay loam about 29 inches thick. The upper part is brown and dark yellowish brown, and the lower part is yellowish brown and dark yellowish brown. The substratum to a depth of about 60 inches is yellowish brown and light olive brown, calcareous loam. In some areas the soil has a thicker subsoil and has a greater depth to carbonates. In nearly level areas the surface layer is thicker and darker.

Permeability is moderate, and runoff is medium. Available water capacity is high. The content of organic matter in the surface layer is about 1 to 2 percent. Reaction in the surface layer typically is slightly acid but ranges from neutral to medium acid. The subsoil typically is medium acid in the upper part and strongly acid to mildly alkaline in the lower part. It generally has a 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. If cultivated crops are grown, erosion is a hazard. A system of conservation tillage that leaves crop residue on the surface and grassed waterways help to prevent excessive soil loss. Contour farming and terracing also are effective in controlling erosion. In places, however, they are difficult because of irregular topography and short slopes. If the surface is exposed in large areas, soil blowing is a hazard. Plowing when the soil is wet results in hard clods when the soil is dry. Because of the cloddiness, preparing a good seedbed is difficult. Tilth generally is fair in the surface layer. Returning crop residue to the soil or regularly adding other organic material helps to maintain tilth, improves fertility, helps to prevent excessive soil blowing and crusting, and increases the infiltration rate.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and deterioration of tilth and increases the runoff rate. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture productive.

Erosion is a slight hazard if this soil is used for the trees and shrubs grown as windbreaks, ornamental plantings, or plantings that enhance wildlife habitat. A permanent plant cover or a mulch cover reduces the susceptibility to erosion.

The land capability classification is IIe.

168C—Hayden loam, 5 to 9 percent slopes. This moderately sloping, well drained soil is on undulating ridgetops and convex side slopes. Individual areas are irregularly shaped and range from 2 to 15 acres in size.

Typically, the surface layer is dark grayish brown, friable loam about 8 inches thick. The subsoil is clay loam about 30 inches thick. The upper part is brown and dark yellowish brown and is friable, the next part is dark yellowish brown and is friable and firm, and the lower part is yellowish brown and dark yellowish brown and is firm and friable. The substratum to a depth of about 60 inches is yellowish brown, mottled, calcareous, friable loam. In places the surface layer is mainly dark yellowish brown or brown clay loam.

Included with this soil in mapping are some eroded areas of the well drained Storden soils. These soils generally are on the higher or more convex parts of the slopes. They are calcareous throughout. Also included are a few areas of sandy soils similar to Dickman soils. Included soils make up less than 5 percent of the unit.

Permeability is moderate in the Hayden soil. Runoff is rapid. Available water capacity is high. The content of organic matter in the surface layer is about 0.5 to 1.5 percent. Reaction typically is medium acid in the surface layer and strongly acid to mildly alkaline in the subsoil. The subsoil generally has a low supply of available phosphorus and a very low supply of available potassium.

Most areas are cultivated. This soil is moderately well suited to corn, soybeans, and small grain and is well suited to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a moderate or severe hazard. It can be controlled by a system of conservation tillage that leaves crop residue on the surface, by grassed waterways, and by contour farming and terracing. In places, however, contour farming and terracing are difficult because of short slopes and irregular topography. Soil blowing is a hazard in areas where the surface is exposed.

Because of the low content of organic matter in this soil, tilth generally is only fair or poor. If worked when too wet, the surface layer readily puddles and becomes hard and cloddy, especially in severely eroded areas. A surface layer that is finely pulverized because of excessive tillage readily crusts as it dries. Returning crop residue to the soil or regularly adding other organic material improves fertility and tilth, helps to prevent excessive erosion and crusting, and increases the rate of water infiltration. More fertilizer, especially nitrogen, generally is needed on this soil than on similar soils in the county.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases the runoff rate and the susceptibility to erosion, damages the stand, and results in lower production. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

This soil is well suited to the trees and shrubs grown as windbreaks, ornamental plantings, or plantings that enhance wildlife habitat. If the surface is bare after site preparation, erosion is a moderate or severe hazard. It can be controlled by a mulch cover and limited site preparation.

The land capability classification is IIIe.

168D2—Hayden loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is on undulating ridgetops and side slopes. Individual areas are irregularly shaped and range from 2 to 10 acres in size.

Typically, the surface layer is mixed brown and yellowish brown, friable loam about 8 inches thick. Because of plowing, it has streaks and pockets of subsoil material. The subsoil is about 28 inches thick. The upper part is dark yellowish brown and brown, friable clay loam; the next part is dark yellowish brown, friable and firm clay loam; and the lower part is yellowish brown, friable and firm clay loam and loam. The substratum to a depth of about 60 inches is yellowish brown, mottled, calcareous, friable loam.

Included with this soil in mapping are small areas of the eroded Storden soils. These soils generally are on the more convex parts of the slopes. They are calcareous throughout. Also included are a few small areas of gravelly sandy loam. Included soils make up less than 5 percent of the unit.

Permeability is moderate in the Hayden soil, and runoff is rapid. Available water capacity is high. The content of organic matter in the surface layer is about 0.5 to 1.0 percent. Reaction typically is medium acid in the surface layer and strongly acid to mildly alkaline in the subsoil. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. A few are pastured, and a few support trees. This soil is poorly suited to corn and soybeans but is well suited to small grain and to grasses and legumes for hay and pasture. If cultivated crops are grown, the hazard of further erosion is severe. A system of conservation tillage that leaves crop residue on the surface, grassed waterways, contour farming, and terracing help to prevent excessive soil loss. Because of short slopes and irregular topography, however, contour farming and terracing are difficult in some areas. Soil blowing is a hazard in areas where the surface is exposed.

In the loam surface layer of this soil, the organic matter content is low and tilth is poor. Preparing a good seedbed is difficult. If the soil is worked when it is wet, the sticky surface layer becomes hard and cloddy as it dries. Returning crop residue to the soil or regularly adding other organic material improves fertility and tilth, helps to prevent excessive erosion and crusting, and increases the rate of water infiltration. More fertilizer, especially nitrogen, generally is needed on this soil than on similar soils that are less eroded.

Mainly because of the severe erosion hazard and the difficulty in preparing a good seedbed, this soil commonly is better suited to pasture and hay than to row crops. A cover of pasture plants or hay is effective in controlling runoff and further erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and increases the runoff rate and the susceptibility to erosion. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

This soil is well suited to the trees and shrubs grown as windbreaks, ornamental plantings, or plantings that enhance wildlife habitat. If the surface is bare after site preparation, erosion is a severe hazard. It can be controlled by a mulch cover and limited site preparation.

The land capability classification is IIIe.

168E—Hayden loam, 14 to 25 percent slopes. This moderately steep and steep, well drained soil is on undulating ridgetops and side slopes. Individual areas are generally long and narrow and range from 2 to 10 acres in size.

Typically, the surface layer is very dark gray, friable loam about 3 inches thick. The subsurface layer is dark gray, friable loam about 3 inches thick. The subsoil is about 27 inches thick. The upper part is dark yellowish brown and yellowish brown, friable and firm clay loam, and the lower part is yellowish brown, friable and firm clay loam and loam. The substratum to a depth of about 60 inches is yellowish brown, mottled, calcareous, friable loam. In cultivated areas the surface layer is mixed brown and dark yellowish brown loam about 8 inches thick. In a few places the slope is more than 25 percent.

Included with this soil in mapping are a few small areas of the eroded Storden soils. These soils generally are on the more convex parts of the slopes. They are calcareous throughout. They make up less than 5 percent of the unit.

Permeability is moderate in the Hayden soil. Runoff is very rapid. Available water capacity is high. The content of organic matter in the surface layer is about 0.5 to 1.5 percent. Reaction typically is medium acid in the surface layer and subsurface layer and strongly acid to mildly alkaline in the subsoil. The subsoil generally has a low supply of available phosphorus and a very low supply of available potassium.

Many areas support trees. Some are cultivated. Because of the slope and a severe erosion hazard, this soil generally is unsuited to cultivated crops. It is moderately suited to hay and well suited to pasture. In areas where the clay loam subsoil is exposed, the rate of water infiltration is slow, runoff is rapid, and the erosion hazard is more severe.

A cover of pasture plants or hay is effective in controlling erosion. It also increases the organic matter content and improves the physical condition of the soil. Overgrazing or grazing when the soil is too wet causes surface compaction and increases the runoff rate and the susceptibility to erosion. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

This soil is well suited to trees and shrubs. Many areas support native hardwoods. These areas are around farmsteads, on steep slopes on farmland, and in pastures. The vegetation in grazed areas is mainly native trees. Grazing damages young seedlings. In some areas the stand consists of trees of various sizes and ages. Seedlings survive fairly well. Closely spacing the seedlings helps to achieve the desired stand density. If site preparation disturbs the surface or leaves it bare, erosion is a severe hazard. It can be controlled by a mulch cover and limited site preparation.

The land capability classification is VIe.

175B—Dickinson fine sandy loam, 2 to 5 percent slopes. This gently sloping, well drained soil is mainly on stream terraces and glacial outwash plains. Individual areas are irregularly shaped and range from 2 to 10 acres in size.

Typically, the surface layer is very dark brown fine sandy loam about 9 inches thick. The subsoil is fine sandy loam about 23 inches thick. The upper part is dark brown, and the lower part is dark yellowish brown. The upper part of the substratum is dark yellowish brown and yellowish brown loamy fine sand. The lower part to a depth of about 60 inches is brown and yellowish brown fine sand. In places the soil is nearly level.

Included with this soil in mapping are areas where the substratum is sand and gravel. Also included are areas of Salida soils, which are calcareous throughout, are coarser textured than the Dickinson soil, and are more droughty. Included soils make up about 5 percent of the unit.

Permeability is moderately rapid in the upper part of the Dickinson soil and rapid in the substratum. Runoff is slow. Available water capacity is moderate. The content of organic matter in the surface layer is about 1 to 2 percent. The surface layer typically is medium acid. The subsoil typically is slightly acid or neutral. It generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is moderately well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Crop growth is poor or moderate, especially in years when rainfall is below average or untimely. Soil blowing is a hazard because the surface layer dries rapidly after tillage. Windblown sand can damage young plants in some years. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil loss, improves fertility, helps to maintain good tilth, and increases the available water capacity. Terracing is difficult because of the instability of the substratum.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing, however, increases the runoff rate and exposes the surface layer to soil blowing. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during extremely dry periods help to keep the pasture in good condition.

Droughtiness is the main limitation if this soil is used for the trees and shrubs grown as windbreaks, ornamental plantings, or plantings that enhance wildlife habitat. A mulch cover or a permanent cover of vegetation conserves moisture and helps to control soil blowing. The species that can withstand droughty conditions should be selected for planting.

The land capability classification is IIe.

221—Palms muck, 0 to 1 percent slopes. This level, very poorly drained soil generally is in upland depressions that formerly contained water much of the time. In some areas the soil is in former lakebeds that have been drained. It is subject to ponding. Many areas are circular, but some are irregularly shaped. Most range from 8 to 30 acres in size, but a few are as much as about 50 acres.

Typically, the surface soil is black muck about 29 inches thick. The upper part of the substratum is black, mottled mucky silt loam. The lower part to a depth of about 60 inches is olive gray, mottled silt loam. In places thin layers of undecomposed organic material are below a depth of about 2 feet. About 10 to 20 inches of loamy overwash covers the outer part of some areas surrounded by steep slopes. In some areas the substratum is black silty clay loam.

Permeability is moderate. This soil has a seasonal high water table about 12 inches below the surface to 12 inches or more above. Surface and internal drainage is very slow in most areas. Available water capacity is very high. The content of organic matter in the surface layer is about 20 to 35 percent. Reaction typically is slightly acid to mildly alkaline throughout the profile. The supply of available phosphorus generally is low, and the supply of available potassium generally is very low. In some areas trace elements are deficient for some crops.

Most areas are drained and are cultivated. If drained and otherwise well managed, this soil is moderately suited to cultivated crops. Surface intakes, shallow ditches, and tile drains are used to reduce the wetness. In places outlets deep enough for drains to function adequately are not readily available. Runoff from the adjacent slopes readily ponds on this soil. In periods of excessive rainfall, crops are sometimes damaged or destroyed before tile can remove the excess water. If this damage occurs early in the growing season, the land is tilled and the crop replanted. The soil warms up slowly in spring. As a result, planting is often delayed. Because the soil is in low lying areas and loses heat rapidly from the surface, frost often injures crops late in spring and early in fall. Planting early maturing varieties helps to prevent excessive crop losses.

Tilth is excellent in this soil. The soil can be tilled throughout a wide range of moisture content. Fall plowing should be avoided because soil blowing is a hazard during dry periods unless the surface is protected. Controlling grasses and weeds is difficult. The application rate for some herbicides should be higher than that on other soils because the very high organic matter content of this soil limits the effectiveness of the herbicides. Small grain tends to lodge badly and generally is of poor quality. Legumes for hay grow poorly and are often winterkilled.

Partly drained areas of this soil are suitable for permanent pasture of bluegrass, bromegrass, and reed canarygrass. Undrained areas generally are suited to wetland wildlife habitat.

The land capability classification is IIIw.

224—Linder loam, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is on stream terraces and outwash plains. Slopes typically are plane or convex, but in places they are slightly concave. Individual areas are irregularly shaped and are 4 to 8 acres in size.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is very dark gray and very dark grayish brown loam about 5 inches thick. The subsoil is dark grayish brown sandy loam about 20 inches thick. It has some gravel in the lower part. The upper part of the substratum is dark grayish brown loamy sand. The lower part to a depth of about 60 inches is dark grayish brown and dark brown gravelly sand. In places the soil has loamy till in the substratum.

Permeability is moderately rapid in the upper part of the profile and very rapid in the substratum. Runoff is slow. A seasonal high water table is at a depth of 24 to 48 inches. Available water capacity is low or moderate. The content of organic matter in the surface layer is about 3 to 4 percent. This layer typically is 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 slightly wet during years of above average rainfall. Crop growth generally is not seriously affected by wetness but is restricted by a lack of sufficient water in dry years or when rainfall is not timely. Water erosion generally is not a problem. Because the surface dries out quickly, however, soil blowing is a hazard. Windblown sand damages young plants in some years. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil loss. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to prevent excessive crusting, and increases the rate of water infiltration.

Because of the limited amount of available water during critical parts of the growing season, this soil is better suited to small grain and to grasses and legumes for hay and pasture than to corn and soybeans. Small grain and grasses and legumes generally mature early in the growing season, before the lack of sufficient water limits crop growth.

A cover of pasture plants or hay is effective in controlling soil blowing. Overgrazing, however, causes surface compaction, increases the runoff rate, results in poor tilth, and reduces forage production. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

The land capability classification is IIs.

236B—Lester loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on ridgetops and convex side slopes. Slopes typically are short. Individual areas are irregularly shaped and range from 3 to 30 acres in size.

Typically, the surface layer is very dark grayish brown, friable loam about 7 inches thick. The subsoil is about 27 inches thick. The upper part is dark yellowish brown, friable clay loam, and the lower part is dark yellowish brown and yellowish brown, friable loam. The substratum to a depth of about 60 inches is light olive brown, mottled, calcareous loam. In places the surface soil is silty clay loam and is thicker and darker.

Included with this soil in mapping are small areas of the somewhat poorly drained Le Sueur soils. These soils are in nearly level areas that have slightly convex slopes. They make up about 5 percent of the unit.

Permeability is moderate in the Lester soil, and runoff is medium. Available water capacity is high. The content of organic matter in the surface layer is about 2 to 3 percent. The surface layer typically is medium acid. The subsoil is slightly acid in the upper part and neutral in the lower part. It generally has a low supply of available nitrogen and 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 system of conservation tillage that leaves crop residue on the surface and grassed waterways help to prevent excessive soil loss. Tilth generally is fair in the surface layer. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to prevent excessive crusting, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

This soil is well suited to trees. A few areas support native hardwoods and grasses. They provide excellent habitat for various kinds of wildlife. Some areas are grazed by domestic livestock. Grazing can damage young seedlings and the wildlife habitat. In a few places competing grasses limit the growth and survival rates of seedlings. If grazing is controlled and competing vegetation is removed or controlled, the seedlings survive and grow well. Erosion should be controlled when sites are prepared for seedlings.

The land capability classification is IIe.

236C2—Lester loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on ridgetops and convex side slopes. Slopes typically are short. Individual areas are irregularly shaped and range from about 3 to 10 acres in size.

Typically, the surface layer is mixed very dark grayish brown and brown, friable loam about 7 inches thick. Plowing has mixed streaks and pockets of dark yellowish brown subsoil material into the surface layer. The subsoil is friable loam about 26 inches thick. The upper part is dark yellowish brown, and the lower part is dark yellowish brown and yellowish brown and is mottled. The substratum to a depth of about 60 inches is light olive brown, mottled loam. In some places the surface layer is sandy loam. In other places the subsoil is mostly sandy loam.

Included with this soil in mapping are a few small areas of the somewhat poorly drained Le Sueur soils in small natural drainageways that extend into the uplands. The wetness of these soils delays tillage in some years. Included soils make up less than 5 percent of the unit.

Permeability is moderate in the Lester soil, and runoff is medium. Available water capacity is high. The content of organic matter in the surface layer is about 1 to 2 percent. Reaction typically is neutral or slightly acid in the surface layer and medium acid in the subsoil. The subsoil generally has a low supply of available nitrogen and phosphorus and a very low supply of available potassium.

Most areas are cultivated. This soil is moderately well suited to corn, soybeans, and small grain and is well suited to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard. A system of conservation tillage that leaves crop residue on the surface and grassed waterways help to prevent excessive soil loss. In some areas applying mechanical erosion-control measures, such as contour farming and terracing, is difficult because of the short slopes and the irregular topography. In many areas, however, these measures are well suited.

Tilth generally is fair in the surface layer of this soil. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to prevent excessive crusting, and increases the rate of water infiltration. More nitrogen generally is needed on this soil than on uneroded soils. Also, more intensive management is needed to maintain productivity and to maintain or improve tilth.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

This soil is well suited to trees. A few areas support native hardwoods and grasses. They provide excellent habitat for various kinds of wildlife. Many areas are grazed by domestic livestock. Grazing can damage young seedlings and the wildlife habitat. In a few places competing grasses limit the growth and survival rates of the seedlings. If grazing is controlled and competing vegetation is removed or controlled, seedlings survive and grow well. A mulch cover and limited site preparation help to control erosion when sites are prepared for seedlings.

The land capability classification is IIIe.

236D2—Lester loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is mainly on convex side slopes. Slopes typically are short. Individual areas are irregularly shaped and range from about 8 to 20 acres in size.

Typically, the surface layer is mixed very dark grayish brown and brown, friable loam about 8 inches thick. Plowing has mixed some streaks and pockets of dark yellowish brown subsoil material into the surface layer. The subsoil is about 28 inches thick. The upper part is brown and dark yellowish brown loam and clay loam, and the lower part is yellowish brown and dark yellowish brown, mottled, friable loam. The substratum to a depth of about 60 inches is light olive brown, mottled, friable, calcareous loam. In a few severely eroded areas, the surface layer is mainly mixed yellowish brown and dark yellowish brown and the soil is not so deep to the calcareous substratum.

Included with this soil in mapping are a few small areas of the well drained Storden soils on the steeper, most convex parts of the slopes. Also included are a few small areas of somewhat poorly drained soils in small natural drainageways that extend into the uplands. Included soils make up less than 5 percent of the unit.

Permeability is moderate in the Lester soil, and runoff is rapid. Available water capacity is high. The content of organic matter in the surface layer is about 0.5 to 1.5 percent. Reaction typically is slightly acid or neutral in the surface layer and medium acid in the subsoil. The subsoil generally has a low supply of available nitrogen and phosphorus and a very low supply of available potassium.

Most areas are cultivated. This soil is poorly suited to corn, soybeans, and small grain but is well suited to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard. A system of conservation tillage that leaves crop residue on the surface and grassed waterways help to prevent excessive soil loss. In some areas applying mechanical erosion-control measures, such as contour farming and terracing, is difficult because of the short slopes and the irregular topography. In most areas, however, these measures are well suited. In severely eroded areas, preparing a good seedbed is difficult because the clay loam subsoil, which is low in content of organic matter, is exposed. Tilth generally is fair in the surface layer. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to prevent excessive crusting, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

This soil is well suited to trees. A few areas support native hardwoods and grasses. They provide excellent habitat for various kinds of wildlife. Some areas are grazed by domestic livestock. Grazing can damage young seedlings and the wildlife habitat. In a few areas competing grasses limit the growth and survival rates of the seedlings. If grazing is controlled and competing vegetation is removed or controlled, seedlings survive and grow well. A mulch cover and limited site preparation help to control erosion when sites are prepared for seedlings.

The land capability classification is IIIe.

236E2—Lester loam, 14 to 18 percent slopes, moderately eroded. This moderately steep, well drained soil is on convex side slopes. Slopes typically are short. Individual areas are irregularly shaped and range from 3 to 10 acres in size.

Typically, the surface layer is dark brown and dark yellowish brown, friable loam about 8 inches thick. Plowing has mixed streaks and pockets of dark yellowish brown subsoil material into the surface layer. The subsoil is about 24 inches thick. The upper part is dark yellowish brown and brown, friable clay loam, and the lower part is yellowish brown, friable loam. The substratum to a depth of about 60 inches is light olive brown, friable, calcareous loam. In places the soil has a surface layer of very dark gray or very dark grayish brown, friable loam about 4 inches thick and a very dark grayish brown or dark grayish brown subsurface layer about 2 or 3 inches thick.

Included with this soil in mapping are areas where the slope is more than 18 percent. The soils in these areas have a surface layer that is thinner than that of the Lester soil. They make up about 10 percent of the unit. Also included are a few small areas of the well drained Storden soils on the steepest, most convex parts of the slopes. These soils make up less than 5 percent of the unit.

Permeability is moderate in the Lester soil, and runoff is very rapid. Available water capacity is high. The content of organic matter in the surface layer is about 0.5 to 1.5 percent. Reaction typically is slightly acid or neutral in the surface layer, medium acid in the upper part of the subsoil, and slightly acid in the lower part. The subsoil generally has a low supply of available nitrogen and phosphorus and a very low supply of available potassium.

Most areas are cultivated. Because of the slope and a severe hazard of erosion, this soil is poorly suited to cultivated crops. It is moderately suited to small grain and to hay and pasture. Because of the slope, tillage and harvesting are difficult. If cultivated crops are grown, minimum tillage and, where practical, terraces and contour farming help to control erosion. Tilth generally is fair in the surface layer. It is poor, however, in severely eroded areas where more subsoil material has been mixed into the surface layer. Returning crop residue to the soil or regularly adding other organic material helps to control erosion, improves fertility and tilth, and increases the rate of water infiltration.

If this soil is used for pasture, proper stocking rates, timely deferment of grazing, and rotation grazing are needed. These measures help to maintain the desirable species and keep the pasture in good condition.

A few areas support mixed hardwoods and grasses. This soil is better suited to native hardwoods than to cultivated crops. The major problems in managing woodland are the hazard of erosion and low fertility. The supply of available water is often low because of the very rapid runoff. Management that maintains an adequate vegetative cover helps to prevent excessive soil loss and increases the available water supply by reducing the runoff rate and the rate of drying. Grazing can damage trees, seedlings, and wildlife habitat. If grazing is controlled and competing vegetation is removed or controlled, seedlings survive and grow well. A mulch cover and limited site preparation help to control erosion when sites are prepared for seedlings.

Areas that are left in their natural state provide good habitat for a variety of wildlife.

The land capability classification is IVe.

236F—Lester loam, 18 to 30 percent slopes. This steep and very steep, well drained soil is on convex side slopes in the uplands. Slopes typically are short. Individual areas generally are elongated and are 5 to 10 acres in size.

Typically, the surface layer is very dark gray loam about 3 inches thick. The subsurface layer is dark grayish brown, friable loam about 2 inches thick. The subsoil is about 24 inches thick. The upper part is brown, dark yellowish brown, and yellowish brown, friable clay loam, and the lower part is yellowish brown, friable, calcareous loam. The substratum to a depth of about 60 inches is light olive brown, mottled, friable, calcareous loam. In places erosion has exposed the yellowish brown subsoil. In a few areas the slope is more than 30 percent.

Included with this soil in mapping are a few small areas of the well drained Storden soils on the steepest, most convex parts of the slopes. These soils are calcareous. They make up about 10 percent of the unit.

Permeability is moderate in the Lester soil, and runoff is very rapid. Available water capacity is high. The content of organic matter in the surface layer is about 1.5 to 2.0 percent. The surface soil typically is slightly acid. The subsoil is medium acid in the upper part and slightly acid in the lower part. It generally has a low supply of available nitrogen and phosphorus and a very low supply of available potassium.

Nearly all areas support timber or mixed timber and grasses. This soil is best suited to trees. The growth of all vegetation, except for trees, generally is poor, and total production is low. The major problems in managing woodland are the hazard of erosion and low fertility. The supply of available water is often low because of the very rapid runoff. Management that maintains an adequate vegetative cover helps to prevent excessive soil loss and increases the available water supply by reducing the runoff rate and the rate of drying. Grazing can damage trees, seedlings, and wildlife habitat. If grazing is controlled, seedlings survive and grow well. A mulch cover and limited site preparation help to control erosion when sites are prepared for seedlings. Slopes are so steep in some areas that operating equipment is hazardous. Areas that are left in their natural state are well suited to wildlife habitat.

If this soil is used for pasture, proper stocking rates, timely deferment of grazing, and rotation grazing are needed. These measures help to maintain the desirable species and keep the pasture in good condition.

The land capability classification is VIe.

307—Dundas silt loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on concave slopes in the uplands. Individual areas are irregularly shaped and range from 3 to 12 acres in size.

Typically, the surface layer is very dark gray silt loam about 9 inches thick. The subsurface layer is grayish brown silt loam about 13 inches thick. In places plowing has mixed the grayish brown subsurface layer into the surface layer. The subsoil is about 33 inches thick. The upper part is grayish brown and dark grayish brown clay loam, the next part is olive and grayish brown clay loam, and the lower part is olive gray and olive loam. The subsoil has a few mottles in the upper part and common mottles in the middle and lower parts. The substratum to a depth of about 60 inches is olive gray, mottled loam.

Permeability is moderately slow, and runoff is slow. This soil has a seasonal high water table. Available water capacity is high. The content of organic matter in the surface layer is about 4 to 5 percent. Reaction typically is slightly acid in the surface layer and medium acid in the subsurface layer and subsoil. The subsoil generally has a low supply of available phosphorus and potassium.

Most areas are cultivated. Because they are small and irregularly shaped, they are managed along with the adjacent soils. This soil is well suited to corn, soybeans, and small grain and to grasses, but it is only moderately suited to legumes. Because of the seasonal high water table, most areas are tile drained. Tile drains work only fairly well because of the moderately slow permeability in the subsoil. Tilth is fair in the surface layer. This layer tends to crust or puddle after heavy rains. If worked when wet, it becomes hard and cloddy as it dries. Returning crop residue to the soil and regularly adding other organic material improve tilth and fertility and help to prevent excessive crusting. In a few slightly depressional areas, water tends to pond for short periods after heavy rains. Legumes, especially alfalfa, are likely to be winterkilled in some areas. Water erosion generally is not a problem. If the larger areas are fall plowed, however, soil blowing is a hazard unless the surface is protected.

If this soil is used for pasture, grazing when the soil is wet causes surface compaction and reduces the rate of water infiltration. Restricted use during wet periods, proper stocking rates, and rotation grazing help to keep the pasture in good condition.

The land capability classification is IIw.

321—Boots muck, 0 to 1 percent slopes. This level, very poorly drained soil is in depressions on uplands. It is subject to ponding. Individual areas typically are somewhat circular and range from 15 to more than 80 acres in size.

Typically, the surface layer is black muck about 7 inches thick. The subsurface layer is dark reddish brown, nonsticky mucky peat about 45 inches thick. The underlying material to a depth of about 60 inches is black, slightly sticky muck.

Included with this soil in mapping are a few small areas where mineral soil is within a depth of 60 inches. Also included are small areas of soils that have calcareous layers of muck and peat. Included soils make up about 5 percent of the unit.

Permeability is moderately rapid in the Boots soil, and runoff is very slow or ponded. Available water capacity is very high. The content of organic matter in the surface layer is more than 20 percent. Reaction typically is neutral or slightly acid throughout the profile. The soil generally has a very low supply of available phosphorus and potassium.

Some areas are cultivated. If drained and otherwise well managed, this soil is moderately suited to corn, soybeans, and small grain and to grasses for hay and pasture. Even in drained areas, however, wetness and ponding are problems after heavy rains and during spring thaws. In some areas shallow drainage ditches are used to reduce the wetness. If tile is installed in the organic material, subsidence is likely to alter the alignment of the tile because the organic material settles when drained. The soil warms up slowly in spring. As a result, planting is often delayed.

Because this soil is in low lying areas and loses heat rapidly from the surface, frost often injures crops late in spring and early in fall. Planting early maturing varieties helps to prevent excessive loss. Small grain tends to lodge badly and generally is of poor quality. Crop growth generally is better in years of somewhat limited rainfall than in years when rainfall is above average.

Tilth generally is poor in the surface layer of this soil. Because of the very high organic matter content, this layer is spongy. As a result, preparing a good seedbed is difficult. Controlling grasses and weeds also is difficult. Herbicides that are effective on organic soils should be applied. The application rate should be higher than that on other soils because the very high organic matter content limits the effectiveness of the herbicides. Legumes, especially alfalfa, grow poorly and are usually winterkilled or drowned out by standing water.

Undrained areas are poorly suited to pasture and generally are left idle. The spongy surface layer cannot support grazing livestock. If drained, this soil is suited to pasture. Stocking or grazing should be restricted during wet periods. Proper stocking rates, pasture rotation, and timely deferment of grazing improve productivity. Some undrained areas, or those that are not sufficiently drained for agricultural uses, provide good habitat for wetland wildlife.

The land capability classification is IIIw.

325—Le Sueur loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on slightly convex to slightly concave slopes in the uplands. Individual areas are irregularly shaped and range from 5 to 20 acres in size.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is very dark brown loam about 5 inches thick. The subsoil is friable clay loam about 21 inches thick. The upper part is dark grayish brown, the next part is dark grayish brown and olive brown, and the lower part is dark grayish brown and mottled. The substratum to a depth of about 60 inches is olive, calcareous loam.

Included with this soil in mapping are small areas of the well drained Lester and poorly drained Cordova soils. Lester soils are on the higher, more convex parts of the slopes. Cordova soils are in nearly level and slightly concave areas. Included soils make up less than 5 percent of the unit.

Permeability is moderate in the Le Sueur soil, and runoff is slow. This soil has a seasonal high water table. Available water capacity is high. The content of organic matter in the surface layer is about 2.5 to 3.5 percent. This layer typically is slightly acid. The subsoil is medium acid. It generally has a low supply of available nitrogen and a very low supply of available phosphorus and potassium.

Most areas are cultivated. A few support native vegetation. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Erosion generally is not a problem. If the soil is fall plowed, however, soil blowing may be a problem unless the surface is protected. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil loss. The soil is slightly wet during periods of high rainfall, but the wetness does not limit crop growth. A drainage system has been installed in many areas to improve the timeliness of fieldwork. Good tilth generally can be easily maintained. Returning crop residue to the soil and delaying tillage when the soil is wet help to maintain good tilth.

A cover of pasture plants or hay is effective in controlling soil blowing. Overgrazing or grazing when the soil is wet causes surface compaction and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is I.

349—Darfur loam, 0 to 1 percent slopes. This level, poorly drained soil is on plane and slightly concave slopes in glacial outwash areas. Individual areas generally are somewhat elongated. They range from about 5 to 30 acres in size.

Typically, the surface layer is black loam about 7 inches thick. The subsurface layer is loam about 11 inches thick. It is black in the upper part and black and very dark gray in the lower part. The subsoil is about 22 inches thick. The upper part is dark gray, mottled loam; the next part is olive, mottled sandy loam; and the lower part is olive gray, mottled loamy sand. The substratum to a depth of about 60 inches is olive gray, mottled, stratified loamy fine sand and fine sandy loam.

Included with this soil in mapping are a few small areas of slightly depressional soils that have a dark surface soil about 30 inches thick. These soils are wetter than the Darfur soil and sometimes are ponded. Also included are a few areas of soils that are calcareous throughout. Included soils make up about 5 percent of the unit.

Permeability is moderate in the upper part of the Darfur soil and moderately rapid in the lower part. Runoff is slow. This soil has a seasonal high water table. Available water capacity is moderate. The content of organic matter in the surface layer is about 4.5 to 5.5 percent. Reaction typically is neutral in the surface soil and the upper part of the subsoil and neutral or mildly alkaline in the lower part of the subsoil. The substratum 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. A drainage system is needed. Tile drainage systems work well, but installation may be difficult because of instability in the substratum. A system of conservation tillage that leaves crop residue on the surface helps to control soil blowing. The surface layer is friable and can be easily tilled. If worked when too wet, however, it becomes cloddy and hard as it dries.

A cover of pasture plants or hay is effective in controlling soil blowing. Overgrazing or grazing when the soil is too wet causes surface compaction and deterioration of tilth and reduces the rate of water infiltration. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is IIw.

384—Collinwood silty clay loam, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is on plane and slightly convex slopes in the uplands. Individual areas are irregularly shaped and range from 5 to 30 acres in size.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer also is black silty clay loam. It is about 11 inches thick. The subsoil is firm silty clay about 21 inches thick. The upper part is dark grayish brown, and the lower part is dark grayish brown and grayish brown and is mottled. The substratum to a depth of about 60 inches is grayish brown, mottled silty clay loam.

Included with this soil in mapping are a few small areas of the poorly drained Waldorf soils in the lower lying swales and in slight depressions. Unless a drainage system is installed, the wetness of these soils delays fieldwork. These soils make up less than 5 percent of the unit.

Permeability is slow in the Collinwood soil. Runoff also is slow. This soil has a seasonal high water table. Available water capacity is high. The content of organic matter in the surface layer is about 6 to 7 percent. Reaction typically is neutral to medium acid in the surface soil, medium acid to mildly alkaline in the subsoil, and mildly alkaline or moderately alkaline in the substratum. 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. Because of the seasonal high water table, a drainage system has been installed in most areas to improve the timeliness of fieldwork. Tile drains do not always function well. They should be more closely spaced in this soil than in soils that have less clay in the subsoil.

Special management generally is needed to maintain good tilth in the surface layer. If worked when wet, this layer becomes hard and cloddy as it dries. If the soil is plowed in the fall, soil blowing is a hazard unless the surface is protected. A system of conservation tillage that leaves crop residue on the surface or incorporates it into the surface layer and regular additions of other organic material help to prevent excessive soil loss, increase the rate of water infiltration, and improve tilth and fertility. Leaving too much crop residue on the surface, however, can slow drying and delay fieldwork.

A cover of pasture plants or hay is effective in controlling soil blowing. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, reduces the rate of water infiltration, and increases the runoff rate. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the soil in good condition.

This soil is moderately suited to the trees and shrubs grown as windbreaks or ornamental plantings. The slow permeability and the seasonal high water table are the main limitations. The high content of clay in the surface layer hinders site preparation.

The land capability classification is IIw.

384B—Collinwood silty clay loam, 2 to 5 percent slopes. This gently sloping, somewhat poorly drained soil is on convex slopes in the uplands. Individual areas are irregularly shaped and range from 5 to 20 acres in size.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is black and very dark grayish brown silty clay loam about 8 inches thick. The subsoil is about 20 inches of dark brown and dark grayish brown, mottled silty clay loam and silty clay. The substratum to a depth of about 60 inches is dark grayish brown and grayish brown, mottled silty clay loam. In places the surface soil and subsoil are clay loam.

Included with this soil in mapping are areas of the well drained Vinje soils on the more convex parts of the slopes. These soils make up less than 5 percent of the unit.

Permeability is slow in the Collinwood soil, and runoff is medium. Available water capacity is high. The content of organic matter in the surface layer is about 5 to 6 percent. Reaction typically is neutral to medium acid in the surface soil, medium acid to mildly alkaline in the subsoil, and mildly alkaline or moderately alkaline in the substratum. 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. Special management generally is needed to maintain good tilth in the surface layer. If cultivated crops are grown, erosion is a hazard. The hazard is greater on this soil than on some soils on similar slopes because of the higher content of clay, which reduces the rate of water infiltration and increases the runoff rate. A system of conservation tillage that leaves crop residue on the surface, contour farming, and grassed waterways help to control erosion. In some areas, however, contour farming is difficult because of irregular topography and short slopes. Returning crop residue to the soil or regularly adding other organic material slows runoff, increases the infiltration rate, helps to control erosion, and improves fertility and tilth.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, reduces the rate of water infiltration, 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 in good condition.

This soil is moderately suited to the trees and shrubs grown as windbreaks or ornamental plantings. The high content of clay in the surface layer hinders site preparation. Erosion is a hazard.

The land capability classification is IIe.

386—Cordova loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is in irregularly shaped swales on ground moraines and till plains. Individual areas typically range from 4 to 15 acres in size, but a few are as large as 20 acres.

Typically, the surface layer is black loam about 6 inches thick. The subsurface layer is black and very dark gray clay loam about 15 inches thick. The subsoil is mottled clay loam about 27 inches thick. The upper part is dark grayish brown, and the lower part is olive gray. The substratum to a depth of about 60 inches is olive gray loam.

Included with this soil in mapping are small areas of the somewhat poorly drained Le Sueur soils in the slightly higher positions on the landscape. These soils make up about 5 percent of the unit.

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

Most areas are cultivated. Some support native vegetation. If drained, this soil is well suited to cultivated crops, hay, and pasture. If the soil is plowed in the fall, soil blowing is a hazard unless the surface is protected. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil loss. In some areas the drainage system should be improved. Tile drains work well, but they function somewhat slowly. Tilth generally is fair in the surface layer. If the soil is worked when too wet, it becomes hard and cloddy as it dries. Returning crop residue to the soil, regularly adding other organic material, and deferring tillage when the soil is wet help to maintain tilth, improve fertility, and increase the rate of water infiltration. Including grasses and legumes in the cropping sequence also helps to maintain tilth.

A few areas support mixed trees and grasses. Some areas are not sufficiently drained for dependable row cropping and are used for pasture. Overgrazing and grazing during wet periods cause surface compaction and poor tilth and reduce forage production.

The land capability classification is IIw.

390—Waldorf silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on the concave tops of hummocks and in the adjacent swales on moraines. Individual areas range from 5 to 40 acres in size. Most are irregularly shaped, but the swales are long and narrow and commonly are adjacent to large depressions.

Typically, the surface layer is black silty clay loam about 7 inches thick. The subsurface layer is black silty clay about 12 inches thick. The subsoil is dark gray and olive gray, mottled silty clay about 25 inches thick. The substratum to a depth of about 60 inches is olive gray, mottled, calcareous silty clay loam. In places the surface layer is clay loam.

Included with this soil in mapping are small areas of Okoboji soils and a few small areas of Collinwood soils. The very poorly drained Okoboji soils are in depressions. The somewhat poorly drained Collinwood soils are on low rises and at the outer margin of the mapped areas, where slopes increase slightly. Included soils make up about 10 percent of the unit.

Permeability is moderately slow in the Waldorf soil. Runoff is slow, and some areas are ponded for short periods. A seasonal high water table is at or near the surface. Available water capacity is high. The content of organic matter in the surface layer is about 6 to 8 percent. Reaction typically is neutral or slightly acid to a depth of about 3 feet and is mildly alkaline or moderately alkaline in the lower part of the subsoil and in the substratum. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. If drained, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If the soil is tilled when wet, the surface layer puddles easily and becomes cloddy and hard as it dries. Fall plowing is common on this soil because freezing and thawing break down the clods, resulting in better soil structure and better tilth. The root zone is deep. In inadequately drained areas, however, it is restricted by the high water table during wet periods. Because of the high content of clay, tile drains function more slowly in this soil than in many other soils in the county. As a result, they should be more closely spaced. Legumes are frequently damaged by soil heaving. In some areas they are drowned out by ponding. If large areas are plowed in the fall, soil blowing is a hazard unless the surface is protected. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil loss.

A few areas are pastured. Overgrazing or grazing when the soil is too wet causes surface compaction and poor tilth and damages the plant cover.

The land capability classification is IIw.

485B—Spillville loam, 2 to 5 percent slopes. This gently sloping, moderately well drained soil is on low, concave foot slopes and alluvial fans. It generally is downslope from the more sloping Clarion and Storden soils and upslope from soils on bottom land and terraces. In many places it is upslope from Nicollet or Webster soils. Individual areas are long and narrow. They generally are 3 to 8 acres in size, but a few are as much as 15 acres.

Typically, the surface layer is very dark grayish brown loam about 10 inches thick. The subsurface layer is black loam about 32 inches thick. The next layer to a depth of about 60 inches is very dark grayish brown loam mixed with streaks of yellowish brown substratum material. In places the soil has a thinner surface layer and has a glacial till substratum at a depth of about 40 inches. In a few places the soil is nearly level. In some areas, the slope is slightly more than 5 percent and the soil is well drained.

Permeability is moderate, and runoff is medium. A seasonal high water table is at a depth of 36 to 60 inches. Available water capacity is high. The content of organic matter in the surface layer is about 5 to 6 percent. Reaction typically is neutral throughout the soil, but in places it is slightly acid. The subsurface layer generally has a low supply of available phosphorus and potassium.

Most areas are cultivated. Some areas that are adjacent to steep soils are pastured. This soil generally is managed along with the adjacent soils. It 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 system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil loss and maintain tilth. Installing diversion terraces upslope from this soil helps to control runoff. Gullies can form in shallow drainageways. If shaped and seeded, they can be used as waterways.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when this soil is too wet causes surface compaction and poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted grazing during wet periods help to keep the pasture in good condition.

The land capability classification is IIe.

507—Canisteo clay loam, 0 to 2 percent slopes. This nearly level, poorly drained, calcareous soil is on undulating till plains and in irregularly shaped swales and draws on uplands. Individual areas are irregularly shaped and range from 5 to many acres in size.

Typically, the surface layer is black, friable clay loam about 8 inches thick. The subsurface layer is black and very dark gray clay loam about 13 inches thick. The subsoil is olive gray, mottled clay loam about 25 inches thick. The substratum to a depth of about 60 inches is olive gray, mottled loam. In places the surface layer is silty clay loam.

Included with this soil in mapping are some small areas of the very poorly drained Okoboji soils in depressions. These soils can be ponded after rains. Also included are small areas of the highly calcareous Harps soils. When dry, these soils are distinctly lighter in color than the Canisteo soil. Included soils make up about 5 percent of the unit.

Permeability is moderate in the Canisteo soil. Runoff is slow, and many areas are ponded for short periods. The soil has a seasonal high water table. Available water capacity is high. The content of organic matter in the surface layer is about 6 to 8 percent. Reaction typically is mildly alkaline or moderately alkaline throughout the profile. The subsoil generally has a very low supply of available phosphorus and potassium and a medium or low supply of available nitrogen. The supply of available iron is low in places because of the excess lime.

Most areas are drained and cultivated. A few small undrained areas are pastured. If drained, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Drainage can be improved by the installation of tile drains, which function well. If the soil is plowed when wet, the surface layer puddles easily and becomes cloddy and hard to work as it dries. If large areas are plowed in the fall, soil blowing is a hazard unless the surface is protected. Excess lime affects the response of plants to the more common fertilizers and to some herbicides. The carry-over effect of the herbicides can restrict the growth of subsequent crops. A system of conservation tillage that leaves crop residue on the surface helps to control soil blowing and improves fertility.

If this soil is used for pasture, proper stocking rates, rotation grazing, timely deferment of grazing, and restricted use during wet periods are needed. These measures help to keep the pasture in good condition.

The land capability classification is IIw.

511—Blue Earth mucky silt loam, 0 to 1 percent slopes. This level, highly calcareous, very poorly drained soil generally is in depressions that formerly contained water much of the time. In some areas it is in former shallow lakebeds that have been drained. It is subject to ponding. Individual areas are circular and range from about 10 to 100 acres in size.

Typically, the surface layer is very dark gray mucky silt loam about 8 inches thick. The substratum to a depth of about 60 inches is black and very dark gray, highly calcareous mucky silt loam. In places the surface layer and substratum are silty clay loam high in content of organic matter. In some areas gray clay loam, loam, sandy loam, or silty clay loam is within a depth of 60 inches.

Permeability is moderate. During periods of heavy rainfall, runoff from the adjacent slopes ponds in some areas. This soil has a seasonal high water table. Available water capacity is very high. The content of organic matter in the surface layer is about 15 percent. The soil typically is moderately alkaline throughout. The substratum generally has a very low supply of available phosphorus and potassium. The supply of iron and some other trace elements may be low for some crops.

Drained areas are used for cultivated crops. Undrained areas commonly provide habitat for wildlife. This soil is moderately suited to cultivated crops. Because of a very low supply of some plant nutrients, the very high organic matter content, and the high content of calcium carbonates, special emphasis should be given to the fertility program and to herbicide selection and use. The content of organic matter and of calcium carbonates affects the response of plants to herbicides. The soil warms up slowly in spring. As a result, planting is delayed. Frost often injures crops late in spring and early in fall. Soil blowing can be a problem unless the surface is protected, especially if the larger areas are fall plowed. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil loss. Small grain tends to lodge badly and generally is of poor quality.

Partly drained areas of this soil are suitable for permanent pasture of water-tolerant species, such as reed canarygrass. Legumes for hay grow poorly on this soil and are often winterkilled. Undrained areas generally are suited only to wetland wildlife habitat.

The land capability classification is IIIw.

583—Minnetonka silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is in drainageways and on low, concave and slightly convex slopes. Individual areas are irregularly shaped and range from 3 to 15 acres in size.

Typically, the surface layer is black silty clay loam about 7 inches thick. The subsurface layer is very dark grayish brown silty clay loam about 5 inches thick. The subsoil is about 35 inches thick. The upper part is black silty clay; the next part is olive gray, mottled silty clay; and the lower part is olive gray, mottled silty clay loam. The substratum to a depth of about 60 inches is light olive gray and olive gray, calcareous silty clay loam. In a few areas the soil is wetter and has a surface layer as much as 30 inches thick. These generally are slightly concave areas.

Included with this soil in mapping are areas of the somewhat poorly drained Shorewood soils in the slightly higher landscape positions. These soils make up less than 5 percent of the unit.

Permeability is slow in the Minnetonka soil. Runoff also is slow. A seasonal high water table is within a depth of 3 feet. Some areas are ponded during wet periods. Available water capacity is high. The content of organic matter is about 5 to 7 percent in the surface layer. This layer typically is medium acid. The subsoil typically is medium acid in the upper part and slightly acid in the lower part. It 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. If cultivated crops are grown, a drainage system is needed. Tile drains do not always function well. They should be more closely spaced than those in soils that have a lower clay content in the subsoil. Because of the high clay content and the wetness, preparing a good seedbed is often difficult. If the soil is tilled when wet, the surface layer becomes hard and cloddy as it dries. Applying some kinds of reduced tillage may be difficult. Leaving too much crop residue on the surface can inhibit drying and delay planting in some years.

This soil is well suited to grasses and legumes for pasture or hay. Because of the wetness, however, some legumes do not grow well and are subject to winterkill. Overgrazing or grazing when the soil is too wet causes surface compaction and poor tilth. Proper stocking rates, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is IIw.

585B—Coland-Spillville complex, 0 to 5 percent slopes. These nearly level and gently sloping soils are in small valleys and upland drainageways. The Coland soil is poorly drained and is occasionally flooded. The Spillville soil is moderately well drained. Individual areas generally are 5 to 10 acres in size, but a few are larger. The areas are about 60 percent Coland soil and 40 percent Spillville soil. The two soils occur as areas so intricately mixed or so small that mapping them separately is not practical.

Typically, the surface layer of the Coland soil is black clay loam about 9 inches thick. The subsurface layer also is black clay loam. It is about 39 inches thick. The substratum to a depth of about 60 inches is black, very dark gray, and gray, mottled clay loam that has strata of sandy loam.

Typically, the surface layer of the Spillville soil is very dark grayish brown loam about 10 inches thick. The subsurface layer is black loam about 32 inches thick. The substratum to a depth of about 60 inches is very dark grayish brown loam that has yellowish brown streaks. In places thin layers of sandy loam, sandy clay loam, or silt loam are in the substratum.

Permeability is moderate, and runoff is slow. The Coland soil has a seasonal high water table at a depth of 12 to 36 inches, and the Spillville soil has one at a depth of 36 to 60 inches. Available water capacity is high in both soils. The content of organic matter is about 5 to 7 percent in the surface layer of the Coland soil and 5 to 6 percent in the surface layer of the Spillville soil. The surface layer and subsurface layer of both soils typically are neutral. The subsurface layer generally has a low supply of available phosphorus and potassium.

Most areas are cultivated. Some are pastured. These soils are well suited to corn, soybeans, and small grain and to grasses and legumes for hay or pasture. Wetness and flooding can be problems on the Coland soil, especially where excess water runs onto this unit from soils on adjoining hillsides. Installing diversion terraces along the upper edges of the mapped areas helps to control runoff, and the soils can be farmed on the contour along with the sloping adjacent soils. Grassed waterways can be used where gully erosion is a problem. Straightening stream channels improves the suitability for farming. Tile drains can be installed in many areas to reduce the wetness of the Coland soil.

Some areas are not easily accessible by farm machinery, and some are cut by meandering stream channels or drainageways that are not crossable. These areas are pastured or left idle. Renovating the pasture and establishing the more productive species in accessible areas generally can increase forage production. Proper stocking rates, timely deferment of grazing, pasture rotation, and restricted use during wet periods improve the pasture.

The high water table and the flooding are the main problems if these soils are used for the trees and shrubs grown as windbreaks, ornamental plantings, or plantings that enhance wildlife habitat. A drainage system is needed. Also, the species selected for planting should be those that can withstand the wetness.

The land capability classification is IIw.

621—Houghton muck, 0 to 1 percent slopes. This level, very poorly drained, organic soil is in depressions in upland lakebeds that formerly contained water much of the time. It is subject to ponding. Individual areas typically are circular and range from about 20 to 150 acres in size.

Typically, the soil is black, friable muck to a depth of about 60 inches. In places thin layers of more fibrous material are within 40 inches of the surface.

Permeability is moderately rapid. This soil has a seasonal high water table and is ponded during periods of heavy rainfall. Available water capacity is high. The content of organic matter in the surface layer is about 20 to 35 percent. Reaction typically is slightly acid or neutral throughout the profile. The supply of available phosphorus generally is low, and the supply of available potassium generally is very low. In places trace elements are deficient for some crops.

Most areas are drained and cultivated. If drained and otherwise well managed, this soil is moderately suited to row crops. Crop growth varies. It generally is better in years of somewhat limited rainfall than in years when rainfall is above average. Runoff from the adjacent slopes readily ponds on this soil. During periods of excessive rainfall, crops are sometimes damaged or destroyed before drains can remove the excess water. If the damage occurs early in the growing season, the land is tilled and the crop replanted. The soil warms up slowly in spring. As a result, planting is delayed.

Because this soil is in low lying areas and loses heat rapidly from the surface, frost often injures crops late in spring and early in fall. Planting early maturing varieties helps to prevent excessive crop loss. Fall plowing should be avoided because the soil is subject to soil blowing during dry periods unless the surface is protected. Controlling grasses and weeds commonly is difficult. Some herbicide rates should be higher than those on other soils because the very high organic matter content limits the effectiveness of the herbicides.

Small grain tends to lodge badly on this soil and is of poor quality. Legumes for hay grow poorly and are often winterkilled. Partly drained areas are suitable for permanent pasture of bluegrass, bromegrass, and reed canarygrass. Areas that are not sufficiently drained for row crops or pasture generally provide good habitat for wetland wildlife.

This soil is well suited to potatoes, radishes, carrots, onions, and other specialty crops. These crops are not commonly grown in the county.

The land capability classification is IIIw.

638B2—Clarion-Storden loams, 2 to 5 percent slopes, moderately eroded. These gently sloping, well drained soils are mainly on low knolls. In a few areas they are on ridgetops. The Storden soil typically is upslope from the Clarion soil. Slopes are short and irregular. Individual areas are irregularly shaped and range from 3 to 12 acres in size. Most are about 65 percent Clarion soil and 25 percent Storden soil. The two soils occur as areas so intricately mixed or so small that mapping them separately is impractical.

Typically, the surface layer of the Clarion soil is very dark grayish brown loam about 8 inches thick. Plowing has mixed streaks and pockets of dark yellowish brown subsoil material into the surface layer. The subsoil is dark yellowish brown loam about 20 inches thick. The substratum to a depth of about 60 inches is yellowish brown and dark yellowish brown, friable, calcareous loam. In a few severely eroded areas, the surface layer is mostly yellowish brown subsoil material.

Typically, the surface layer of the Storden soil is mixed dark grayish brown and brown loam about 8 inches thick. The upper part of the substratum is light olive brown loam that has very dark grayish brown streaks. The lower part to a depth of about 60 inches is light olive brown, mottled, calcareous loam. In a few places the light colored substratum is exposed.

Included with these soils in mapping are small areas of the nearly level, somewhat poorly drained Crippin soils. These included soils are lower on the landscape than the Clarion and Storden soils. They make up about 10 percent of the unit.

Permeability is moderate in the Clarion and Storden soils, and runoff is medium. Available water capacity is high. The content of organic matter is about 2 to 3 percent in the surface layer of the Clarion soil and 1 to 2 percent in the surface layer of the Storden soil. The surface layer and the upper part of the subsoil in the Clarion soil typically are slightly acid or neutral. The Storden soil typically is moderately alkaline throughout. Both soils have an excess of calcium carbonates. The subsoil of the Clarion soil generally has a very low or low supply of available phosphorus and a very low supply of available potassium. The substratum of the Storden soil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. These soils are well 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 system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil loss. Applying mechanical erosion-control measures, such as contour farming and terracing, is difficult in most areas because of the irregular topography and the short slopes. In some areas, however, these measures are suitable. Returning crop residue to the soil or regularly adding other organic material improves fertility, reduces the susceptibility to erosion, helps to prevent excessive crusting, and helps to maintain good tilth.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing, however, causes surface compaction and deterioration of tilth, increases the runoff rate, and reduces forage production. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

The land capability classification is IIe.

638C2—Clarion-Storden loams, 5 to 9 percent slopes, moderately eroded. These moderately sloping, well drained soils are on knobs, convex side slopes, and ridges in the uplands. The Clarion soil is on the smoother side slopes and ridges. The Storden soil is on the more convex knobs and side slopes. Individual areas are irregularly shaped and range from 5 to more than 50 acres in size. They are about 55 percent Clarion soil and 40 percent Storden soil. The two soils occur as areas so intricately mixed or so small that mapping them separately is impractical.

Typically, the surface layer of the Clarion soil is mixed very dark grayish brown and brown loam about 8 inches thick. Plowing has mixed streaks and pockets of dark yellowish brown subsoil material into the surface layer. The subsoil is friable loam about 14 inches thick. The upper part is brown and dark yellowish brown, and the lower part is dark yellowish brown. The substratum to a depth of about 60 inches is dark yellowish brown and yellowish brown, mottled, friable, calcareous loam.

Typically, the surface layer of the Storden soil is dark grayish brown, calcareous loam about 8 inches thick. Plowing has mixed streaks and pockets of brown, friable loam into the surface layer. The substratum to a depth of about 60 inches is friable, calcareous loam. The upper part is yellowish brown, and the lower part is light olive brown and mottled.

Included with these soils in mapping are small areas of Dickman and Salida soils. These included soils are more droughty than the Clarion and Storden soils. Dickman soils are on convex nose slopes and the lower lying knobs. The gravelly Salida soils are in scattered areas, mostly on knobs. The gravel in their surface layer interferes with tillage. Included soils make up about 5 percent of the unit.

Permeability is moderate in the Clarion and Storden soils, and runoff is medium. Available water capacity is high. The content of organic matter is about 2 to 3 percent in the surface layer of the Clarion soil and 1 to 2 percent in the surface layer of the Storden soil. Reaction typically is neutral or slightly acid in the surface layer of the Clarion soil and mildly alkaline or moderately alkaline throughout the Storden soil. The subsoil of the Clarion soil and the substratum of the Storden soil generally have a very low supply of available phosphorus and potassium.

Most areas are cultivated. A few are pastured. These soils are moderately well suited to corn, soybeans, and small grain and are well suited to grasses and legumes for hay or pasture. If cultivated crops are grown, further erosion is a hazard. A system of conservation tillage that leaves crop residue on the surface and grassed waterways help to prevent excessive soil loss. Contour farming and terracing also are effective in controlling erosion but are difficult in some areas because of the undulating topography and the short, uneven slopes. If terraces are constructed, a considerable amount of cutting and filling generally is needed.

Tilth generally is fair in the surface layer of these soils. Returning crop residue to the soil or regularly adding other organic material helps to control erosion, improves fertility, and increases the rate of water infiltration. Even though the Storden soil has a high available water capacity, much of the rainfall runs off the surface. As a result, crops grow poorly during dry periods. Because of the high content of lime and moderately low content of organic matter in the Storden soil, the response of plants to applications of fertilizer is restricted. As a result, heavy applications are needed. Iron and other minor nutrients may be deficient for some crops. The carry-over effect of herbicides applied during one year can easily damage some crops grown the next year.

An adequate cover of pasture plants or hay is effective in controlling erosion. Overgrazing, however, increases the runoff rate and the susceptibility to erosion. Proper stocking rates, pasture rotation, and timely deferment of grazing increase forage production.

These soils are suited to the trees and shrubs grown as windbreaks, ornamental plantings, and plantings that enhance wildlife habitat. Excess calcium carbonates restrict the growth of some species. Minimal site preparation and a mulch cover help to control runoff and erosion.

The land capability classification is IIIe.

638D2—Clarion-Storden loams, 9 to 14 percent slopes, moderately eroded. These strongly sloping, well drained soils are on convex side slopes and nose slopes on glacial moraines. The Clarion soil is on the smoother side slopes. The Storden soil is on the more convex parts of the slopes (fig. 10). Individual areas are irregularly shaped and range from 5 to more than 30 acres in size. They are about 55 percent Clarion soil and 40 percent Storden soil. The two soils occur as areas so intricately mixed or so small that mapping them separately is impractical.

Typically, the surface layer of the Clarion soil is mixed very dark grayish brown and brown loam about 8 inches thick. Plowing has mixed streaks and pockets of dark yellowish brown subsoil material into the surface layer. The subsoil is friable loam about 14 inches thick. The

Figure 10.—An area of Clarion-Storden loams, 9 to 14 percent slopes, moderately eroded, in the background. Storden loam is in the light colored areas. Canisteo clay loam is in the foreground.

upper part is brown and dark yellowish brown, and the lower part is dark yellowish brown. The substratum to a depth of about 60 inches is dark yellowish brown and yellowish brown, mottled, friable, calcareous loam.

Typically, the surface layer of the Storden soil is dark grayish brown, calcareous loam about 8 inches thick. Plowing has mixed streaks and pockets of brown, friable loam into the surface layer. The substratum to a depth of about 60 inches is friable, calcareous loam. The upper part is yellowish brown, and the lower part is light olive brown and mottled. In some severely eroded areas, the surface layer is mostly brown and yellowish brown loam.

Included with these soils in mapping are small areas of Dickman and Salida soils. These included soils are more droughty than the Clarion and Storden soils. Dickman soils are on convex nose slopes and the lower lying knobs. The gravelly Salida soils are in scattered areas, mostly on knobs. The gravel in their surface layer interferes with tillage. Included soils make up about 5 percent of the unit.

Permeability is moderate in the Clarion and Storden soils, and runoff is rapid. Available water capacity is high. The content of organic matter is about 2 to 3 percent in the surface layer of the Clarion soil and 1 to 2 percent in the surface layer of the Storden soil. Reaction typically is neutral or slightly acid in the surface layer of the Clarion soil and is mildly alkaline or moderately alkaline throughout the Storden soil. The subsoil of the Clarion soil and the substratum of the Storden soil generally have a very low supply of available phosphorus and potassium.

Most areas are cultivated. A few are pastured. These soils are moderately well suited to corn, soybeans, and small grain and are well suited to grasses and legumes for hay or pasture. If cultivated crops are grown, further erosion is a hazard. A system of conservation tillage that leaves crop residue on the surface and grassed waterways help to prevent excessive soil loss. Contour farming and terracing also are effective in controlling erosion but are difficult in some areas because of the undulating topography and the short, uneven slopes. If terraces are constructed, a considerable amount of cutting and filling generally is needed.

Tilth generally is fair in the surface layer of these soils. Returning crop residue to the soil or regularly adding other organic material helps to control erosion, improves fertility, and increases the rate of water infiltration. Even though the Storden soil has a high available water capacity, much of the rainfall runs off the surface. As a result, crops grow poorly during dry periods. Because of the high content of lime in the Storden soil, the response of plants to applications of fertilizer is restricted. As a result, heavy applications are needed. Iron and other minor nutrients may be deficient for some crops. The carry-over effect of herbicides applied during one year can easily damage crops grown the next year.

An adequate cover of pasture plants or hay is effective in controlling erosion. Overgrazing, however, increases the runoff rate and the susceptibility to erosion. Proper stocking rates, pasture rotation, and timely deferment of grazing increase forage production.

These soils are suited to the trees and shrubs grown as windbreaks, ornamental plantings, and plantings that enhance wildlife habitat. Excess calcium carbonates restrict the growth of some species. Minimal site preparation and a mulch cover help to control runoff and erosion.

The land capability classification is IIIe.

638E2—Clarion-Storden loams, 14 to 18 percent slopes, moderately eroded. These moderately steep, well drained soils are on convex side slopes and nose slopes on glacial moraines. Some areas border small streams, some of which have been straightened and deepened. The Clarion soil is on the smoother side slopes. The Storden soil is on the more complex side slopes and nose slopes. Individual areas are irregularly shaped and range from about 5 to 30 acres in size. They are about 50 percent Clarion soil and 40 percent Storden soil. The two soils occur as areas so intricately mixed or so small that mapping them separately is impractical.

Typically, the surface layer of the Clarion soil is mixed very dark grayish brown and brown loam about 8 inches thick. Plowing has mixed streaks and pockets of dark yellowish brown subsoil material into the surface layer. The subsoil is friable loam about 14 inches thick. The upper part is brown and dark yellowish brown, and the lower part is dark yellowish brown. The substratum to a depth of about 60 inches is dark yellowish brown and yellowish brown, mottled, friable, calcareous loam.

Typically, the surface layer of the Storden soil is dark grayish brown, calcareous loam about 8 inches thick. Plowing has mixed streaks and pockets of brown, friable loam into the surface layer. The substratum to a depth of about 60 inches is friable, calcareous loam. The upper part is yellowish brown, and the lower part is light olive brown and mottled. In places the surface layer is brown and light olive brown.

Included with these soils in mapping are small areas of Dickman and Salida soils. These included soils are more droughty than the Clarion and Storden soils. They are generally on the more convex side slopes and nose slopes and on the lower lying knobs. The gravel in the surface layer of the Salida soils can interfere with tillage. Included soils make up about 10 percent of the unit.

Permeability is moderate in the Clarion and Storden soils, and runoff is rapid. Available water capacity is high. Because of the rapid runoff, however, much of the rainfall does not penetrate the surface. The content of organic matter is about 2 to 3 percent in the surface layer of the Clarion soil and less than 1 percent to 2 percent in the surface layer of the Storden soil. Reaction typically is neutral in the surface layer of the Clarion soil and is mildly alkaline or moderately alkaline throughout the Storden soil. The subsoil of the Clarion soil and the substratum of the Storden soil generally have a very low supply of available phosphorus and potassium.

These soils are used for cultivated crops or for pasture. Because of the slope and a severe erosion hazard, they are poorly suited to cultivated crops. They are better suited to small grain and to grasses and legumes for hay and pasture. Because of the slope, operating machinery is hazardous. If cultivated crops are grown, grassed waterways and no-till planting or other systems of conservation tillage that leave crop residue on the surface are needed to prevent excessive soil loss. By slowing runoff, these measures increase the amount of water available to crops. Returning crop residue to the soil or regularly adding other organic material slows runoff, increases the rate of water infiltration, and improves fertility. Because of the high content of lime and low or moderately low content of organic matter in the Storden soil, the response of plants to applications of fertilizer is restricted. As a result, heavy applications are needed. Iron and other minor nutrients may be deficient for some crops. The carry-over effect of herbicides applied during one year can easily damage crops grown the next year.

An adequate cover of pasture plants or hay is effective in controlling erosion. Overgrazing, however, increases the runoff rate and the susceptibility to erosion. Proper stocking rates, pasture rotation, and timely deferment of grazing increase forage production.

These soils are suited to the trees and shrubs grown as windbreaks, ornamental plantings, and plantings that enhance wildlife habitat. Excess calcium carbonates restrict the growth of some species. Minimal site preparation and a mulch cover help to control runoff and erosion.

The land capability classification is IVe.

655—Crippin loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on slight knolls. Individual areas are irregularly shaped or long and narrow and range from 3 to 10 acres in size.

Typically, the surface layer is black loam about 9 inches thick. The subsurface layer is about 11 inches of black and very dark brown loam and clay loam. The subsoil is calcareous clay loam about 14 inches thick. The upper part is dark grayish brown, and the lower part is dark grayish brown and light olive brown. The substratum to a depth of about 60 inches is light olive brown, mottled, calcareous loam. In places the surface soil is thinner. In a few areas the substratum is silt loam or stratified silt loam and very fine sand. In a few other areas reaction is neutral in the surface layer.

Included with this soil in mapping are some small areas of the calcareous Storden soils. These soils are lower in content of organic matter than the Crippin soil and generally are distinctly lighter in color. They are on the highest part of the slopes. Also included are small areas of Clarion and Harps soils. Clarion soils are in the higher landscape positions and are well drained. The highly calcareous Harps soils are on the lower parts of the slopes, generally adjacent to potholes. Included soils make up about 10 percent of the unit.

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

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to legumes for hay or pasture. Erosion generally is not a problem. If the soil is fall plowed, however, soil blowing can be a problem unless the surface is protected. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil loss. The soil generally is not drained. In some areas, however, a drainage system would improve the timeliness of fieldwork. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material and deferring tillage when the soil is wet help to maintain tilth, improve fertility, help to prevent surface crusting, and increase the rate of water infiltration. More phosphorus and potassium generally are needed on this soil than on similar soils, such as Nicollet soils.

A cover of pasture plants or hay is effective in controlling soil blowing and maintaining good tilth. Overgrazing or grazing when the soil is wet, however, causes surface compaction and poor tilth, increases the runoff rate, and reduces forage production. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

The land capability classification is I.

658—Mayer loam, 0 to 2 percent slopes. This nearly level, poorly drained, calcareous soil is on low stream terraces and glacial outwash plains. Individual areas are irregularly shaped and range from about 5 to 20 acres in size.

Typically, the surface layer is black, friable, calcareous loam about 9 inches thick. The subsurface layer is black and very dark gray, mottled, friable, calcareous loam about 13 inches thick. The subsoil is mottled, friable, calcareous loam about 11 inches thick. The upper part is dark grayish brown, and the lower part is dark grayish brown and olive. The substratum to a depth of about 60 inches is olive gray and olive, calcareous gravelly sand. In a few places it has no coarse fragments.

Included with this soil in mapping are areas of very poorly drained soils in depressions. Also included, generally around the rims of the depressions, are poorly drained soils that are more calcareous than the Mayer soil. Included soils make up about 5 percent of the unit.

Permeability is moderate in the upper part of the Mayer soil and rapid in the substratum. Runoff is slow. The soil has a seasonal high water table. Available water capacity is moderate or low. The underlying calcareous sand and gravel somewhat restrict root development and the available water capacity. The content of organic matter in the surface layer is about 4 to 6 percent. The soil is mildly alkaline or moderately alkaline throughout. It has a very low supply of available phosphorus and potassium.

Most areas are cultivated. Some are pastured. This soil is moderately well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. A drainage system is needed in some areas. Tile drains can remove excess water. In some areas, however, installation is difficult because of instability in the substratum. Because of the limited available water capacity, the soil should not be overdrained. The amount of available water may be deficient, especially when rainfall is below average or is not timely.

This soil is subject to soil blowing, especially if the surface of a fall-plowed area is bare. A system of conservation tillage that leaves crop residue on the surface helps to prevent excessive soil blowing and conserves moisture. A good soil testing and fertility program is important because of the excess lime, which restricts the availability of some plant nutrients and the response of plants to some herbicides. The carry-over effect of the herbicides can restrict the growth of subsequent crops.

If this soil is used for pasture, proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods are needed. These measures help to keep the pasture in good condition.

The high water table, flooding, and excess lime are the main problems if this soil is used for the trees and shrubs grown as windbreaks, ornamental plantings, or plantings that enhance wildlife habitat. The species selected for planting should be those that can grow in a wet, calcareous soil.

The land capability classification is IIw.

777—Wapsie loam, 0 to 2 percent slopes. This nearly level, well drained soil is in outwash areas on uplands. Individual areas are irregularly shaped and generally range from 2 to 15 acres in size.

Typically, the surface layer is very dark brown, friable loam about 9 inches thick. The subsoil is about 24 inches thick. It is dark yellowish brown and friable. The upper part is loam, and the lower part is sandy clay loam. The substratum to a depth of about 60 inches is dark yellowish brown, yellowish brown, and brown, loose gravelly sand. In some places the subsoil is loam throughout. In other places it has been mixed with the surface layer by plowing. In some areas the sand and gravel are leached to a depth of about 50 inches or more.

Included with this soil in mapping are areas where the surface layer and subsoil are sandy loam and the depth to sand and gravel is 12 to 18 inches. These areas are slightly wetter than the Wapsie soil. They make up about 10 percent of the unit.

Permeability is moderate in the upper part of the Wapsie soil and very rapid in the substratum. Runoff is slow. Available water capacity is low or moderate. The content of organic matter in the surface layer is about 1.5 to 2.0 percent. Reaction typically is medium acid in the surface layer and slightly acid or medium acid in the subsoil. 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 gravelly sand substratum. In most years the amount of water available for crop growth, especially row crops, is deficient during the middle and latter parts of the growing season. Soil blowing may be a problem because the surface dries quickly after tillage. No-till planting or other systems of conservation tillage that leave crop residue on the surface and regular additions of other organic material improve fertility, conserve moisture, and help to control erosion and soil blowing.

If this soil is used for pasture, proper stocking rates, pasture rotation, and timely deferment of grazing are needed. These measures help to prevent overgrazing, which reduces the extent of the plant cover and thus increases the susceptibility to soil blowing.

The seasonal droughtiness is the main limitation if this soil is used for the trees and shrubs grown as windbreaks, ornamental plantings, or plantings that enhance wildlife habitat. The species that can withstand the droughtiness should be selected for planting. A mulch cover is effective in conserving moisture.

The land capability classification is IIs.

777B—Wapsie loam, 2 to 5 percent slopes. This gently sloping, well drained soil is in outwash areas on uplands. Individual areas are irregularly shaped and generally range from 2 to 15 acres in size.

Typically, the surface layer is very dark brown, friable loam about 8 inches thick. The subsoil is about 22 inches thick. It is dark yellowish brown and friable. The upper part is loam, and the lower part is sandy clay loam. The substratum to a depth of about 60 inches is dark yellowish brown and yellowish brown, loose gravelly sand. In some places the subsurface layer has been mixed with the subsoil by plowing. In other places the depth to sand and gravel is greater. In some areas the sand and gravel are leached to a depth of 50 inches or more.

Included with this soil in mapping are areas where the surface layer is sand or sandy loam and the depth to sand and gravel is 12 to 18 inches. These areas make up less than 5 percent of the unit.

Permeability is moderate in the upper part of the Wapsie soil and very rapid in the substratum. Runoff is medium. Available water capacity is low or moderate. The content of organic matter in the surface layer is about 1.5 to 2.0 percent. Reaction typically is medium acid in the surface layer and slightly acid or medium acid in the subsoil. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is moderately well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. It is seasonally droughty because of the gravelly sand substratum. In most years the amount of water available for crop growth, especially for row crops, is deficient during the middle and latter parts of the growing season. Soil blowing may be a problem because the surface dries quickly after tillage. No-till planting or other systems of conservation tillage that leave crop residue on the surface and regular additions of other organic material help to prevent excessive soil loss. Tilling or planting on the contour also is effective in preventing excessive soil loss. Terraces generally are not constructed on this soil because the gravelly sand substratum is too close to the surface.

If this soil is used for pasture, proper stocking rates, pasture rotation, and timely deferment of grazing are needed. These measures help to prevent overgrazing, which reduces the extent of the plant cover and thus increases the susceptibility to water erosion and soil blowing.

The seasonal droughtiness is the main limitation if this soil is used for the trees and shrubs grown as windbreaks, ornamental plantings, and plantings that enhance wildlife habitat. The species that can withstand the droughtiness should be selected for planting. A mulch cover is effective in conserving moisture.

The land capability classification is IIe.

777C—Wapsie loam, 5 to 9 percent slopes. This well drained soil is in outwash areas on uplands. Individual areas are irregularly shaped and generally range from 2 to 10 acres in size.

Typically, the surface layer is very dark brown and dark grayish brown, friable loam about 8 inches thick. The subsoil is friable loam about 6 inches thick. The upper part is dark yellowish brown, and the lower part is brown. The substratum to a depth of about 60 inches is yellowish brown, loose, calcareous gravelly sand. In places the sand and gravel are leached to a depth of 40 inches or more.

Included with this soil in mapping are areas where the surface soil is sand or sandy loam and the depth to sand and gravel is 12 to 18 inches. Also included are a few areas where gravel is exposed. Included areas make up about 10 percent of the unit.

Permeability is moderate in the upper part of the Wapsie soil and very rapid in the substratum. Runoff is medium. Available water capacity is low or moderate. The content of organic matter in the surface layer is about 1.0 to 1.5 percent. The surface layer typically is medium acid. The subsoil typically is slightly acid or medium acid. It 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. The soil is seasonally droughty because of the gravelly sand substratum. In most years the amount of water available for crop growth, especially for row crops, is deficient during the middle and latter parts of the growing season. Soil blowing may be a problem because the surface dries quickly after tillage. No-till planting or other systems of conservation tillage that leave crop residue on the surface and regular additions of other organic material help to prevent excessive soil loss. Tilling or planting on the contour also is effective in preventing excessive soil loss. Terraces generally are not constructed on this soil because the gravelly sand substratum is too close to the surface.

If this soil is used for pasture, proper stocking rates, pasture rotation, and timely deferment of grazing are needed. These measures help to prevent overgrazing, which reduces the extent of the plant cover and thus increases the susceptibility to water erosion and soil blowing.

The seasonal droughtiness is the main limitation if this soil is used for the trees and shrubs grown as windbreaks, ornamental plantings, or plantings that enhance wildlife habitat. The species that can withstand the droughtiness should be selected for planting. A mulch cover is effective in conserving moisture.

The land capability classification is IIIe.

787B—Vinje silty clay loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on rises and side slopes in the uplands. Individual areas are irregularly shaped and range from about 4 to 10 acres in size.

Typically, the surface layer is very dark brown silty clay loam about 7 inches thick. The subsurface layer is very dark brown silty clay loam about 6 inches thick. The subsoil is silty clay loam about 28 inches thick. The upper part is dark brown, the next part is dark yellowish brown, and the lower part is grayish brown and olive brown. The upper part of the substratum is grayish brown, mottled silt loam. The lower part to a depth of about 60 inches is grayish brown and yellowish brown, mottled loam. In places the texture is clay loam to a depth of about 40 inches. In a few nearly level areas, it is silty clay loam to a depth of about 60 inches.

Permeability is moderately slow in the upper part of the profile and moderate in the lower part. Runoff is medium. Available water capacity is high. The content of organic matter in the surface layer is about 3 to 4 percent. The surface soil and subsoil typically are 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. If row crops are grown, erosion is a hazard. A system of conservation tillage that leaves crop residue on the surface, contour farming, terraces, and grassed waterways help to prevent excessive soil loss. In places, however, contour farming and terracing are difficult because of irregular topography and short slopes.

The high content of clay reduces the rate of water infiltration and increases the runoff rate. Also, preparing a good seedbed is difficult because of the content of clay. Tilth generally is fair in the surface layer. If tilled when too wet, this layer becomes hard and cloddy as it dries. Returning crop residue to the soil or regularly adding other organic material improves fertility and tilth, increases the rate of water infiltration, and decreases the runoff rate.

A cover of pasture plants or hay is effective in controlling erosion and tends to improve tilth. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is IIe.

787C2—Vinje silty clay loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on rises and side slopes in the uplands. Individual areas are irregularly shaped and range from about 4 to 15 acres in size.

Typically, the surface layer is very dark grayish brown silty clay loam about 7 inches thick. Plowing has mixed some streaks and pockets of brown subsoil material into the surface layer. The subsoil is silty clay loam about 25 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 grayish brown and yellowish brown loam. In some areas the lower part of the subsoil is grayish brown silt loam. In places the texture is silty clay loam to a depth of about 60 inches. In many areas the surface layer and subsoil are clay loam.

Included with this soil in mapping are small areas of Storden soils. These soils typically are on the most sharply convex part of the slopes. They are calcareous throughout and are lower in content of organic matter than the Vinje soil. They make up less than 5 percent of the unit.

Permeability is moderately slow in the upper part of the Vinje soil and moderate in the substratum. Runoff is rapid. Available water capacity is high. The content of organic matter in the surface layer is about 2 to 3 percent. The surface layer and subsoil typically are slightly acid. The subsoil generally has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is moderately well suited to corn, soybeans, and small grain and is well suited to grasses and legumes for hay and pasture. If row crops are grown, further erosion is a hazard. A system of conservation tillage that leaves crop residue on the surface, contour farming, terraces, and grassed waterways help to prevent excessive soil loss. In places, however, contour farming and terracing are difficult because of irregular topography and short slopes.

The high content of clay reduces the rate of water infiltration and increases the runoff rate. Also, preparing a good seedbed is difficult because of the content of clay. Tilth generally is fair in the surface layer. If tilled when too wet, this layer becomes hard and cloddy as it dries. Returning crop residue to the soil or regularly adding other organic material improves fertility and tilth, increases the rate of water infiltration, and decreases the runoff rate.

A cover of pasture plants or hay is effective in controlling erosion and tends to improve tilth. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases the runoff rate and the susceptibility to erosion, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is IIIe.

787D2—Vinje silty clay loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is on side slopes in the uplands. Individual areas are irregularly shaped and range from about 5 to 15 acres in size.

Typically, the surface layer is mixed dark brown and brown silty clay loam about 7 inches thick. Plowing has mixed some streaks and pockets of dark yellowish brown subsoil material into the surface layer. The subsoil is silty clay loam about 20 inches thick. The upper part is brown and dark yellowish brown, and the lower part is dark yellowish brown. The substratum to a depth of about 60 inches is dark yellowish brown and yellowish brown loam. In some areas shale fragments are in the subsoil and substratum. In places the surface layer and subsoil are clay loam.

Included with this soil in mapping are small areas of Storden soils. These soils typically are on the most sharply convex part of the slopes. They are calcareous throughout and are lower in content of organic matter than the Vinje soil. They make up about 5 to 10 percent of the unit.

Permeability is moderately slow in the upper part of the Vinje soil and moderate in the substratum. Runoff is rapid. Available water capacity is high. The content of organic matter in the surface layer is about 2 to 3 percent. The surface layer and subsoil typically are slightly acid. 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. Because of the slope and the rapid runoff, further erosion is a serious hazard if cultivated crops are grown. A system of conservation tillage that leaves crop residue on the surface, contour farming, terraces, and grassed waterways help to prevent excessive soil loss. In places, however, contour farming and terracing are difficult because of irregular topography and short slopes.

The high content of clay reduces the rate of water infiltration and increases the runoff rate. Also, preparing a good seedbed is difficult because of the content of clay. Tilth generally is fair in the surface layer. If tilled when too wet, this layer becomes hard and cloddy as it dries. Returning crop residue to the soil or regularly adding other organic material improves fertility and tilth, increases the rate of water infiltration, and decreases the runoff rate.

A cover of pasture plants or hay is effective in controlling erosion and tends to improve tilth. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases the runoff rate and the susceptibility to erosion, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is IIIe.

811—Muskego muck, 0 to 1 percent slopes. This level, very poorly drained soil is in depressions in old glacial lake basins. It is subject to ponding. Individual areas typically are circular and range from 15 to 80 acres in size.

Typically, the surface soil is black muck about 26 inches thick. The substratum to a depth of 60 inches or more is black and very dark gray, highly calcareous mucky silt loam. It has grayish brown mottles in the lower part. In places thin layers of sand or loam are within a depth of 60 inches.

Permeability is moderately rapid in the upper part of the profile and slow in the lower part. Runoff is very slow or ponded. The soil has a seasonal high water table and is ponded during some periods of heavy rainfall and in the spring. Available water capacity is very high. The content of organic matter in the surface layer is about 20 to 35 percent. Reaction typically is neutral to mildly alkaline in the surface layer. The supply of available phosphorus and potassium is very low. Trace elements may be deficient for some crops.

Much of the acreage is drained and used for cultivated crops. If drained and otherwise well managed, this soil is moderately suited to corn, soybeans, and small grain. Runoff from the adjacent slopes readily ponds in some areas of this soil. During periods of excessive rainfall, crops are sometimes damaged or destroyed before tile can remove the excess water. If this damage occurs early in the growing season, the soil is tilled and the crop replanted. The soil warms up slowly in spring. As a result, planting is often delayed.

Because this soil is in low lying areas and loses heat rapidly from the surface, frost often injures crops late in spring and early in fall. Planting early maturing varieties helps to prevent excessive crop loss. Small grain tends to lodge badly and generally is of poor quality. The growth of all crops generally is better in years of somewhat limited rainfall than in years of above average rainfall. Tilth is excellent in the surface layer. The soil can be tilled throughout a wide range of moisture content. Fall plowing should be avoided because soil blowing is a hazard during dry periods unless the surface is protected. The kind of herbicide and the rate of application should be carefully selected because the very high organic matter content limits the effectiveness of many herbicides.

Partly drained areas commonly are pastured. Hay and pasture plants are highly susceptible to winterkill. This soil is poorly suited to legumes for hay and pasture, but it is well suited to many grasses, especially reed canarygrass and other species that can withstand the wetness. Rotation grazing and deferment of grazing when the soil is wet help to prevent excessive trampling by livestock and increase forage production. Areas that are not drained sufficiently for use as pasture provide good habitat for wetland wildlife.

The land capability classification is IIIw.

823—Ridgeport sandy loam, 0 to 2 percent slopes. This nearly level, somewhat excessively drained soil is on plane and slightly convex slopes on glacial outwash plains and stream terraces. Individual areas are irregularly shaped and range from about 5 to 50 acres in size.

Typically, the surface layer is very dark brown sandy loam about 9 inches thick. The subsurface layer also is very dark brown sandy loam. It is about 4 inches thick. The subsoil is sandy loam about 25 inches thick. The upper part is very dark grayish brown, dark brown, and brown; the next part is dark brown and brown; and the lower part is dark yellowish brown. The substratum to a depth of about 60 inches is dark yellowish brown and yellowish brown. It is loamy sand in the upper part and gravelly loamy sand in the lower part. In places the depth to the substratum is less than 30 inches.

Included with this soil in mapping are small areas of the somewhat poorly drained Linder soils and areas of soils that have loamy glacial till at a depth of 36 to 60 inches. Linder soils are in slightly concave areas. Both of the included soils are somewhat less droughty and more productive than Ridgeport soil. They make up less than 5 percent of the unit.

Permeability is moderately rapid in the upper part of the Ridgeport soil and very rapid in the coarse textured substratum. Runoff is slow. Available water capacity is low. The content of organic matter in the surface layer is about 1 to 2 percent. The surface soil and subsoil typically are slightly acid or neutral. The substratum is neutral in the upper part and mildly alkaline in the lower part. 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. An insufficient supply of available water frequently limits crop growth during parts of most growing seasons, especially in years when rainfall is below average or is poorly distributed. Small grain and legumes generally grow better than row crops. Soil blowing is a hazard if the soil is plowed in the fall. Windblown sand damages young plants in some years. A system of conservation tillage that leaves crop residue on the surface conserves moisture and helps to control soil blowing. Good tilth generally can be easily maintained.

A cover of pasture plants or hay is effective in controlling soil blowing. Proper stocking rates, pasture rotation, and timely deferment of grazing help to keep the pasture in good condition.

The land capability classification is IIIs.

823B—Ridgeport sandy loam, 2 to 5 percent slopes. This gently sloping, somewhat excessively drained soil is on convex slopes on stream terraces and glacial outwash plains. Individual areas typically are elongated. They generally are 5 to 6 acres in size, but a few are about 10 acres.

Typically, the surface layer is very dark brown sandy loam about 8 inches thick. The subsurface layer is very dark brown and very dark grayish brown sandy loam about 4 inches thick. The subsoil is sandy loam about 23 inches thick. The upper part is brown and dark brown, and the lower part is brown, dark yellowish brown, and yellowish brown. The substratum to a depth of about 60 inches is dark yellowish brown and yellowish brown and is calcareous. It is loamy sand in the upper part and gravelly loamy sand in the lower part. In places the depth to the substratum is less than 30 inches.

Permeability is moderately rapid in the upper part of the profile and very rapid in the coarse textured substratum. Runoff is medium. Available water capacity is low. The content of organic matter in the surface layer is about 1 to 2 percent. The surface soil and subsoil typically are slightly acid or neutral. The substratum typically is mildly alkaline or moderately alkaline, but in some areas it is 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. If cultivated crops are grown, erosion is a hazard. The soil is often droughty during parts of some growing seasons because the gravelly substratum limits the available water capacity. Crop growth is restricted during parts of most growing seasons, especially in years when rainfall is below average or is poorly distributed. Small grain and grasses and legumes generally grow better than row crops.

This soil warms up quickly in the spring and can be worked soon after rains. The surface layer tends to dry quickly after tillage, and soil blowing is sometimes a hazard. Windblown sand can damage young plants in some years. Contour farming and a system of conservation tillage that leaves crop residue on the surface help to prevent excessive soil loss. Terraces generally are not constructed on this soil because excavations could expose the coarse textured substratum. Good tilth generally can be easily maintained. Returning crop residue to the soil or regularly adding other organic material improves fertility, conserves moisture, and reduces the susceptibility to erosion and soil blowing.

This soil is moderately suited to grasses and legumes for hay and pasture. Overgrazing reduces the extent of the plant cover and thus increases the runoff rate and the susceptibility to erosion.

Erosion is a slight hazard if this soil is used for the trees and shrubs grown as windbreaks or ornamental plantings. Site preparation that retains much of the existing vegetation or a mulch cover helps to control erosion and conserves moisture. The species that can withstand droughtiness should be selected for planting, or supplemental water should be applied if irrigation is practical.

The land capability classification is IIIe.

836B—Kilkenny clay loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on ridges on glacial end moraines. Individual areas are irregularly shaped and range from 3 to 15 acres in size.

Typically, the surface layer is very dark gray clay loam about 9 inches thick. The subsurface layer is dark grayish brown clay loam about 6 inches thick. It is mixed with dark brown material. The subsoil is clay loam about 49 inches thick. The upper part is brown and dark yellowish brown, the next part is olive brown and mottled, and the lower part is grayish brown and mottled. The substratum to a depth of about 60 inches is light olive brown, mottled clay loam. In some cultivated areas the upper part of the subsoil has been mixed with the surface soil by plowing.

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

Permeability is moderately slow in the Kilkenny soil, and runoff is medium. Available water capacity is high. The content of organic matter in the surface layer is about 2.5 to 3.5 percent. Reaction typically is neutral in the surface soil. The subsoil typically is medium acid to neutral. It generally has a 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 hay and pasture. Erosion is a hazard if the soil is cultivated. A system of conservation tillage that leaves crop residue on the surface and grassed waterways help to prevent excessive soil loss. Terracing and contour farming also are effective in controlling erosion. Tilth generally is fair in the surface layer. If tilled when wet, the soil can become hard and cloddy as it dries. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to prevent excessive crusting, and increases the rate of water infiltration.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

This soil is well suited to trees. A few small areas support mixed native hardwoods and grasses. These areas provide excellent habitat for various kinds of wildlife.

The land capability classification is IIe.

836C2—Kilkenny clay loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on convex side slopes on glacial end moraines. Individual areas are irregularly shaped and range from 2 to 10 acres in size.

Typically, the surface layer is very dark grayish brown clay loam about 8 inches thick. Plowing has mixed some streaks and pockets of brown subsoil material into the surface layer. The subsoil is clay loam about 49 inches thick. The upper part is brown, the next part is olive brown, and the lower part is olive brown and light olive brown. The substratum to a depth of about 60 inches is light olive brown, mottled clay loam. In places the soil is silty clay loam throughout.

Included with this soil in mapping are areas of the somewhat poorly drained Shorewood soils. These soils are in small natural drainageways. Also included are small areas of Storden soils. These soils are calcareous throughout. They generally are on the most convex part of the slopes. Included soils make up about 5 percent of the unit.

Permeability is moderately slow in the Kilkenny soil, and runoff is medium or rapid. Available water capacity is high. The content of organic matter in the surface layer is about 2.0 to 2.5 percent. Reaction typically is slightly acid or neutral in the surface layer. The subsoil typically is medium acid in the upper part and slightly acid or neutral in the lower part. It generally has a low supply of available phosphorus and a very low supply of available potassium.

Most areas are cultivated. A few support mixed trees and grasses. This soil is moderately suited to corn, soybeans, and small grain and to hay and pasture. If the soil is cultivated, further erosion is a hazard. Grassed waterways and a system of conservation tillage that leaves crop residue on the surface help to prevent excessive soil loss. In places where slopes are long enough, contour farming and terracing are suitable. Tilth generally is fair in the surface layer. If tilled when wet, the soil can become hard and cloddy as it dries. Returning crop residue to the soil or regularly adding other organic material improves fertility, helps to prevent excessive crusting, increases the rate of water infiltration, and helps to maintain tilth.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is IIIe.

836D2—Kilkenny clay loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is on convex side slopes on glacial end moraines. Slopes typically are short. Individual areas are irregularly shaped and range from 2 to 15 acres in size.

Typically, the surface layer is dark brown clay loam about 8 inches thick. Plowing has mixed streaks and pockets of yellowish brown subsoil material into the surface layer. The subsoil is clay loam about 33 inches thick. The upper part is olive brown and yellowish brown, and the lower part is olive brown and light olive brown. The substratum to a depth of about 60 inches is olive brown and light olive brown, mottled, calcareous clay loam and loam. In places the surface layer is very dark gray and is about 8 inches thick. In some areas the soil is silty clay loam throughout.

Included with this soil in mapping are a few small areas of Storden soils. These soils are calcareous throughout. They generally are on the most convex part of the slopes. They make up less than 5 percent of the unit.

Permeability is moderately slow in the Kilkenny soil, and runoff is rapid. Available water capacity is high. The content of organic matter in the surface layer is about 2.0 to 2.5 percent. Reaction in the surface layer typically is neutral. The subsoil typically is medium acid in the upper part and slightly acid or neutral in the lower part. It generally has a low supply of available phosphorus and a very low supply of available potassium.

Most areas are cultivated. A few support mixed trees and grasses. This soil is poorly suited to corn, soybeans, and small grain but is well suited to grasses and legumes for hay and pasture. If the soil is cultivated, further erosion is a hazard. A system of conservation tillage that leaves residue on the surface, grassed waterways, and crop rotations that include grasses help to prevent excessive soil loss. In areas where slopes are long enough and smooth enough, contour farming and terracing also can help to control erosion. Tilth generally is fair in the surface layer. If tilled when wet, the soil becomes hard and cloddy as it dries. Returning crop residue to the soil or regularly adding other organic material improves fertility, reduces the susceptibility to erosion, and helps to maintain tilth.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction, increases the runoff rate, and results in poor tilth. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture productive.

The land capability classification is IVe.

836E2—Kilkenny clay loam, 14 to 18 percent slopes, moderately eroded. This moderately steep, well drained soil is on glacial end moraines. Slopes generally are short. Individual areas are irregularly shaped and range from 2 to 10 acres in size.

Typically, the surface layer is mixed brown and dark brown clay loam about 8 inches thick. Plowing has mixed some streaks and pockets of subsoil material into the surface layer. The subsoil is clay loam about 31 inches thick. The upper part is olive brown and yellowish brown, and the lower part is olive brown and light olive brown. The substratum to a depth of about 60 inches is olive brown and light olive brown, mottled, friable, calcareous clay loam and loam. In some places the surface layer is mainly mixed olive brown and yellowish brown clay loam. In other places the soil is silty clay loam throughout.

Included with this soil in mapping are a few small areas of Storden soils. These soils are calcareous throughout. They generally are on the most convex part of the slopes. They make up about 5 percent of the unit.

Permeability is moderately slow in the Kilkenny soil, and runoff is rapid. Available water capacity is high. The content of organic matter in the surface layer is about 2.0 to 2.5 percent. Reaction in the surface layer typically is neutral. The subsoil typically is medium acid in the upper part and slightly acid or neutral in the lower part. It generally has a low supply of available phosphorus and a very low supply of available potassium.

Most areas are cultivated. This soil is generally unsuitable for cultivation. It is moderately well suited to grasses and legumes for hay or pasture. A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction and deterioration of tilth 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 productive.

In some areas this soil supports oak trees and grasses. These areas provide good habitat for woodland wildlife. Trees grow well, but most areas have been damaged by grazing livestock. Few seedlings can survive in these areas. In a few places competing grasses and brushy undergrowth inhibit the growth and survival of the seedlings. If grazing is controlled and competing vegetation is removed or controlled, seedlings can survive and grow well. A mulch cover and limited site preparation help to control erosion when sites are prepared for seedlings.

The land capability classification is VIe.

836F—Kilkenny clay loam, 18 to 35 percent slopes. This steep and very steep, well drained soil is on glacial end moraines. Individual areas are irregularly shaped and range from 3 to 10 acres in size.

Typically, the surface layer is very dark gray and very dark grayish brown clay loam about 4 inches thick. The subsurface layer is very dark grayish brown and dark grayish brown clay loam about 3 inches thick. The subsoil is clay loam about 28 inches thick. The upper part is brown and olive brown, and the lower part is olive brown and light olive brown. The substratum to a depth of about 60 inches is light olive brown and light brownish gray, calcareous clay loam and loam. In some areas the soil is silty clay loam throughout.

Included with this soil in mapping are a few small areas of Storden soils. These soils are calcareous throughout. They generally are on the most convex part of the slopes. They make up about 10 percent of the unit.

Permeability is moderately slow in the Kilkenny soil, and runoff is very rapid. Available water capacity is high. The content of organic matter in the surface layer is about 2.0 to 2.5 percent. Reaction is slightly acid or neutral in the surface soil and subsoil and mildly alkaline or moderately alkaline in the substratum. The subsoil generally has a low supply of available phosphorus and a very low supply of available potassium.

Nearly all of the areas support native hardwoods and grasses. This soil is best suited to trees. It is well suited to woodland wildlife habitat. The growth of all vegetation, except for trees, generally is poor, and total production is low. The major problems in managing woodland are the hazard of erosion and low fertility. The supply of available water is sometimes low because of the very rapid runoff. In areas that are grazed, proper stocking rates, timely deferment of grazing, and rotation grazing are needed to help maintain a good cover of the desirable species. Grazing can damage trees, seedlings, and wildlife habitat. In a few places competing grasses and other undergrowth inhibit the growth and survival of seedlings. If grazing is controlled and competing vegetation is removed or controlled, seedlings can survive and grow well. A mulch cover and limited site preparation help to control erosion when sites are prepared for seedlings.

The land capability classification is VIe.

855—Shorewood silty clay loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on slightly convex, low rises and in slightly concave areas on moraines. Individual areas are irregularly shaped and range from 5 to 30 acres in size.

Typically, the surface layer is black silty clay loam about 10 inches thick. The subsurface layer also is black silty clay loam. It is about 5 inches thick. The subsoil is about 27 inches thick. The upper part is dark grayish brown, mottled silty clay loam and silty clay, and the lower part is dark grayish brown and grayish brown, mottled silty clay. The substratum to a depth of about 60 inches is grayish brown and light olive brown silty clay loam.

Included with this soil in mapping are small areas of the poorly drained Minnetonka soils on the somewhat lower, slightly concave parts of the landscape. Unless a drainage system is installed, the wetness of these soils often delays fieldwork. These soils make up about 5 percent of the unit.

Permeability is slow in the Shorewood soil. Runoff also is slow. The soil has a seasonal high water table. Available water capacity is high. The content of organic matter in the surface layer is about 5.5 to 6.5 percent. The surface layer and subsurface layer typically are neutral or slightly acid, but in some areas they are medium acid. The subsoil is slightly acid or medium acid in the upper part. It 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. Because of the seasonal high water table, a drainage system is installed in most areas to improve the timeliness of fieldwork. Tile drains do not always function well. They should be more closely spaced than those in soils that have less clay in the subsoil. If the soil is plowed in the fall, soil blowing is a hazard unless the surface is protected. Returning crop residue to the soil or regularly adding other organic material helps to control soil blowing and improves tilth and fertility.

A cover of pasture plants or hay is effective in controlling erosion. Overgrazing or grazing when the soil is too wet, however, causes surface compaction 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 in good condition.

This soil is moderately suited to the trees and shrubs grown as ornamental plantings. Seedlings survive and grow well if competing vegetation is controlled or removed by adequate site preparation, by prescribed burning, or by spraying, cutting, or girdling.

The land capability classification is IIw.

1133—Colo silty clay loam, channeled, 0 to 2 percent slopes. This nearly level, poorly drained soil is adjacent to the major streams, mainly the Winnebago River. It is dissected by oxbows and meandering stream channels and is among the first soils to be flooded when streams overflow their banks. Most areas are long and narrow and are several hundred acres in size. Areas where the oxbows are more numerous, however, are wider and larger.

Typically, the surface soil is silty clay loam about 47 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 dark gray silty clay loam. In places the soil is clay loam throughout. In a few areas it is sandy loam at a depth of about 40 inches.

Included with this soil in mapping are a few small areas of Spillville soils adjacent to the stream channels. These soils contain less clay than the Colo soil. Also included are soils that are calcareous throughout. These soils are in the same landscape positions as the Colo soil. Included soils make up about 10 percent of the unit.

Permeability is moderate in the Colo soil, and runoff is slow. The soil has a seasonal high water table. Available water capacity is high. The content of organic matter in the surface layer is about 5 to 7 percent. Reaction typically is neutral or slightly acid throughout the profile. The subsurface layer generally has a low supply of available phosphorus and potassium.

Flooding is a severe hazard on this soil. As a result, most areas support native grasses and are used for pasture or are idle. Some support scattered brush and trees. When flooding is not too severe, most areas provide good grazing for livestock. Those along the Winnebago River, however, are subject to long periods of flooding during the wetter years. Some low lying areas are managed as wildlife habitat. If flooding could be controlled and the old stream channels filled, this soil would be well suited to row crops or hay, but the expense is likely to be prohibitive.

If this soil is used for pasture, overgrazing or grazing when the soil is too wet causes surface compaction and reduces forage production. Proper stocking rates, pasture rotation, timely deferment of grazing, and restricted use during wet periods help to keep the pasture in good condition.

The land capability classification is Vw.

2811—Muskego muck, ponded, 0 to 1 percent slopes. This level, very poorly drained, organic soil is in undrained depressions. In a few areas it is adjacent to the Winnebago River and some of its tributaries. The soil generally is covered with water most of the time. The water is as much as 3 feet deep. Individual areas range from about 5 to more than 80 acres in size.

Typically, the surface soil is black muck about 26 inches thick. Below this to a depth of 60 inches or more is black and very dark gray, highly calcareous mucky silt loam. In places about 12 inches of loamy overwash is along the outer perimeter of the depression. In some areas adjacent to the river, stratified sandy material is within a depth of 60 inches.

Included with this soil in mapping are areas of the ponded Boots soils, which have thick layers of peat. These soils make up about 15 percent of the unit.

Permeability is moderately rapid in the upper part of the Muskego soil and slow in the lower part. Runoff is very slow or ponded. The soil has a seasonal high water table and is ponded during some periods of heavy rainfall and in the spring. Available water capacity is very high. The content of organic matter in the surface layer is about 20 to 25 percent. The surface layer typically is slightly acid to mildly alkaline. The supply of available phosphorus and potassium is very low. Trace elements may be deficient for some crops.

This soil is unsuitable for farming. It can be used as habitat for waterfowl, muskrats, and other wetland wildlife. Some areas have been designated as game refuges and public hunting grounds. These areas include Myre Slough, Rice Lake, Lake Harmon, Thrope Park, and Hogsback Ridge.

The land capability classification is VIIw.

5010—Pits, sand and gravel. This map unit is in areas where deposits of sand and gravel are of sufficient quality and quantity to be mined for commercial uses. It is on level or nearly level stream terraces and in areas of glacial outwash. Some of the pits are abandoned because most of the gravel suitable for road surfacing has been removed. Individual areas range from 2 to 30 acres in size.

The deposits of sand and gravel are strip mined, and the unit now has little value as farmland. Some areas can be reclaimed as farmland if the landscape is leveled and the overburden is returned to the site. Most water-filled abandoned pits support a varied aquatic life. During the migration season, ducks and geese use the ponds as resting and feeding areas. The fish in the ponds include bullheads, largemouth and smallmouth bass, sunfish, and northern pike. A large area of several pits near the town of Leland is maintained as a park and is intensively fished.

The pits are used mainly as public recreation areas, but some are privately owned. This map unit has excellent potential as a site for picnicking, hunting, fishing, snowmobiling, motorcycle trails, and camping. Landscaping and planting trees, shrubs, and grasses improve the suitability for these uses.

No land capability classification is assigned to this unit.

5040—Orthents, loamy. These nearly level to moderately sloping, somewhat excessively drained to moderately well drained soils are in areas that have been cut and filled. Individual areas generally are rectangular and range from 1 to 15 acres in size.

Typically, the cut areas have a soil profile and soil characteristics similar to those of Storden soils. The upper 5 feet is yellowish brown and grayish brown, friable and firm, calcareous loam. In other areas, cuts are deeper and seasonal wetness is a problem. Cobbles and pebbles are common on the surface in many areas. About 4 to 10 inches of topsoil has been redistributed throughout some borrow areas. The surface color in these areas ranges from very dark gray to dark brown.

Many cut and filled areas are on the edge of fields adjacent to roads and paved highways. In many areas small pockets of sand and gravel have been removed for use as roadfill or building material. Some areas are used as cropland. The soils generally have a very low content of organic matter and available plant nutrients. Tilth is poor in most areas. In many areas the soils cannot readily support farm equipment during the wetter periods. Returning crop residue to the soil and regularly adding other organic material improve tilth and the available water capacity.

Filled areas have a variety of soil characteristics, depending on the source of the fill material. Many are not used for agricultural purposes. Most are built-up areas adjacent to sites for roads or buildings. They generally are built up to a level surface. A few have fairly steep marginal slopes. Onsite investigation is needed to determine the engineering properties that affect construction uses.

No land capability classification is assigned to these soils.

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, should encourage and facilitate the wise use of our Nation's prime farmland.

Prime farmland, as defined by the U.S. Department of Agriculture, is the land that is best suited to food, feed, forage, fiber, and oilseed crops. It may be cultivated land, 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 crops or is available for those crops. The soil qualities, growing season, and moisture supply are those needed for a well managed soil to produce a sustained high yield of crops in an economic manner. 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 has an adequate and dependable supply of moisture from precipitation or irrigation. The temperature and growing season are favorable. The level of acidity or alkalinity is acceptable. Prime farmland has few or no rocks and is permeable to water and air. It is not excessively erodible or saturated with water for long periods and is not frequently flooded during the growing season. The slope ranges mainly from 0 to 6 percent. More detailed information about the criteria for prime farmland is available at the local office of the Soil Conservation Service.

About 167,272 acres in the survey area, or nearly 65 percent of the total acreage, meets the soil requirements for prime farmland. About 160,000 acres of this land is used for crops, mainly corn and soybeans. The crops grown on this land account for an estimated 80 percent of the county's total agricultural income each year.

A recent trend in land use in some parts of the county has been the loss of some prime farmland to industrial and urban uses. The loss of prime farmland to other uses puts pressure on marginal lands, which generally are more erodible, droughty, and less productive and cannot be easily cultivated.

The map units in the survey area 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. The soil qualities that affect use and management are described under the heading "Detailed Soil Map Units."

Some soils that have a seasonal high water table qualify for prime farmland only in areas where this limitation has been overcome by drainage measures. The need for these measures is indicated after the map unit name 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 1983, about 240,800 acres in Winnebago County was used for agricultural purposes (*8*). Of this total, approximately 214,500 acres was used for corn and soybeans, 4,700 acres for oats, and 4,400 acres for hay. The rest was used for woodland, farmsteads, roads, or miscellaneous crops or was idle land.

The paragraphs that follow describe the major concerns in managing the soils in the county for crops and pasture. These concerns are water erosion and soil blowing, drainage, fertility, and tilth.

Water erosion is a major problem on about 92,000 acres, or 35.85 percent of the cropland and pasture in the county. If the slope is 3 percent or more, erosion is a hazard. Measures that control erosion are needed on Clarion, Collinwood, Dickinson, Dickman, Hayden, Kilkenny, Lester, Ridgeport, Salida, Storden, Vinje, and Wapsie soils.

Loss of the surface layer through erosion reduces the productivity of soils and results in sedimentation in streams and lakes. Productivity is reduced as the surface layer is lost and part of the subsoil is incorporated into the plow layer. Loss of the surface layer is especially damaging on soils having a subsurface layer or subsoil that is very low in fertility. On soils that have a fine textured subsoil, such as Collinwood, Kilkenny, and Vinje soils, erosion exposes soil material in which fertility and the infiltration rate are lower and tilth is poor. Thus, preparing a good seedbed is much more difficult and erosion is greatly accelerated. Erosion also reduces the productivity of soils that tend to be droughty, such as Dickman, Dickinson, Ridgeport, Salida, and Wapsie soils. Control of erosion helps to maintain the productivity of soils. By minimizing the pollution of streams and lakes, it also improves the quality of water for municipal use, for recreation, and for fish and other wildlife.

Erosion-control practices provide a protective cover, reduce the runoff rate, and increase the rate of water infiltration. A cropping system that keeps a vegetative cover on the soil for extended periods can hold soil losses to an amount that will not reduce the productive capacity of the soils. On livestock farms including forage crops of grasses and legumes in the cropping sequence not only helps to control erosion on sloping land but also provides nitrogen and improves tilth for the following crop.

A system of conservation tillage that leaves a protective amount of crop residue on the surface is effective in controlling erosion. No-till, or 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 about 90 percent of the surface. Strip-till, till-plant, or ridge planting 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 total row width. 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. Preparing the seedbed and planting may be one or separate operations.

Terraces and diversions reduce the length of slopes and thus the runoff rate and the risk of erosion. They are most practical on deep, well drained soils that have long, uniform slopes. In some areas gully-control structures and grassed waterways are needed (fig. 11). Grassed waterways slow runoff, trap sediments, and help to prevent gullying. In Winnebago County the slopes commonly are not very uniform, but many soils are suitable for terracing. Examples are Clarion, Hayden, Lester, and Storden soils. Other soils, such as Kilkenny and Vinje, are less well suited because of a fine textured subsoil. Terracing generally is not practical on soils that have coarse or moderately coarse textures in the surface layer or are shallow to such textures. Examples are Dickinson, Dickman, Ridgeport, Salida, and Wapsie soils.

Soil blowing is a serious hazard on Dickinson, Dickman, Ridgeport, Salida, and Wapsie soils and is a somewhat lesser hazard on Harps, Mayer, and Linder soils. All of these soils, except for Harps, tend to dry quickly and have sandy material in the surface layer.

Figure 11.—Sediment deposited at the end of a waterway. A grassed waterway would have controlled or prevented this deposition.

This material is highly susceptible to soil blowing. Harps soils are highly susceptible because they have a weak grade of structure. Windblown sand can damage young plants in a few hours if winds are strong and the surface is bare. Soil blowing also is a serious hazard in bare areas of the organic Blue Earth, Boots, Houghton, Muskego, and Palms soils. These soils are particularly susceptible if they are tilled in the fall. Soil blowing can be controlled by a good plant cover, surface mulch, or tillage methods that keep the surface rough. Windbreaks of suitable trees and shrubs also help to control soil blowing.

Drainage is a management concern on 123,274 acres, or 48 percent of the cropland and pasture in the county. The very poorly drained Blue Earth, Boots, Houghton, Muskego, Palms, and Okoboji soils are naturally so wet that the production of the crops commonly grown in the county generally is not possible. These soils make up about 32,639 acres in the county. Most of the acreage of these soils has been artificially drained and is cropped. In extremely wet years, however, many areas are flooded and crops are destroyed or are not planted.

Unless they are drained, the poorly drained Canisteo, Coland, Colo, Cordova, Darfur, Dundas, Hanska, Harps, Mayer, Minnetonka, Waldorf, and Webster soils are so wet that crops are damaged in most years. These soils make up about 90,635 acres in the county. They are more productive and more easily managed if they are drained. All of the soils, except for Colo, have been drained, but measures that improve drainage are needed in some areas.

The design of both surface and subsurface drainage systems varies with the kind of soil. If the very poorly drained soils are intensively row cropped, a combination of tile drainage and surface intakes generally is needed. In some areas a surface drainage system also is needed. Tile drains generally are adequate in the poorly drained soils. The drains should be more closely spaced in slowly permeable or very slowly permeable soils than in the more rapidly permeable soils. Care is needed to prevent overdraining of soils that formed in outwash or of soils that have a sandy substratum, such as Darfur, Hanska, and Mayer soils.

Tile drainage is very slow in Okoboji, Waldorf, and Minnetonka soils because of a fine textured subsoil and the lack of suitable outlets in many areas. Locating satisfactory outlets for a tile drainage system also is difficult in some areas of very poorly drained soils, such as Blue Earth, Boots, Houghton, Muskego, and Palms soils, and in many areas of the poorly drained Colo and Darfur soils. Adequate outlets generally are more readily available in areas of the other poorly drained soils. In many of these areas, measures that improve drainage are needed.

Organic soils oxidize and subside when their pore space is filled with air. A drainage system that keeps the water table at the level required by the crops during the growing season and raises it to the surface during other parts of the year minimizes the oxidation and subsidence of these soils. This kind of drainage system generally has not been installed in the organic soils in the county. As a result, a few years after it is installed, the tile is too shallow for satisfactory drainage in some areas.

Further information about the design and application of erosion-control practices and drainage systems is available at the local office of the Soil Conservation Service.

Soil fertility is affected by the supply of available phosphorus and potassium in the subsoil, by reaction, and by the content of organic matter. The supply of available phosphorus is low or very low in most of the soils in the county. Most of the soils west of the Winnebago River are slightly acid to moderately alkaline in the subsoil. East of the river, however, many of the soils range to medium acid in the subsoil. These are mainly the soils that formed in areas where the native vegetation was trees or mixed trees and grasses. On these soils and on many other soils in the county, applications of ground limestone are needed to raise the pH level sufficiently for crops, particularly alfalfa, to grow well.

Many soils in Winnebago County have excess carbonates in the surface layer and subsoil. Examples are Blue Earth, Canisteo, Crippin, Harps, Mayer, Salida, and Storden soils. The high pH level of these soils, particularly Harps soils, reduces the supply of available phosphorus, potassium, and some micronutrients.

The amount of nitrogen available to plants is related to the content of organic matter. In Winnebago County most of the well drained and somewhat poorly drained upland soils that formed under a native vegetation of prairie grasses, such as Clarion and Nicollet soils, have a moderate or high content of organic matter. The content generally is very low, however, in Storden soils. It is very high in the very poorly drained Boots, Blue Earth, Houghton, Palms, and Muskego soils and in some areas of the very poorly drained Okoboji soils and is high in the poorly drained soils.

The well drained or somewhat poorly drained Hayden, Lester, and Le Sueur soils and other soils that formed under a native vegetation of trees or mixed trees and grasses have a low or moderate content of organic matter. They generally have a lower content than the soils that formed under a native vegetation of prairie grasses. In eroded areas the content of organic matter generally is very low. It generally is low or very low in moderately coarse textured soils, such as Salida, Ridgeport, and Dickman soils, but is moderate in Dickinson soils.

Darfur, Dickinson, Dickman, Hanska, Linder, Mayer, Ridgeport, Salida, and Wapsie soils have a limited available water capacity. The other soils in the county, however, have a high or very high available water capacity and generally are very productive if the proper kinds and amounts of fertilizer are applied.

Applications of herbicide are affected by the content of organic matter, the pH level, carbonates, and texture. Applications of lime and fertilizer should be based on the results of soil tests, on the needs of the crops, and on the expected level of yields. The Cooperative Extension Service can help in determining the kinds and amounts of fertilizer, herbicide, and lime to be applied.

Tilth is an important factor affecting the germination of seeds, the infiltration of water into the soil, and the ease of preparing a good seedbed. Soils in which tilth is good are granular, generally are high in content of organic matter, and are porous.

Many of the well drained and somewhat poorly drained soils that are intensively row cropped have a loam surface layer. Examples are Clarion and Nicollet soils. The lighter colored Hayden and Lester soils also have a loam surface layer, but this layer is lower in content of organic matter than that of the Clarion and Nicollet soils, has a weaker structure, and is more likely to form a crust during periods of intense rainfall. The crust is hard when dry. It reduces the rate of water infiltration and increases the rate of runoff. In other soils, such as Storden, the content of organic matter also is low or very low and tilth is poor. Rainfall readily runs off the surface of these soils, causing erosion. Regular additions of crop residue, manure, and other organic material improve soil structure and help to prevent excessive crusting. Including legumes and grasses in the cropping sequence improves tilth and reduces the susceptibility to erosion.

Tilth is somewhat poorer in the finer textured, well drained soils, such as Kilkenny and Vinje soils, than in medium textured, well drained soils. The finer textured soils generally are sticky when wet and hard and cloddy when dry. Careful management and timely fieldwork are needed to obtain a good seedbed. Regular additions of organic material, such as crop residue and manure, and a cropping sequence that includes grasses and legumes improve tilth and help to control erosion.

Preparing a good seedbed is somewhat difficult on Collinwood and Shorewood soils and on the poorly drained Waldorf and Minnetonka soils. All of these soils have a high content of clay in the surface layer. Fall plowing is common on these soils. Freezing and thawing improve tilth on soils that have been plowed in the fall. A good seedbed is more easily prepared in fall-plowed soils than in soils that are plowed in the spring. If large areas are fall plowed, however, soil blowing can be a problem as the soil dries in the spring. It can be controlled by leaving alternating protective strips or by leaving crop residue on the surface or mixing it into the surface layer. Chisel plowing also is effective in controlling soil blowing. These soils are well suited to ridge planting.

Permanent pasture in the county generally is planted to bluegrass, but many pastured areas also support trees and brush. Some have been renovated and are planted to legume-grass mixtures, such as alfalfa and bromegrass. Most of the pastures are not used as cropland because the soils are too steep or too wet for cultivation, are frequently flooded, or support trees.

Forage production can be increased by renovating the pasture, which helps to establish the more productive grasses and legumes, and by planting warm-season grasses, including switchgrass, big bluestem, and indiangrass. Improved drainage is needed in many areas. Brush and trees should be removed or thinned in some areas.

The management needed on established stands includes applications of fertilizer, control of weeds and brush, rotation and deferred grazing in a full-season grazing system, proper stocking rates, and adequate livestock watering facilities. If the protective plant cover is destroyed when pasture or hayland is renovated, erosion is a serious hazard in the steeper areas. If cultivated crops are grown prior to reseeding, contour farming, grassed waterways, and no-till planting or other systems of conservation tillage that leave crop residue on the surface are needed to control erosion. Interseeding grasses and legumes into the existing sod eliminates the need for destroying the plant cover during seedbed preparation.

Field crops suited to the soils and climate in the county include many that are not commonly grown. The main crops are corn and soybeans. Grain sorghum, sunflowers, sugar beets, sweet corn, popcorn, and canning peas are among the crops that can be grown if economic and other conditions are favorable. Oats is the most common close-growing crop. Wheat, barley, rye, and flax could be grown. A variety of forage crops could also be grown, and seed could be produced from these crops.

Specialty crops are not commonly grown in the county, but a small acreage is used for sweet corn or canning peas. Sunflowers are periodically grown in some areas. Most of the upland soils are suited to a variety of specialty crops, such as orchards. Some of the organic soils are suited to potatoes.

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 land capability classification of each map unit also is shown in the table.

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 ensures 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 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, woodland, wildlife habitat, or recreation.

The capability classification of each map unit is given in the section "Detailed Soil Map Units" and in the yields table.

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 ensure plant survival, a healthy planting stock of suitable species should be planted properly on a well prepared site and maintained in good condition.

Table 7 shows the height that locally grown trees and shrubs are expected to reach in 20 years on various soils. The estimates in table 7 are based on measurements and observation of established plantings that have been given adequate care. They can be used as a guide in planning windbreaks and screens.

Additional information on planning windbreaks and screens and planting and caring for trees and shrubs can be obtained from local offices of the Soil Conservation Service or the Cooperative Extension Service or from a commercial nursery.

Recreation

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

In table 8, the degree of soil limitation is expressed as slight, moderate, or severe. *Slight* means that soil properties are generally favorable and that limitations are minor and easily overcome. *Moderate* means that limitations can be overcome or alleviated by planning, design, or special maintenance. *Severe* means that soil properties are unfavorable and that limitations can be offset only by costly soil reclamation, special design, intensive maintenance, limited use, or by a combination of these measures.

The information in table 8 can be supplemented by other information in this survey, for example, interpretations for septic tank absorption fields in table 11 and interpretations for dwellings without basements and for local roads and streets in table 10.

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

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

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

Winnebago County has a large and varied population of wildlife. White-tailed deer, squirrels, ring-necked pheasant, Hungarian partridge, and various species of waterfowl are the chief game species in the county. Teal and wood ducks are the main waterfowl. Fishing generally is limited to gravel pits, the Winnebago River, and Rice Lake. Smallmouth bass, catfish, northern pike, bullheads, and sunfish are the main species.

The habitat for waterfowl in the county formerly was excellent. Intensive farming and the installation of drainage systems in many small sloughs and potholes have reduced the extent of this habitat. Many large depressions in the eastern part of the county provided excellent habitat, but most of these have been drained. Many migratory ducks and geese continue to rest and feed each fall on the remaining wetlands, particularly Myre Slough, Lake Harmon, and Rice Lake. In areas around Rice Lake, Canada geese have been reintroduced and many nest on nearby wetlands.

Most of the white-tailed deer and squirrels are in the wooded areas, but many squirrels are around farmsteads and some deer are attracted to brushy areas near drainage ditches, along small streams, and in marshes. Cottontail rabbit, red fox, mink, beaver, muskrat, and raccoon find food and cover in various parts of the county. Among the common songbirds are robins, English sparrows, meadowlarks, blackbirds, mourning doves, purple martins, wrens, chickadees, brown thrashers, swallows, orioles, woodpeckers, and starlings.

Introduced ring-necked pheasant and Hungarian partridge have adapted well to the county. The numbers of these species vary from year to year, depending on the amount of nesting cover and on weather conditions. A lack of cover in winter and at nesting time and severe weather at nesting time greatly reduce the number of pheasants. The best pheasant range is probably in areas of soil associations 3, 4, and 5, which are described under the heading "General Soil Map Units." The more desirable cover is available on the steeply sloping soils in these associations. Some areas include or are adjacent to wet marshes that provide the needed winter cover. Nesting areas are along the edges of fields.

Pheasants are somewhat less abundant in areas of the other associations in the county. Many of the soils in these associations are nearly level or gently sloping, and much of the acreage is farmed intensively. Consequently, little food or cover is available for the pheasants in winter and the number of nesting sites is limited.

Nesting cover is the most critical factor affecting the number of pheasants. The best nesting sites in intensively farmed areas are in road ditches and along fence lines. Only a few of these sites are available in the intensively farmed areas in the county. As a result, the pheasant population is limited in these areas. It can be significantly increased if the plant cover in ditches and along fence lines is left unclipped until early summer.

Winter cover can be provided by farmstead windbreaks and plantings that enhance the wildlife habitat. The cover should be near a source of food. Leaving a few rows of grain in a field adjacent to a windbreak or wildlife planting helps to provide food.

Small, odd-shaped areas that are unsuitable for farming can provide excellent wildlife habitat. These areas are most likely to occur in associations 3 through 7. The other associations also may have areas that are well suited to wildlife habitat, including small, steep, severely eroded, or gravelly areas of cropland; small gravel pits; railroad right-of-ways; and tracts isolated by a stream or drainage ditch.

The type of existing cover and the location of the odd-shaped areas determine whether or not any additional vegetation should be established. In many of these small areas, the only measures needed to develop wildlife habitat are those that protect the habitat from fire or grazing. In other areas planting and measures that maintain the habitat may be necessary. A satisfactory wildlife habitat consists of low-growing plant cover, such as locally adapted grasses and legumes, which provide nesting sites and some food; a taller cover of grasses and shrubs, which provide refuge and resting areas; and clumps of evergreens and shrubs, which provide the best winter cover.

Measures that maintain the wildlife habitat are needed in many areas. Deferment of mowing before mid-summer helps to protect ground-nesting birds and rabbits. Control of invading woody plants by chemical or mechanical means helps to maintain an adequate cover of grasses and legumes. Reseeding is occasionally needed. Further information about planning wildlife areas can be obtained from the Soil Conservation Service or the wildlife management biologist of the Iowa Conservation Commission.

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

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

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

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

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

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

Shallow excavations are trenches or holes dug to a maximum depth of 5 or 6 feet for basements, graves, utility lines, open ditches, and other purposes. The ratings are based on soil properties, site features, and observed performance of the soils. The ease of digging, filling, and compacting is affected by the depth to bedrock 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, slope, 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 11 shows the degree and kind of soil limitations that affect septic tank absorption fields, sewage lagoons, and sanitary landfills. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increases in construction costs, and possibly increased maintenance are required.

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

Septic tank absorption fields are areas in which effluent from a septic tank is distributed into the soil through subsurface tiles or perforated pipe. Only that part of the soil between depths of 24 and 72 inches is evaluated. The ratings are based on soil properties, site features, and observed performance of the soils.

Permeability, a high water table, depth to bedrock, 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 11 gives ratings for the natural soil that makes up the lagoon floor. The surface layer and, generally, 1 or 2 feet of soil material below the surface layer are excavated to provide material for the embankments. The ratings are based on soil properties, site features, and observed performance of the soils. Considered in the ratings are slope, permeability, a high water table, depth to bedrock, 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 11 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 12 gives information about the soils as a source of roadfill, sand, gravel, and topsoil. The soils are rated *good, fair,* or *poor* as a source of roadfill and topsoil. They are rated as a *probable* or *improbable* source of sand and gravel. The ratings are based on soil properties and site features that affect the removal of the soil and its use as construction material. Normal compaction, minor processing, and other standard construction practices are assumed. Each soil is evaluated to a depth of 5 or 6 feet.

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

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

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

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

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

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

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

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

Plant growth is affected by 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 or stones, or soils that have slopes of 8 to 15 percent. The soils are not so wet that excavation is difficult.

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

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

Water Management

Table 13 gives information on the soil properties and site features that affect water management. The degree and kind of soil limitations are given for pond reservoir areas; embankments, dikes, and levees; and aquifer-fed excavated ponds. 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, 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.

Aquifer-fed excavated ponds are pits or dugouts that extend to a ground-water aquifer or to a depth below a permanent water table. Excluded are ponds that are fed only by surface runoff and embankment ponds that impound water 3 feet or more above the original surface. Excavated ponds are affected by depth to a permanent water table, permeability of the aquifer, and quality of the water as inferred from the salinity of the soil. Depth to bedrock and the content of large stones affect the ease of excavation.

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 calcium carbonates. Availability of drainage outlets is not considered in the ratings.

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.

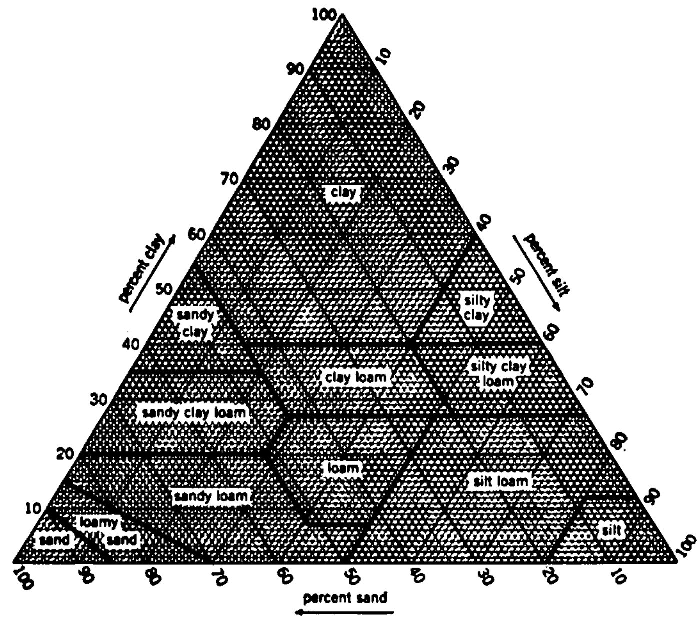

Figure 12.—Percentages of clay, silt, and sand in the basic USDA soil textural classes.

Engineering Index Properties

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

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

Texture is given in the standard terms used by the U.S. Department of Agriculture. These terms are defined according to percentages of sand, silt, and clay in the fraction of the soil that is less than 2 millimeters in diameter (fig. 12). "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, CL-ML.

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.

The estimates of grain-size distribution, liquid limit, and plasticity index are generally rounded to the nearest 5 percent. Thus, if the ranges of gradation and Atterberg limits extend a marginal amount (1 or 2 percentage points) across classification boundaries, the classification in the marginal zone is omitted in the table.

Physical and Chemical Properties

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

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

The amount and kind of clay greatly affect the fertility and physical condition of the soil. They determine the ability of the soil to adsorb cations and to retain moisture. They influence shrink-swell potential, permeability, and plasticity, the ease of soil dispersion, and other soil properties. The amount and kind of clay in a soil also affect tillage and 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. 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 20 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 20 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.

Soil and Water Features

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

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

The four hydrologic soil groups are:

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

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

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

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

If a soil is assigned to two hydrologic groups in table 16, 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 16 gives the frequency and duration of flooding and the time of year when flooding is most likely.

Frequency, duration, and probable dates of occurrence are estimated. Frequency is expressed as none, rare, occasional, and frequent. *None* means that flooding is not probable; *rare* that it is unlikely but possible under unusual weather conditions; *occasional* that it occurs, on 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 16 are the depth to the seasonal high water table; the kind of water table—that is, perched or apparent; and the months of the year that the water table commonly is high. A water table that is seasonally high for less than 1 month is not indicated in table 16.

An *apparent* water table is a thick zone of free water in the soil. It is indicated by the level at which water stands in an uncased borehole after adequate time is allowed for adjustment in the surrounding soil. A *perched* water table is water standing above an unsaturated zone. In places an upper, or perched, water table is separated from a lower one by a dry zone.

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

Potential frost action is the likelihood of upward or lateral expansion of the soil caused by the formation of segregated ice lenses (frost heave) and the subsequent collapse of the soil and loss of strength on thawing. Frost action occurs when moisture moves into the freezing zone of the soil. Temperature, texture, density, permeability, content of organic matter, and depth to the water table are the most important factors considered in evaluating the potential for frost action. It is assumed that the soil is not insulated by vegetation or snow and is not artificially drained. Silty and highly structured clayey soils that have a high water table in winter are 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 (*30*). 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 17 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. 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* (*29*). Many of the technical terms used in the descriptions are defined in *Soil Taxonomy* (*30*). 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."

Blue Earth Series

The Blue Earth series consists of very poorly drained, moderately permeable soils in depressions and old, shallow lakebeds in the uplands. These soils formed in coprogenous earth. The native vegetation was grasses and sedges. Slopes are 0 to 1 percent.

Typical pedon of Blue Earth mucky silt loam, 0 to 1 percent slopes; 25 feet east and 45 feet south of the northwest corner of sec. 35, T. 99 N., R. 23 W.

Ap—0 to 8 inches; very dark gray (10YR 3/1) mucky silt loam (coprogenous earth), gray (10YR 5/1) dry; weak fine granular structure; very friable; few fine roots; many snail shell fragments; few faint reddish brown (5YR 4/4) organic stains; about 3 percent plant fibers; compaction resembling medium and coarse platy structure in the lower part; strong effervescence; moderately alkaline; abrupt smooth boundary.

C1—8 to 15 inches; very dark gray (10YR 3/1) mucky silt loam (coprogenous earth), gray (10YR 5/1) dry; weak medium granular structure; very friable; many snail shell fragments; common fine plant fibers that disappear if rubbed; common faint dark reddish brown (5YR 3/3) and reddish brown (5YR 4/4) organic stains, mostly along and in old root pores; few clear bleached sand grains; strong effervescence; moderately alkaline; clear smooth boundary.

C2—15 to 27 inches; black (10YR 2/1) mucky silt loam (coprogenous earth), dark gray (10YR 4/1) and gray (10YR 5/1) dry; weak medium granular structure; very friable; many snail shell fragments; common fine plant fibers that disappear if rubbed; few dark reddish brown (5YR 3/3) and reddish brown (5YR 4/4) stains and partly decomposed plant fibers; few clear bleached sand grains; strong effervescence; moderately alkaline; clear smooth boundary.

C3—27 to 34 inches; very dark gray (10YR 3/1) mucky silt loam (coprogenous earth), dark gray (10YR 4/1) and gray (10YR 5/1) dry; massive; very friable; common snail shell fragments; common fine plant fibers that generally disappear if rubbed; few dark reddish brown (5YR 3/3) and reddish brown (5YR 4/4) stains and partly decomposed plant fibers; strong effervescence; moderately alkaline; clear smooth boundary.

C4—34 to 60 inches; black (10YR 2/1) mucky silt loam (coprogenous earth); massive; very friable; common snail shell fragments; common fine plant fibers that generally disappear if rubbed; few dark reddish brown (5YR 3/3) and reddish brown (5YR 4/4) stains and partly decomposed plant fibers; a horizontal band of very dark gray (10YR 3/1) very fine sand and snail shell fragments between depths of 48 and 50 inches; strong effervescence; moderately alkaline.

The thickness of the coprogenous earth over glacial till or lacustrine sediments ranges from 30 to more than 60 inches. The coprogenous earth 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). In most pedons a few partly decomposed plant fibers are at the surface and below the plow layer. The organic matter content commonly is between 10 and 30 percent. Reddish brown or dark reddish brown organic stains or mottles are common.

Some pedons have a 2C horizon. This horizon is very dark grayish brown (2.5Y 3/2) to olive gray (5Y 5/2). It typically is silty clay loam, loam, or clay loam, but it has thin layers of sandy material in some pedons. Olive (5Y 5/3 and 5/4) mottles are common.

Boots Series

The Boots series consists of very poorly drained, moderately rapidly permeable soils in large depressions on till plains and glacial moraines. These soils formed in herbaceous organic deposits more than 51 inches thick. The native vegetation was water-tolerant sedges, reeds, and grasses. Slopes are 0 to 1 percent.

Typical pedon of Boots muck, 0 to 1 percent slopes; 2,490 feet north and 40 feet west of the southeast corner of sec. 24, T. 99 N., R. 23 W.

Op—0 to 7 inches; black (5YR 2/1) sapric material, dark reddish brown (5YR 2/2) rubbed; about 15 percent fiber, 8 percent rubbed; massive; very friable; neutral; abrupt smooth boundary.

Oe—7 to 52 inches; dark reddish brown (5YR 2/2) hemic material, dark reddish brown (5YR 3/2) rubbed; about 70 percent fiber, 20 percent rubbed; massive; very friable; neutral; clear smooth boundary.

Oa—52 to 60 inches; black (5YR 2/1) sapric material, dark reddish brown (5YR 2/2) rubbed; about 25 percent fiber, 10 percent rubbed; massive; very friable; slightly acid.

The organic material is more than 51 inches thick. It is commonly neutral or slightly acid. It has hue of 10YR, 7.5YR, or 5YR, value of 2 or 3, and chroma of 1 to 3. The Op horizon is primarily sapric material, but in some pedons it is hemic. In some pedons layers of sapric material are within the Oe horizon. Their total thickness is less than 10 inches.

Canisteo Series

The Canisteo series consists of poorly drained, moderately permeable soils in the uplands. These soils formed in calcareous glacial till or in sediments derived from glacial till. The native vegetation was prairie grasses. Slopes range from 0 to 2 percent.

Typical pedon of Canisteo clay loam, 0 to 2 percent slopes; 25 feet north and 2,580 feet west of the southeast corner of sec. 15, T. 98 N., R. 26 W.

Ap—0 to 8 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; few fine roots; slight effervescence; mildly alkaline; abrupt smooth boundary.

A1—8 to 14 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; few very dark gray (10YR 3/1) coatings on faces of peds; weak fine subangular blocky structure parting to weak fine granular; friable; few fine roots; strong effervescence; mildly alkaline; clear smooth boundary.

A2—14 to 21 inches; black (10YR 2/1) and very dark gray (10YR 3/1) clay loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; common fine distinct olive gray (5Y 4/2) mottles; weak fine and medium subangular blocky structure parting to weak fine granular; friable; few fine roots; few fine tubular pores; strong effervescence; mildly alkaline; clear smooth boundary.

Bg1—21 to 29 inches; 75 percent olive gray (5Y 5/2) and 25 percent dark gray (5Y 4/1) clay loam; common fine faint olive (5Y 5/3) mottles; weak fine and medium subangular blocky structure; friable; few fine roots; few fine tubular pores; common fine soft rounded masses of calcium carbonate; strong effervescence; moderately alkaline; clear smooth boundary.

Bg2—29 to 46 inches; olive gray (5Y 5/2) clay loam; common fine distinct yellowish brown (10YR 5/8) and light olive brown (2.5Y 5/6) mottles; weak medium subangular blocky structure; friable; few fine tubular pores; few very fine black (10YR 2/1) and reddish brown (5YR 4/3) concretions (manganese and iron oxides); few fine soft powdery masses of calcium carbonate; violent effervescence; moderately alkaline; gradual smooth boundary.

Cg—46 to 60 inches; olive gray (5Y 5/2) loam; many fine and medium distinct yellowish brown (10YR 5/8) mottles; massive; friable; few fine tubular pores; few fine black (10YR 2/1) and strong brown (7.5YR 5/6) concretions (manganese and iron oxides); few fine soft rounded masses of calcium carbonate; violent effervescence; moderately alkaline.

The solum ranges from 20 to 50 inches in thickness. Carbonates are throughout the profile.

The Ap or A1 horizon is black (N 2/0 or 10YR 2/1). The A2 horizon is black (10YR 2/1) or very dark gray (N 3/0, 10YR 3/1, or 5Y 3/1). The A horizon is clay loam or silty clay loam. It has a moderate content of sand. It ranges from about 14 to 24 inches in thickness. Value of 3 extends below a depth of 24 inches only in discontinuous coatings. The Bg horizon typically has hue of 5Y, but some pedons have hue of 2.5Y. This horizon has value of 4 or 5 and chroma of 1 or 2. It typically is clay loam, but in some pedons it is silty clay loam that has a moderate content of sand. The Cg 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.

Clarion Series

The Clarion series consists of well drained, moderately permeable soils on knolls, undulating ridgetops, and side slopes in the uplands. These soils formed in glacial till. The native vegetation was prairie grasses. Slopes range from 2 to 18 percent.

Typical pedon of Clarion loam, 2 to 5 percent slopes; 1,110 feet east and 600 feet south of the northwest corner of sec. 6, T. 98 N., R. 26 W.

Ap—0 to 10 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine and medium granular structure; friable; few fine roots; slightly acid; clear smooth boundary.

A—10 to 17 inches; black (10YR 2/1) and very dark grayish brown (10YR 3/2) loam, very dark gray (10YR 3/1) and brown (10YR 4/3) dry; mixed with dark brown (10YR 3/3) streaks and pockets in the lower part; weak fine subangular blocky structure parting to weak fine medium granular; few fine roots; neutral; clear smooth boundary.

Bw1—17 to 23 inches; dark brown (10YR 3/3) and dark yellowish brown (10YR 4/4) loam; some very dark grayish brown (10YR 3/2) in the upper part; weak fine subangular blocky structure; friable; few fine roots; neutral; clear smooth boundary.

Bw2—23 to 30 inches; brown (10YR 4/3) and dark yellowish brown (10YR 4/4) loam; weak fine subangular blocky structure; friable; few fine roots; few very fine reddish brown (5YR 4/4) concretions (iron oxide); few small pebbles and shale fragments; neutral; clear smooth boundary.

C1—30 to 38 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) loam; few fine faint brownish yellow (10YR 6/8) mottles in the upper part, increasing to common in the lower part; massive; friable; few very fine dark reddish brown (5YR 3/4) and common fine black (10YR 2/1) concretions (iron and manganese oxides); common fine soft rounded masses of calcium carbonate; few small pebbles and shale fragments; strong effervescence; mildly alkaline; gradual smooth boundary.

C2—38 to 50 inches; yellowish brown (10YR 5/4) loam; few fine prominent strong brown (7.5YR 5/8) and few fine faint brownish yellow (10YR 6/8) mottles; massive; friable; few very fine dark reddish brown (5YR 3/4), strong brown (7.5YR 5/6), and black (10YR 2/1) concretions (iron and manganese oxides); common fine soft rounded masses of calcium carbonate; few fine pebbles and shale fragments; violent effervescence; mildly alkaline; gradual smooth boundary.

C3—50 to 60 inches; yellowish brown (10YR 5/4) loam; common fine faint brownish yellow (10YR 6/8) mottles; massive; friable; few fine dark reddish brown (5YR 3/4) and common fine black (10YR 2/1) concretions (iron and manganese oxides); common fine soft rounded masses of calcium carbonate; few small pebbles and shale fragments; strong effervescence; mildly alkaline.

The thickness of the solum ranges from 18 to 50 inches. The depth to carbonates generally is from 18 to 40 inches but ranges to about 50 inches.

The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), or very dark grayish brown (10YR 3/2). Unless eroded, it is 10 to 18 inches thick. The Bw horizon typically is brown (10YR 4/3) and dark yellowish brown (10YR 4/4). In many pedons, however, it includes dark brown (10YR 3/3) in the upper part and yellowish brown (10YR 5/4) in the lower part. It typically is loam, but in some pedons it is clay loam in the upper part and in others it is sandy loam in the lower part. It is 10 to 30 inches thick and commonly extends into calcareous material. The C horizon has hue of 2.5Y or 10YR, value of 4 or 5, and chroma of 4 to 6.

Coland Series

The Coland series consists of poorly drained, moderately permeable soils on bottom land. These soils formed in loamy alluvium. The native vegetation was water-tolerant grasses. Slopes range from 0 to 5 percent.

Typical pedon of Coland clay loam, 0 to 2 percent slopes; 260 feet west and 1,940 feet north of the southeast corner of sec. 14, T. 98 N., R. 23 W.

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

A1—9 to 22 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure parting to weak fine and medium granular; friable; neutral; gradual smooth boundary.

A2—22 to 35 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak fine and medium subangular blocky structure parting to weak fine and medium granular; friable; common fine tubular pores; neutral; gradual smooth boundary.

A3—35 to 44 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak fine and medium subangular blocky structure parting to weak fine and medium granular; friable; few fine tubular pores; neutral; gradual smooth boundary.

AC—44 to 48 inches; black (10YR 2/1) and very dark gray (10YR 3/1) clay loam, dark gray (10YR 4/1) and gray (10YR 5/1) dry; common medium distinct grayish brown (2.5Y 5/2), few fine faint very dark grayish brown (2.5Y 3/2), and few fine prominent strong brown (7.5YR 5/8) mottles; weak medium and fine subangular blocky structure; friable; common fine reddish brown (5YR 4/4) concretions (iron oxide) in the lower part; neutral; clear wavy boundary.

Cg—48 to 60 inches; black (N 2/0), very dark gray (5Y 3/1), and gray (5Y 5/1) stratified sandy loam and clay loam; common fine prominent yellowish red (5YR 5/8) and medium faint olive (5Y 5/3) mottles; massive; friable; common reddish brown (5YR 4/4) concretions (iron oxide); neutral.

The solum ranges from 36 to 48 inches in thickness. Free carbonates commonly do not occur in the solum but are in the substratum of some pedons.

The A horizon commonly is black (N 2/0 or 10YR 2/1) but in some pedons is very dark gray (N 3/0 or 10YR 3/1) in the lower part. The clay content in this horizon ranges from about 30 to 35 percent. The AC horizon has hue of 10YR to 5Y or is neutral in hue. It has value of 2 to 4 and chroma of 0 or 1. Some pedons have a Bg horizon instead of an AC horizon. The Bg horizon has colors and textures that are similar to those of the AC horizon. The Cg horizon has hue of 2.5Y or 5Y or is neutral in hue. It has value of 2 to 5 and chroma of 0 or 1. Mottles and oxide concretions are common. This horizon is dominantly loam or clay loam but has strata of sandy loam or loamy sand.

Coland clay loam, 2 to 5 percent slopes, is a taxadjunct to the Coland series because it is somewhat poorly drained and has slightly more clay in the control section than is definitive for the series.

Collinwood Series

The Collinwood series consists of somewhat poorly drained, slowly permeable soils on plane or slightly concave slopes in the uplands. These soils formed in clayey and silty glaciolacustrine sediments 4 to 8 feet deep over glacial till (fig. 13). The native vegetation was prairie grasses. Slopes range from 0 to 5 percent.

Typical pedon of Collinwood silty clay loam, 0 to 2 percent slopes; 450 feet east and 2,620 feet south of the northwest corner of sec. 28, T. 99 N., R. 23 W.

Ap—0 to 8 inches; black (10YR 2/1) silty clay loam (36 percent clay), very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; fine and very fine subangular blocky structure; firm; many fine roots; medium acid; abrupt smooth boundary.

A—8 to 19 inches; black (10YR 2/1) silty clay loam (33 percent clay), very dark gray (10YR 3/1) dry; moderate fine and medium granular structure; firm; common fine roots; neutral; gradual smooth boundary.

BA—19 to 26 inches; dark grayish brown (2.5Y 4/2) silty clay (40 percent clay); mixed with black (10YR 2/1) and very dark gray (10YR 3/1) streaks and pockets in the upper part; moderate fine and medium granular structure in the upper part and some moderate fine and very fine subangular blocky structure in the lower part; firm; few fine roots; neutral; clear smooth boundary.

Bw1—26 to 34 inches; dark grayish brown (2.5Y 4/2) silty clay (40 percent clay); weak medium prismatic structure parting to moderate fine and very fine

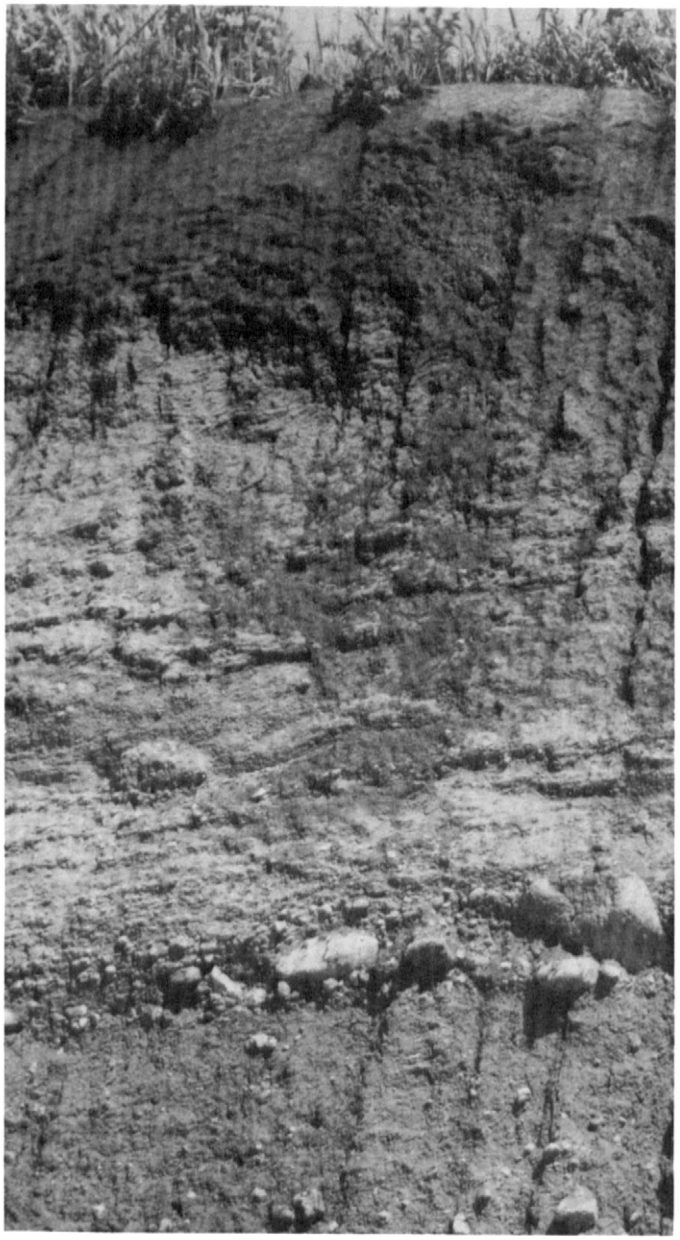

Figure 13.—Typical profile of Collinwood silty clay loam. The depth to a pebble band is about 5 feet.

angular and subangular blocky; firm; few fine tubular pores; thin discontinuous very dark grayish brown (2.5Y 3/2) clay films; few black (N 2/0) fillings in root channels; common fine yellowish brown (10YR 5/6) concretions (iron and manganese oxides); neutral; gradual smooth boundary.

Bw2—34 to 40 inches; dark grayish brown (2.5Y 4/2) and grayish brown (2.5Y 5/2) silty clay (42 percent clay); common fine prominent yellowish brown (10YR 5/6) mottles; weak medium prismatic structure parting to weak fine and medium angular and subangular blocky; firm; thin to thick patchy clay films on faces of peds; few fine tubular pores; few fine black (10YR 2/1) concretions (manganese oxide); mildly alkaline; gradual smooth boundary.

C1—40 to 49 inches; grayish brown (2.5Y 5/2) silty clay loam (33 percent clay); common fine prominent yellowish brown (10YR 5/6 and 5/8) mottles; weak medium prismatic structure; firm; few fine tubular pores; few fine black (10YR 2/1) concretions (manganese oxide); few thin threadlike streaks of calcium carbonate; slight effervescence; mildly alkaline; gradual smooth boundary.

C2—49 to 60 inches; grayish brown (2.5Y 5/2) silty clay loam (32 percent clay); olive gray (5Y 5/2) faces on cleavage planes in the lower part; common fine prominent strong brown (7.5YR 5/8) mottles; massive; firm; few fine tubular pores; common fine black (10YR 2/1) concretions (manganese oxide); common thin threadlike streaks of calcium carbonate; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 24 to 48 inches. The mollic epipedon is 14 to 24 inches thick.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1. It typically is silty clay loam, but silty clay is within the range. The content of clay in this horizon ranges from 35 to 42 percent. The Bw horizon has hue of 10YR or 2.5Y in the upper part and 2.5Y in the lower part, has value of 3 to 5 throughout, and has chroma of 2 in the upper part and 2 to 4 in the lower part. Faces of peds commonly have value of 2 or 3 and chroma of 1 or 2. This horizon is silty clay, clay, or silty clay loam. It has a clay content of about 38 to 45 percent. The C horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 2 to 4. It typically is silty clay loam, silty clay, or clay, but silt loam is in the lower part of some pedons. The content of clay in this horizon ranges from about 32 to 45 percent.

Colo Series

The Colo series consists of poorly drained, moderately permeable soils on bottom land and in upland drainageways. These soils formed in silty alluvium. The native vegetation was water-tolerant prairie grasses. Slopes range from 0 to 2 percent.

Typical pedon of Colo silty clay loam, channeled, 0 to 2 percent slopes; 1,180 feet north and 65 feet west of the southeast corner of sec. 11, T. 98 N., R. 24 W.

A1—0 to 12 inches; black (N 2/0) silty clay loam, very dark gray (N 3/0) dry; moderate fine granular structure; friable; neutral; gradual smooth boundary.

A2—12 to 26 inches; black (N 2/0) silty clay loam, very dark gray (N 3/0) dry; weak fine granular structure; friable; neutral; clear smooth boundary.

A3—26 to 40 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; weak fine subangular blocky structure; friable; neutral; clear smooth boundary.

A4—40 to 47 inches; very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) kneaded, gray (10YR 5/1) dry; black (10YR 2/1) coatings on faces of peds; weak fine subangular blocky structure; friable; common dark reddish brown (5YR 2/2) concretions (iron oxide); neutral; clear smooth boundary.

Cg—47 to 60 inches; dark gray (10YR 4/1) silty clay loam; very dark gray (10YR 3/1) coatings on faces of peds; few fine distinct mottles, brown (7.5YR 4/4) dry; massive; friable; common dark reddish brown (5YR 2/2) concretions (iron oxide); neutral.

The solum ranges from 36 to 54 inches in thickness. The mollic epipedon is 36 or more inches thick.

The A horizon typically is black (N 2/0 or 10YR 2/1) or very dark gray (10YR 3/1). It is 24 to 50 inches thick. It is silty clay loam in which the clay content ranges from 27 to 35 percent. An AC or Bg horizon is below a depth of 36 inches in some pedons. These horizons are very dark gray (10YR or 5Y 3/1) or dark gray (10YR or 5Y 4/1). Strong brown (7.5YR 5/6), dark brown (10YR 3/3), or yellowish brown (10YR 5/4) mottles are below a depth of 36 inches in some pedons. The Bg horizon generally is silty clay loam, but clay loam also occurs. Some pedons have sandy clay loam, sandy loam, or sand below a depth of 50 inches.

Cordova Series

The Cordova series consists of poorly drained, moderately slowly permeable soils that formed in loamy glacial till on ground moraines and till plains. These soils are in swales or upland drainageways and in low, slightly concave areas on broad flats. The native vegetation was deciduous trees, prairie grasses, and sedges. Slopes range from 0 to 2 percent.

Typical pedon of Cordova loam, 0 to 2 percent slopes; 1,300 feet north and 100 feet east of the southwest corner of sec. 22, T. 98 N., R. 23 W.

A1—0 to 6 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; black (N 2/0) coatings on faces of peds; weak fine and medium granular and subangular blocky structure; friable; few bleached silt coatings, light brownish gray (10YR 6/2) dry; neutral; clear smooth boundary.

A2—6 to 15 inches; black (10YR 2/1) clay loam, dark gray (10YR 4/1) and very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; weak fine subangular blocky structure parting to weak fine granular; friable; common silt coatings on faces of peds, light gray (10YR 7/1) dry; neutral; clear smooth boundary.

A3—15 to 21 inches; very dark gray (10YR 3/1) clay loam, dark gray (10YR 4/1) and dark grayish brown (10YR 4/2) dry; some black (10YR 2/1) coatings on faces of peds; weak fine and medium subangular blocky structure; friable; common silt coatings on faces of peds, gray (10YR 6/1) dry; few brown (7.5YR 4/4) concretions (iron and manganese oxides); slightly acid; clear smooth boundary.

Btg1—21 to 29 inches; dark grayish brown (2.5Y 4/2) clay loam; very dark gray (10YR 3/1) and black (10YR 2/1) coatings on faces of peds; common fine distinct light olive brown (2.5Y 5/6) mottles; weak coarse prismatic structure parting to weak fine and medium subangular blocky; friable; thin or medium black (10YR 2/1) and very dark gray (10YR 3/1) clay films on faces of peds; common tubular pores; few brown (7.5YR 4/4) concretions (iron and manganese oxides); slightly acid; clear smooth boundary.

Btg2—29 to 39 inches; olive gray (5Y 5/2) clay loam; common fine prominent strong brown (7.5YR 5/6) and common fine distinct light olive brown (2.5Y 5/6) mottles; weak coarse prismatic structure parting to weak medium subangular blocky; friable; common thin to thick patchy very dark grayish brown (2.5Y 3/2) and black (10YR 2/1) clay films on faces of prisms; common black (N 2/0 and 10YR 2/1) clay fillings in pores and root channels; common fine black (10YR 2/1) and dark brown (7.5YR 3/2) concretions (manganese and iron oxides); neutral; clear smooth boundary.

BCg—39 to 48 inches; olive gray (5Y 5/2) clay loam; many fine prominent strong brown (7.5YR 5/6 and 5/8) mottles; weak coarse prismatic structure; friable; few very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) clay films in the upper part; few tubular pores; common fine black (10YR 2/1) and yellowish red (5YR 5/6 and 5/8) concretions (manganese and iron oxides); neutral; clear smooth boundary.

Cg1—48 to 56 inches; olive gray (5Y 5/2) loam; many fine prominent strong brown (7.5YR 5/6 and 5/8) mottles; massive; friable; few tubular pores; common black (10YR 2/1) and yellowish red (5YR 5/6 and 5/8) concretions (manganese and iron oxides); mildly alkaline; gradual smooth boundary.

Cg2—56 to 60 inches; olive gray (5Y 5/2) loam; many medium prominent brown (7.5YR 4/4) and strong brown (7.5YR 5/6 and 5/8) mottles; massive; friable; few dark brown (7.5YR 3/2) and black (10YR

2/1) and many brown (7.5YR 4/4) concretions (iron and manganese oxides); mildly alkaline.

The thickness of the solum and the depth to free carbonates range from 24 to 50 inches. The mollic epipedon is 10 to 24 inches thick.

The A horizon is black (N 2/0 or 10YR 2/1) or very dark gray (10YR 3/1). It is loam, silty clay loam, or clay loam. The B horizon has hue of 10YR to 5Y, value of 4 or 5, and chroma of 1 or 2. It generally has distinct or prominent mottles in some parts. It is silty clay loam or clay loam. Some pedons have a BA horizon. The BC and C horizons are loam or clay loam. The C horizon has hue of 5Y or 2.5Y, value of 4 to 6, and chroma of 2 to 4.

Crippin Series

The Crippin series consists of somewhat poorly drained, moderately permeable soils on slightly convex slopes in the uplands. These soils formed in glacial till. The native vegetation was prairie grasses. Slopes range from 1 to 3 percent.

Typical pedon of Crippin loam, 1 to 3 percent slopes; 300 feet west and 25 feet north of the southeast corner of sec. 15, T. 98 N., R. 26 W.

Ap—0 to 9 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; weak fine and very fine granular structure; friable; common fine roots; slight effervescence; mildly alkaline; abrupt smooth boundary.

A1—9 to 14 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; friable; common fine roots; slight effervescence; mildly alkaline; clear smooth boundary.

A2—14 to 20 inches; black (10YR 2/1) and very dark brown (10YR 2/2) clay loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; mixed with some very dark grayish brown (10YR 3/2) streaks and pockets in the lower part; black (N 2/0) coatings on faces of peds; weak fine granular structure and some weak fine subangular blocky structure; friable; few fine roots; strong effervescence; mildly alkaline; clear smooth boundary.

Bw1—20 to 28 inches; dark grayish brown (2.5Y 4/2) clay loam; very dark grayish brown (2.5Y 3/2) coatings on faces of peds; weak fine and very fine subangular blocky structure; friable; few fine tubular pores; strong effervescence; moderately alkaline; gradual smooth boundary.

Bw2—28 to 34 inches; dark grayish brown (2.5Y 4/2) and light olive brown (2.5Y 5/4) clay loam; weak fine and very fine subangular blocky structure; friable; few soft rounded masses of calcium carbonate; strong effervescence; moderately alkaline; clear wavy boundary.

C1—34 to 44 inches; light olive brown (2.5Y 5/4) loam; mixed with some dark grayish brown (2.5Y 4/2) streaks and pockets; few dark brown (7.5YR 3/2) stains on cleavage faces; common fine faint light olive brown (2.5Y 5/6) and few fine distinct yellowish brown (10YR 5/6) mottles; massive; friable; few tubular pores; few reddish brown (5YR 4/4) and black (10YR 2/1) concretions (iron and manganese oxides); common soft rounded masses of calcium carbonate; strong effervescence; moderately alkaline; gradual smooth boundary.

C2—44 to 60 inches; light olive brown (2.5Y 5/4) loam; common fine distinct strong brown (7.5YR 5/8) and yellowish brown (10YR 5/8) mottles; massive; friable; few tubular pores; common fine reddish brown (5YR 4/4) and black (10YR 2/1) concretions (iron and manganese oxides); few soft masses of calcium carbonate; strong effervescence; moderately alkaline.

The thickness of the solum typically is 30 to 36 inches but ranges from 20 to 48 inches. The texture is loam or clay loam throughout the profile.

The A horizon is black (10YR 2/1) or very dark gray (10YR 3/1) in the upper part and very dark grayish brown (10YR 3/2) in the lower part. It is 10 to 20 inches thick. The clay content in this horizon is about 22 to 28 percent. The B horizon is dark grayish brown (10YR or 2.5Y 4/2) or very dark grayish brown (10YR 3/2) in the upper part and grayish brown (2.5Y 5/2), dark grayish brown (2.5Y 4/2), or light olive brown (2.5Y 5/4) in the lower part. The C horizon has hue of 10YR to 5Y, value of 4 or 5, and chroma of 2 to 4.

Darfur Series

The Darfur series consists of poorly drained soils in outwash areas on uplands. These soils formed in loamy and sandy glacial outwash sediments. Permeability is moderate in the upper part of the profile and moderately rapid in the lower part. The native vegetation was water-tolerant prairie grasses. Slopes are 0 to 1 percent.

Typical pedon of Darfur loam, 0 to 1 percent slopes; 1,640 feet north and 1,920 feet west of the southeast corner of sec. 16, T. 100 N., R. 23 W.

Ap—0 to 7 inches; black (N 2/0) loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; common clear quartz grains; neutral; abrupt smooth boundary.

A1—7 to 13 inches; black (N 2/0) loam, very dark gray (10YR 3/1) dry; few fine distinct dark grayish brown (2.5Y 4/2) mottles; weak fine and medium granular structure; friable; few fine tubular pores; common clear quartz grains; neutral; clear smooth boundary.

A2—13 to 18 inches; black (N 2/0 and 10YR 2/1) and very dark gray (10YR 3/1) loam, very dark gray

(10YR 3/1) and dark gray (10YR 4/1) dry; few fine distinct olive gray (5Y 5/2) mottles; weak fine and medium granular structure; friable; neutral; clear smooth boundary.

Bg1—18 to 22 inches; dark gray (5Y 4/1) loam; common fine and medium distinct olive (5Y 5/3) mottles; weak fine and medium subangular blocky structure parting to weak medium granular; friable; neutral; clear wavy boundary.

Bg2—22 to 28 inches; olive (5Y 5/3) sandy loam; few fine faint olive gray (5Y 5/2) and olive yellow (5Y 6/6) mottles; weak medium and coarse subangular blocky structure; very friable; few yellowish red (5YR 4/6) and black (N 2/0) concretions (iron and manganese oxides); neutral; clear wavy boundary.

BCg—28 to 40 inches; olive gray (5Y 5/2) loamy sand; common fine faint olive (5Y 5/4) mottles; weak coarse blocky structure; very friable; few yellowish red (5YR 4/6) and black (N 2/0) concretions (iron and manganese oxides); neutral; clear wavy boundary.

Cg—40 to 60 inches; olive gray (5Y 5/2) stratified loamy fine sand and fine sandy loam; few fine faint olive (5Y 5/6) mottles; single grained; very friable; neutral.

The solum ranges from 20 to 40 inches in thickness. The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is 14 to 24 inches thick. It is loam in the upper part and loam or fine sandy loam in the lower part. The Bg horizon ranges from fine sandy loam or loam in the upper part to loamy sand in the lower part. In some pedons it has a few coarse fragments in the lower part. It has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. The Cg horizon ranges from loamy fine sand to fine sandy loam. In most pedons it has a few shale fragments in the lower part. It has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 1 or 2. Some pedons have a 2C horizon of loamy glacial till at a depth of about 55 inches.

Dickinson Series

The Dickinson series consists of well drained soils on glacial outwash plains and stream terraces. These soils formed in loamy sediments over sandy material. They are moderately rapidly permeable in the solum and rapidly permeable in the sandy substratum. The native vegetation was prairie grasses. Slopes range from 2 to 5 percent.

Typical pedon of Dickinson fine sandy loam, 2 to 5 percent slopes; 2,100 feet west and 250 feet north of the southeast corner of sec. 17, T. 100 N., R. 23 W.

Ap—0 to 9 inches; very dark brown (10YR 2/2) fine sandy loam, dark grayish brown (10YR 4/2) dry; weak fine granular structure and some weak fine and medium subangular blocky structure; friable; few fine roots; medium acid; abrupt smooth boundary.

BA—9 to 15 inches; dark brown (10YR 3/3) fine sandy loam; mixed with brown (10YR 4/3) streaks and pockets; very dark grayish brown (10YR 3/2) coatings on faces of peds; weak fine and medium subangular blocky structure; friable; few fine roots; medium acid; gradual smooth boundary.

Bw1—15 to 21 inches; dark brown (10YR 3/3) fine sandy loam; weak fine and medium subangular blocky structure; very friable; few fine roots; medium acid; gradual smooth boundary.

Bw2—21 to 26 inches; dark yellowish brown (10YR 4/4) fine sandy loam; few very dark grayish brown (10YR 3/2) coatings on faces of peds; weak fine and medium subangular blocky structure; very friable; few fine roots; medium acid; gradual smooth boundary.

BC—26 to 32 inches; dark yellowish brown (10YR 4/4) fine sandy loam; weak fine subangular blocky structure; very friable; medium acid; gradual smooth boundary.

C1—32 to 38 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) loamy fine sand; single grained; loose; slightly acid; gradual smooth boundary.

C2—38 to 60 inches; brown (10YR 4/3 and 5/3) and yellowish brown (10YR 5/4) fine sand; single grained; loose; neutral.

The solum ranges from 30 to 48 inches in thickness. Free carbonates are as shallow as 4 feet in some pedons.

The A horizon typically has hue of 10YR, value of 2 or 3, and chroma of 1, but in a few pedons it has value of 3 and chroma of 2. It is loam or fine sandy loam. The BA horizon has hue of 10YR, value of 3 or 4, and chroma of 3. The Bw horizon has hue of 10YR, value of 3 to 5, and chroma of 3 to 6. The BC horizon has hue of 10YR, value of 4 or 5, and chroma of 4 to 6. It typically is fine sandy loam but is loamy fine sand in some pedons. The C horizon has hue of 10YR, value of 4 or 5, and chroma of 3 to 6. It is dominantly fine sand but is loamy fine sand in some pedons.

Dickman Series

The Dickman series consists of well drained soils in convex areas on uplands and stream terraces. These soils formed in loamy and sandy glacial outwash. They are moderately rapidly permeable in the upper part and rapidly permeable in the lower part. The native vegetation was prairie grasses. Slopes range from 2 to 7 percent.

Typical pedon of Dickman sandy loam, 2 to 7 percent slopes; 1,520 feet north and 950 feet west of the southeast corner of sec. 16, T. 100 N., R. 23 W.

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

AB—7 to 12 inches; dark brown (10YR 3/3) and very dark grayish brown (10YR 3/2) sandy loam; very dark grayish brown (10YR 3/2) coatings on faces of peds; weak fine subangular blocky structure parting to weak fine and medium granular; very friable; few fine roots; slightly acid; clear smooth boundary.

Bw1—12 to 18 inches; dark yellowish brown (10YR 4/4) loamy fine sand; dark brown (10YR 3/3) coatings on faces of peds; weak fine and medium subangular blocky structure; very friable; few very dark brown (10YR 2/2) fillings in root channels; slightly acid; gradual smooth boundary.

Bw2—18 to 24 inches; yellowish brown (10YR 5/4) loamy fine sand; few dark yellowish brown (10YR 4/4) coatings on faces of peds; weak medium subangular blocky structure; very friable; few very dark brown (10YR 2/2) fillings in root channels; neutral; gradual smooth boundary.

Bw3—24 to 36 inches; yellowish brown (10YR 5/4) loamy fine sand; few dark yellowish brown (10YR 4/4) coatings on vertical faces of peds; weak medium and coarse subangular blocky structure; very friable; neutral; gradual smooth boundary.

BC—36 to 47 inches; yellowish brown (10YR 5/4) and dark yellowish brown (10YR 4/4) loamy fine sand; weak coarse subangular blocky structure; very friable; neutral; gradual smooth boundary.

C—47 to 60 inches; yellowish brown (10YR 5/4) and dark yellowish brown (10YR 4/4) fine sand; single grained; loose; few fine strong brown (7.5YR 5/6) concretions (iron and manganese oxides); neutral.

The solum ranges from 30 to 50 inches in thickness. It is free of carbonates. It is loamy to a depth of 12 to 20 inches. It has mollic colors to a depth of 10 to 20 inches.

The A horizon is 7 to 18 inches thick. It ranges from black (10YR 2/1) to very dark grayish brown (10YR 3/2). It is sandy loam or fine sandy loam. The B horizon has hue of 10YR and value and chroma of 3 or 4 in the upper part and has hue of 10YR, value of 4 or 5, and chroma of 3 or 4 in the lower part. This horizon is sandy loam, fine sandy loam, or loamy fine sand. The C horizon has hue of 7.5YR or 10YR, value of 5 or 6, and chroma of 3 or 4. It ranges from fine sand to coarse sand.

Dundas Series

The Dundas series consists of poorly drained, moderately slowly permeable soils in the uplands. Slopes generally are slightly concave, but a few are plane or slightly convex. These soils formed in glacial till. The native vegetation was trees. Slopes range from 0 to 2 percent.

Typical pedon of Dundas silt loam, 0 to 2 percent slopes; 1,480 feet west and 465 feet south of the northeast corner of sec. 35, T. 99 N., R. 23 W.

Ap—0 to 9 inches; very dark gray (10YR 3/1) silt loam, grayish brown (10YR 5/2) and light brownish gray (10YR 6/2) dry; few black (10YR 2/1) coatings on faces of peds; weak fine and very fine granular structure; friable; slightly acid; abrupt smooth boundary.

E1—9 to 17 inches; grayish brown (10YR 5/2) silt loam, light brownish gray (10YR 6/2) and light gray (10YR 7/2) dry; dark grayish brown (10YR 4/2) coatings on faces of most peds; few fine faint brown (10YR 4/3) and dark yellowish brown (10YR 4/4) stains on faces of plates; moderate thin platy structure; friable; common thin discontinuous light gray (10YR 7/1) silt coatings on faces of peds; few fine tubular pores; few strong brown (7.5YR 5/6) concretions (iron and manganese oxides); medium acid; clear wavy boundary.

E2—17 to 22 inches; grayish brown (10YR 5/2) silt loam, light brownish gray (10YR 6/2) and light gray (10YR 7/2) dry; dark grayish brown (10YR 4/2) coatings on faces of some peds; few fine faint yellowish brown (10YR 5/4) mottles; moderate medium platy structure parting to moderate very fine granular; friable; common thin or medium light gray (10YR 7/1) silt coatings on faces of peds; few fine tubular pores; few strong brown (7.5YR 5/6) and black (10YR 2/1) concretions (iron and manganese oxides); medium acid; clear wavy boundary.

Btg1—22 to 29 inches; grayish brown (2.5Y 5/2) and dark grayish brown (2.5Y 4/2) clay loam; few fine distinct strong brown (7.5YR 5/6 and 5/8) mottles; moderate fine and very fine subangular blocky structure; friable; few thin patchy dark grayish brown (2.5Y 4/2) clay films; common medium light gray (10YR 7/1) silt coatings on faces of peds; few very fine tubular pores; common very fine reddish brown (5YR 4/4) and strong brown (7.5YR 5/6) concretions (iron and manganese oxides); medium acid; clear smooth boundary.

Btg2—29 to 33 inches; olive (5Y 5/3) clay loam; few fine distinct yellowish brown (10YR 5/8) mottles; moderate fine and medium subangular blocky structure; friable; few thin patchy dark grayish brown (2.5Y 4/2) clay films; few dark yellowish brown (10YR 4/4) stains on faces of peds; common medium light gray (10YR 7/1) silt coatings on faces of peds; common very fine reddish brown (5YR 4/4) and strong brown (7.5YR 5/6) concretions (iron and manganese oxides); medium acid; clear smooth boundary.

Btg3—33 to 45 inches; grayish brown (2.5Y 5/2) clay loam; common fine and medium distinct yellowish brown (10YR 5/6) and strong brown (7.5YR 5/8) mottles; weak fine and medium subangular blocky structure; friable; common thin or medium discontinuous very dark grayish brown (10YR 3/2) and dark grayish brown (10YR 4/2) clay films; common reddish brown (5YR 4/4) and strong brown (7.5YR 5/6) and a few black (10YR 2/1) concretions (iron and manganese oxides); medium acid; gradual smooth boundary.

Btg4—45 to 55 inches; olive gray (5Y 5/2) and olive (5Y 5/3) loam; common medium distinct reddish brown (5YR 4/4) to strong brown (7.5YR 5/8) mottles; weak medium and coarse prismatic structure; few thin or medium discontinuous very dark grayish brown (10YR 3/2) clay films on faces of peds; common black (N 2/0) and very dark gray (10YR 3/1) clay fillings in old root channels; few black (10YR 2/1) and reddish brown (5YR 4/4) concretions (manganese and iron oxides) and stains; slightly acid; gradual smooth boundary.

Cg—55 to 60 inches; olive gray (5Y 5/2) loam; many medium distinct yellowish brown (10YR 5/8) mottles; massive; friable; common black (N 2/0) clay fillings in old root channels; few fine tubular pores; few black (N 2/0) and strong brown (7.5YR 5/6) concretions (iron and manganese oxides); few accumulations of calcium carbonate; slight effervescence; mildly alkaline.

The thickness of the solum and the depth to free carbonates range from 30 to 55 inches. The A or Ap horizon has hue of 10YR, value of 2 or 3, and chroma of 1. The A horizon is loam or silt loam. It has weak or moderate structure. The E horizon has hue of 10YR, value of 4 or 5, and chroma of 1 or 2. The Btg horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 to 3. It is loam or clay loam. The lower part generally has silt coatings on faces of peds. This horizon has clay films that are dominantly discontinuous and are thin or medium. The Cg horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 2 or 3. It commonly is mottled.

Hanska Series

The Hanska series consists of poorly drained soils in outwash areas on uplands. These soils formed in loamy and sandy glacial outwash. Permeability is moderately rapid in the solum and rapid in the substratum. The native vegetation was prairie grasses and sedges. Slopes range from 0 to 2 percent.

Typical pedon of Hanska loam, 0 to 2 percent slopes; 750 feet south and 50 feet east of the northwest corner of sec. 8, T. 100 N., R. 23 W.

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

A—8 to 11 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; weak fine and medium granular structure; friable; slightly acid; clear smooth boundary.

AB—11 to 17 inches; very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; few black (10YR 2/1) coatings on faces of some peds; weak fine subangular blocky structure parting to weak medium granular; friable; slightly acid; clear smooth boundary.

Bg1—17 to 25 inches; dark grayish brown (2.5Y 4/2) sandy loam; very dark grayish brown (2.5Y 3/2) coatings on faces of peds; common fine distinct olive gray (5Y 5/2) mottles; weak medium subangular blocky structure; friable; few fine reddish brown (5YR 4/4) concretions (iron oxide); slightly acid; clear smooth boundary.

Bg2—25 to 29 inches; dark grayish brown (2.5Y 4/2) sandy loam; common fine distinct olive gray (5Y 5/2) mottles; weak medium and coarse subangular blocky structure; very friable; few fine reddish brown (5YR 4/4) and black (10YR 2/1) concretions (iron and manganese oxides); about 5 percent fine pebbles; slightly acid; gradual smooth boundary.

Bg3—29 to 38 inches; olive gray (5Y 5/2) sandy loam; common fine faint olive (5Y 5/3) mottles; weak coarse subangular blocky structure; very friable; few fine reddish brown (5YR 4/4) and black (10YR 2/1) concretions (iron and manganese oxides); about 10 percent fine pebbles and a few shale fragments; slightly acid; gradual wavy boundary.

2Cg—38 to 60 inches; olive gray (5Y 5/2) and olive (5Y 5/3) loamy sand; single grained; loose; about 10 percent fine pebbles; slightly cemented in places; few fine reddish brown (5YR 4/4) and black (10YR 2/1) concretions (iron and manganese oxides); neutral.

The thickness of the solum typically is 28 to 40 inches but ranges to about 44 inches. The A horizon is loam 10 to 22 inches thick. It is black (N 2/0 or 10YR 2/1) in the upper part and black (10YR 2/1), very dark gray (10YR 3/1), or very dark grayish brown (10YR or 2.5Y 3/2) in the lower part. The B horizon is dark gray (5Y 4/1), gray (5Y 5/1), dark grayish brown (2.5Y 4/2), grayish brown (2.5Y 5/2), or olive gray (5Y 4/2 or 5/2). It commonly is sandy loam, but the upper part is loam in a few pedons. Many pedons have a BC horizon. This horizon typically is sandy loam or loamy sand but in a few pedons is sand.

Harps Series

The Harps series consists of poorly drained, moderately permeable soils that generally are on convex rims of depressions or potholes in the uplands. A few areas are on rises on broad flats. These soils formed in glacial till and in sediments derived from glacial till. The native vegetation was prairie grasses. Slopes range from 1 to 3 percent.

Typical pedon of Harps loam, 1 to 3 percent slopes; 1,910 feet north and 140 feet west of the southeast corner of sec. 11, T. 98 N., R. 26 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) and gray (10YR 5/1) dry; weak fine and very fine granular structure; friable; few fine snail shell fragments; violent effervescence; moderately alkaline; abrupt smooth boundary.

Ak1—8 to 12 inches; black (10YR 2/1) loam, gray (10YR 5/1) dry; weak fine and very fine granular structure; friable; few fine snail shell fragments; violent effervescence; moderately alkaline; clear smooth boundary.

Ak2—12 to 16 inches; very dark gray (10YR 3/1) loam, gray (5Y 5/1 and 6/1) dry; few fine faint dark gray (5Y 4/1) mottles in the lower part; weak fine and very fine granular structure and some weak very fine subangular blocky structure; friable; few fine snail shell fragments; violent effervescence; moderately alkaline; clear smooth boundary.

ABk—16 to 23 inches; very dark gray (10YR 3/1) and dark gray (5Y 4/1) clay loam; few fine faint olive (5Y 5/3) mottles; weak fine and very fine subangular blocky structure parting to weak fine and medium granular; violent effervescence; moderately alkaline; clear smooth boundary.

Bgk1—23 to 31 inches; gray (5Y 5/1) and olive gray (5Y 5/2) clay loam; common fine faint olive (5Y 5/3) and few fine prominent strong brown (7.5YR 5/8) mottles; weak fine subangular blocky structure; friable; few fine tubular pores; few very fine black (10YR 2/1) and reddish brown (5YR 4/4) concretions (manganese and iron oxides); common soft rounded masses of calcium carbonate; violent effervescence; moderately alkaline; clear smooth boundary.

Bgk2—31 to 40 inches; olive gray (5Y 5/2) clay loam; common fine distinct yellowish brown (10YR 5/6 and 5/8) and few fine distinct light olive brown (2.5Y 5/6) mottles; weak medium subangular blocky structure; few fine and medium tabular pores; few black (10YR 2/1) and reddish brown (5YR 4/4) concretions and stains (manganese and iron oxides); common soft rounded masses of calcium carbonates; violent effervescence; moderately alkaline; gradual smooth boundary.

Cg—40 to 60 inches; gray (5Y 5/1) and olive gray (5Y 5/2) loam; common fine distinct yellowish brown (10YR 5/6 and 5/8) and few fine distinct dark yellowish brown (10YR 4/6) mottles; massive; friable; few fine and medium pores; common reddish brown (5YR 4/4) and few black (10YR 2/1) concretions (iron and manganese oxides); common soft rounded masses of calcium carbonate; violent effervescence; moderately alkaline.

The solum ranges from 30 to 48 inches in thickness. It has carbonates throughout.

The A or Ap horizon is loam or clay loam. The A horizon is 10 to 16 inches thick. When moist, this horizon is black (10YR 2/1) or very dark gray (10YR 3/1 or N 3/0). When dry, it is dark gray (10YR 4/1 or N 4/0) or gray (10YR 5/1). The AB horizon is dominantly very dark gray (N 3/0 or 10YR 3/1) but can be as much as 40 percent dark gray (N 4/0, 10YR 4/1, or 5Y 4/1). The B horizon is loam, clay loam, or sandy clay loam. It has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of dominantly 1 or 2. Some pale olive (5Y 6/3) or olive (5Y 5/3) also is common. The C horizon generally is loam, but in some pedons it is clay loam or sandy clay loam. It has colors similar to those of the B horizon.

Hayden Series

The Hayden series consists of well drained, moderately permeable soils on glacial moraines and till plains. Slopes typically are convex. These soils formed in calcareous, loamy glacial till. The native vegetation was deciduous trees. Slopes range from 2 to 25 percent.

Typical pedon of Hayden loam, 2 to 5 percent slopes; 2,220 feet south and 1,470 feet west of the northeast corner of sec. 35, T. 99 N., R. 23 W.

Ap—0 to 8 inches; dark grayish brown (10YR 4/2) and grayish brown (10YR 5/2) loam, light brownish gray (10YR 6/2) and grayish brown (10YR 5/2) dry; some very dark grayish brown (10YR 3/2) coatings on faces of peds; weak fine and very fine granular structure; friable; common silt coatings on faces of peds, light gray (10YR 7/1) dry; slightly acid; abrupt smooth boundary.

BE—8 to 17 inches; dark yellowish brown (10YR 4/4) clay loam; moderate fine and medium subangular blocky structure; friable; few very dark grayish brown (10YR 3/2) clay films on faces of peds in the lower part; common silt coatings on faces of peds, light gray (10YR 7/1) and light brownish gray (10YR 6/2) dry; few fine tubular pores; medium acid; clear smooth boundary.

Bt1—17 to 28 inches; dark yellowish brown (10YR 4/4) and brown (10YR 4/3) clay loam; some very dark grayish brown (10YR 3/2) coatings on faces of peds; weak medium prismatic structure parting to weak medium subangular blocky; firm; common thin or medium discontinuous dark brown (7.5YR 3/2) clay films on vertical faces of peds; common silt coatings on faces of peds, gray (10YR 6/1) and light gray (10YR 7/1) dry; few fine reddish brown (5YR

4/4) concretions (iron oxide); few fine tubular pores; medium acid; clear smooth boundary.

Bt2—28 to 37 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) clay loam; moderate coarse prismatic structure parting to moderate medium subangular blocky; firm; thin to thick continuous dark brown (7.5YR 3/2) and black (N 2/0) clay films on faces of peds; many black (N 2/0) clay fillings in old root channels and in pores; few fine reddish brown (5YR 4/4) concretions (iron oxide); few fine tubular pores; slightly acid; clear smooth boundary.

2C1—37 to 45 inches; yellowish brown (10YR 5/4) loam; few fine faint strong brown (7.5YR 5/8) mottles; weak coarse prismatic structure; friable; common dark brown (7.5YR 3/2) and black (N 2/0) fillings in root channels; few fine reddish brown (5YR 4/4) concretions (iron oxide); few threadlike streaks and soft rounded masses of calcium carbonate; slight effervescence; mildly alkaline; gradual smooth boundary.

2C2—45 to 60 inches; yellowish brown (10YR 5/6) and light olive brown (2.5Y 5/6) loam; massive; friable; common dark brown (7.5YR 3/2) and black (N 2/0) fillings in old root channels; few fine reddish brown (5YR 4/4) concretions (iron oxide); few threadlike streaks and soft rounded masses of calcium carbonate; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 24 to 54 inches. The Ap horizon is friable or very friable. The A horizon typically is loam but is sandy loam or fine sandy loam in some pedons. The Ap horizon has hue of 10YR, value of 4 or 5, and chroma of 1 or 2. In uncultivated areas the A horizon has value of 2 or 3 and chroma of 1 or 2. Some pedons have an E horizon, which has hue of 10YR, value of 4 or 5, and chroma of 1 or 2. The B horizon is friable or firm. It typically is clay loam or loam, but the range includes sandy clay loam, sandy loam, and fine sandy loam. This horizon has hue of 10YR in the upper part and hue of 10YR or 2.5Y in the lower part. It has value of 4 or 5 and chroma of 3 to 5.

The 2C horizon typically is loam but is fine sandy loam or sandy loam in some pedons. It has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 3 to 6.

Houghton Series

The Houghton series consists of very poorly drained, moderately rapidly permeable soils that generally are in upland depressions. A few areas in the northern part of the county are on the bottom land along the Winnebago River. These soils formed in organic material 51 inches to more than 10 feet deep over stratified, loamy sediments. The native vegetation was water-tolerant grasses and sedges. Slopes are 0 to 1 percent.

Typical pedon of Houghton muck, 0 to 1 percent slopes; 45 feet north and 36 feet west of the southeast corner of sec. 25, T. 98 N., R. 23 W.

Op—0 to 8 inches; black (N 2/0), broken face and rubbed, sapric material, the same color dry; about 7 percent fiber, a trace rubbed; weak very fine granular structure; very friable; neutral; abrupt smooth boundary.

Oa1—8 to 17 inches; black (N 2/0), broken face and rubbed, sapric material, the same color dry; about 8 percent fiber, a trace rubbed; weak fine granular structure; very friable; neutral; clear smooth boundary.

Oa2—17 to 29 inches; black (N 2/0), broken face and rubbed, sapric material, the same color dry; about 15 percent fiber, less than 5 percent rubbed; weak fine granular structure; very friable; neutral; clear smooth boundary.

Oa3—29 to 41 inches; black (N 2/0), broken face and rubbed, sapric material, the same color dry; about 10 percent fiber, a trace rubbed; weak fine granular structure; very friable; neutral; clear smooth boundary.

Oa4—41 to 60 inches; black (N 2/0), broken face and rubbed, sapric material, the same color dry; about 5 percent fiber, a trace rubbed; massive; very friable; neutral.

The organic material is 51 inches to more than 10 feet thick. It ranges from black (N 2/0) to dark brown (7.5YR 3/2 or 10YR 3/3). It is dominantly sapric material. In some pedons, however, hemic and fibric layers are within 40 inches of the surface. They commonly have value and chroma of 4. The hemic layers generally are less than about 10 inches thick, and the fibric layers generally are less than about 5 inches thick. Below the organic material is silty clay loam, loam, or silt loam, which is commonly stratified. Fine sandy loam and sand are in some pedons. They occur as thin strata in some of these pedons.

Kilkenny Series

The Kilkenny series consists of well drained, moderately slowly permeable soils on moraines. These soils formed in loamy glaciolacustrine sediments and in the underlying loamy glacial till. The native vegetation was mixed prairie grasses and deciduous trees. Slopes range from 2 to 35 percent.

Typical pedon of Kilkenny clay loam, 5 to 9 percent slopes, moderately eroded; 800 feet east and 1,000 feet north of the southwest corner of sec. 15, T. 98 N., R. 23 W.

Ap—0 to 8 inches; very dark grayish brown (10YR 3/2) clay loam, grayish brown (10YR 5/2) dry; brown

(10YR 4/3) streaks and pockets of subsoil material; weak fine granular structure; friable; neutral; abrupt smooth boundary.

Bt1—8 to 13 inches; brown (10YR 4/3) clay loam; few very dark grayish brown (10YR 3/2) coatings on faces of some peds; weak fine subangular blocky structure; firm; few thin patchy clay films on faces of some peds; common light gray (10YR 7/2) silt coatings on faces of peds; few shale fragments; medium acid; clear smooth boundary.

Bt2—13 to 23 inches; olive brown (2.5Y 4/4) clay loam; dark grayish brown (2.5Y 4/2) coatings on faces of peds; common fine distinct light olive brown (2.5Y 5/6) mottles; weak very fine prismatic structure parting to weak fine subangular blocky; firm; common thin nearly continuous very dark grayish brown (2.5Y 3/2) clay films on faces of peds; common light gray (10YR 7/2) silt coatings on faces of peds; few reddish brown (5YR 4/4) and black (10YR 2/1) concretions (iron and manganese oxides); few shale fragments; medium acid; gradual smooth boundary.

Bt3—23 to 33 inches; olive brown (2.5Y 4/4) clay loam; common fine faint light olive brown (2.5Y 5/6) mottles; weak fine prismatic structure parting to weak medium subangular blocky; firm; common thin nearly continuous very dark grayish brown (2.5Y 3/2) clay films on faces of peds and in old root pores; common light gray (10YR 7/2) silt coatings on faces of peds; few reddish brown (5YR 4/4) and black (10YR 2/1) concretions (iron and manganese oxides); few shale fragments; medium acid; gradual smooth boundary.

Bt4—33 to 45 inches; olive brown (2.5Y 4/4) clay loam; common fine faint light olive brown (2.5Y 5/4) mottles; weak fine prismatic structure parting to weak medium and coarse subangular blocky; common thin or medium discontinuous very dark grayish brown (2.5Y 3/2) clay films on faces of peds and fillings in old root pores; few light gray (10YR 7/2) silt coatings on faces of peds; few reddish brown (5YR 4/4) and black (10YR 2/1) concretions (iron and manganese oxides); few shale fragments; slightly acid; gradual smooth boundary.

BC—45 to 57 inches; olive brown (2.5Y 4/4) and light olive brown (2.5Y 5/4) clay loam; common fine distinct yellowish brown (10YR 5/8) mottles; weak fine prismatic structure; friable; few thin discontinuous very dark grayish brown (10YR 3/2) clay films on faces of peds and fillings in old root pores; common fine reddish brown (5YR 4/4) and few black (10YR 2/1) concretions (iron and manganese oxides); few shale fragments; neutral; clear wavy boundary.

C—57 to 60 inches; light olive brown (2.5Y 5/4) clay loam; few medium distinct strong brown (7.5YR 5/6) mottles; massive; friable; few very dark grayish brown (10YR 3/2) fillings in old root pores; common fine reddish brown (5YR 4/4) and few black (10YR 2/1) concretions (iron and manganese oxides); few soft rounded masses of calcium carbonate; few shale fragments; slight effervescence; mildly alkaline.

The thickness of the solum and the depth to free carbonates range from 36 to 64 inches. The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1. It typically is clay loam, but the range includes loam, silt loam, and silty clay loam. The E horizon has hue of 10YR, value of 3 or 4, and chroma of 1 or 2. The BE horizon has value of 4 and chroma of 3 or 4. The B horizon has hue of 10YR or 2.5Y in the upper part and 2.5Y in the lower part. It has value of 4 or 5 and chroma of 3 to 5. The BC horizon has value of 4 or 5 and chroma of 2 to 4. The BE horizon is clay loam, silty clay loam, loam, or silt loam. The B horizon is clay loam, silty clay loam, silty clay, or clay. The BC and C horizons are clay loam or loam.

Le Sueur Series

The Le Sueur series consists of somewhat poorly drained, moderately permeable soils on slightly convex upland slopes. These soils formed in glacial till. The native vegetation was mixed prairie grasses and deciduous trees. Slopes range from 1 to 3 percent.

Typical pedon of Le Sueur loam, 1 to 3 percent slopes; 670 feet east and 125 feet north of the southwest corner of sec. 25, T. 99 N., R. 23 W.

Ap—0 to 9 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak fine and medium granular structure; friable; slightly acid; abrupt smooth boundary.

A—9 to 14 inches; very dark brown (10YR 2/2) loam, dark gray (10YR 4/1) and grayish brown (10YR 5/2) dry; black (10YR 2/1) coatings on faces of peds; weak medium granular structure and some weak fine subangular blocky structure in the lower part; friable; many grayish brown (10YR 5/2) silt coatings on faces of peds; few fine tubular pores; few brown (10YR 4/3) wormcasts; few very fine strong brown (7.5YR 5/6) and black (10YR 2/1) concretions (iron and manganese oxides); slightly acid; abrupt smooth boundary.

BE—14 to 20 inches; dark grayish brown (2.5Y 4/2) clay loam, dark grayish brown (2.5Y 4/2) kneaded; very dark gray (10YR 3/1) coatings on faces of peds; weak fine and very fine subangular blocky structure; friable; many grayish brown (10YR 5/2) silt coatings on faces of peds; few fine tubular pores; few brown (10YR 4/3) wormcasts; few fine strong brown (7.5YR 5/6) and black (10YR 2/1) concretions (iron and manganese oxides); medium acid; clear smooth boundary.

Bt1—20 to 29 inches; dark grayish brown (2.5Y 4/2) and olive brown (2.5Y 4/4) clay loam; many fine faint light olive brown (2.5Y 5/6) mottles; few fine faint light brownish gray (2.5Y 6/2) mottles in the lower part; moderate medium prismatic structure parting to weak medium subangular blocky; friable; common thin to thick very dark grayish brown (2.5Y 3/2) clay films on faces of most prisms; common fine and medium black (N 2/0) fillings in root channels; few tubular pores; few fine strong brown (7.5YR 5/6) concretions (iron oxide); few scattered black (N 2/0) clay balls; medium acid; clear smooth boundary.

Bt2—29 to 35 inches; dark grayish brown (2.5Y 4/2) clay loam; common fine faint light olive brown (2.5Y 5/6) and olive (5Y 5/3) mottles; weak medium prismatic structure; friable; thick continuous to thin patchy very dark grayish brown (2.5Y 3/2) clay films on faces of prisms; common fine black (N 2/0) fillings in root channels; few fine tubular pores; few fine strong brown (7.5YR 5/6) concretions (iron and manganese oxides); slightly acid; clear smooth boundary.

Cg—35 to 60 inches; olive (5Y 5/3) loam; many fine distinct yellowish brown (10YR 5/6) mottles; massive; friable; few tubular pores; large vertical pores; thick black (N 2/0) and dark brown (7.5YR 3/2) organic and clay fillings in most root channels; few strong brown (7.5YR 5/6) and reddish brown (5YR 4/4) concretions (iron and manganese oxides); few soft rounded accumulations of calcium carbonate; strong effervescence; mildly alkaline.

The thickness of the solum and the depth to free carbonates range from 28 to 50 inches. The A horizon is very dark brown (10YR 2/2), very dark grayish brown (10YR 3/2), very dark gray (10YR 3/1), or black (10YR 2/1). It typically is loam, but in some pedons it is clay loam. The BE horizon has hue of 10YR, value of 3 to 5, and chroma of 2 or 3. It is loam or clay loam. The Bt horizon also is loam or clay loam. It has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 2 to 4 in the upper part and hue of 2.5Y, value of 4 or 5, and chroma of 2 to 4 in the lower part. The C horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 2 to 4.

Lester Series

The Lester series consists of well drained, moderately permeable soils in the uplands. These soils formed in glacial till. The native vegetation was mixed deciduous trees and prairie grasses. Slopes range from 2 to 30 percent.

Typical pedon of Lester loam, 2 to 5 percent slopes; 800 feet south and 80 feet west of the northeast corner of sec. 24, T. 98 N., R. 23 W.

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) and grayish brown (10YR 5/2) dry; weak fine and medium granular structure; friable; common fine roots; medium acid; abrupt smooth boundary.

Bt1—7 to 13 inches; dark yellowish brown (10YR 4/4) clay loam; few fine faint yellowish brown (10YR 5/8) mottles; moderate medium and fine subangular blocky structure; friable; common thin or medium discontinuous dark brown (10YR 3/3) or very dark grayish brown (10YR 3/2) clay films; few light gray (10YR 7/1) silt or very fine sand coatings on faces of some peds; few very fine roots; few very dark grayish brown (10YR 3/2) wormcasts and fillings in old root pores; slightly acid; clear smooth boundary.

Bt2—13 to 21 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) clay loam; few fine faint yellowish brown (10YR 5/8) mottles; moderate medium platy structure parting to moderate fine and medium subangular blocky; friable; common thin to thick dark brown (10YR 3/3) or very dark grayish brown (10YR 3/2) clay films; few light gray (10YR 7/1) silt or very fine sand coatings on faces of some peds; few very fine roots; few dark brown (7.5YR 3/2) clay and organic fillings in old root pores; neutral; gradual smooth boundary.

Bt3—21 to 28 inches; yellowish brown (10YR 5/4) loam; common fine faint yellowish brown (10YR 5/8) mottles; weak medium and coarse prismatic structure parting to weak medium and coarse subangular blocky; friable; common thin or medium discontinuous dark brown (10YR 3/3) or very dark grayish brown (10YR 3/2) clay films and fillings in some old root pores; few very fine roots; few fine strong brown (7.5YR 5/6) to reddish brown (5YR 4/4) concretions (iron oxide); neutral; gradual smooth boundary.

Bt4—28 to 34 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) loam; common fine faint yellowish brown (10YR 5/8) and distinct strong brown (7.5YR 5/8) mottles; weak medium and coarse prismatic structure parting to weak medium and coarse subangular blocky; friable; common thin to thick discontinuous dark brown (10YR 3/3 and 7.5YR 3/2) clay films; many black (N 2/0) or dark brown (7.5YR 3/2) fillings in old root pores; few fine strong brown (7.5YR 5/6) to reddish brown (5YR 4/4) concretions (iron oxide); neutral; gradual wavy boundary.

C—34 to 60 inches; light olive brown (2.5Y 5/4) loam; common fine and medium distinct strong brown (7.5YR 5/8) mottles; weak medium prismatic structure grading to massive with increasing depth; friable; dark brown (7.5YR 3/2) or black (N 2/0) organic fillings in old root pores; some dark brown (7.5YR 3/2) to reddish brown (5YR 4/4) stains along some cleavage faces; few fine strong brown

(7.5YR 5/6) concretions (iron oxide) surrounding some pores; strong effervescence; mildly alkaline.

The thickness of the solum and the depth to free carbonates range from 20 to 48 inches. The Ap or A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. The A horizon typically is loam or clay loam, but the range includes sandy loam, fine sandy loam, and silt loam. Some pedons have an E horizon. This horizon has hue of 10YR, value of 3 or 4, and chroma of 1 or 2. It is loam, fine sandy loam, or silt loam. The B horizon has hue of 10YR, value of 4, and chroma of 3 or 4 in the upper part and hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 3 or 4 in the lower part. This horizon is clay loam or loam. The BC horizon has textures and colors similar to those in the lower part of the B horizon. The C horizon has hue of 2.5Y, value of 4 to 6, and chroma of 3 to 6. It is loam or clay loam.

Linder Series

The Linder series consists of somewhat poorly drained soils on outwash plains and stream terraces. These soils formed in loamy glacial outwash over calcareous sand and gravel. Permeability is moderately rapid in the solum and very rapid in the substratum. The native vegetation was prairie grasses. Slopes range from 0 to 2 percent.

Typical pedon of Linder loam, 0 to 2 percent slopes; 1,300 feet west and 1,300 feet south of the northeast corner of sec. 17, T. 100 N., R. 23 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; few fine roots; neutral; clear smooth boundary.

AB—8 to 13 inches; very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) loam, dark gray (10YR 4/1) and dark grayish brown (10YR 4/2) dry; mixed with few dark grayish brown (2.5Y 4/2) streaks and pockets from the B horizon; weak fine and medium subangular blocky structure; friable; few fine roots; neutral; clear smooth boundary.

Bw1—13 to 17 inches; dark grayish brown (2.5Y 4/2) sandy loam; few very dark gray (10YR 3/1) coatings on faces of peds; weak fine and medium subangular blocky structure; friable; neutral; gradual smooth boundary.

Bw2—17 to 27 inches; dark grayish brown (2.5Y 4/2) sandy loam; few fine distinct yellowish brown (10YR 5/6) mottles in the lower part; weak fine and medium subangular blocky structure; very friable; few black (10YR 2/1) concretions (manganese oxide); neutral; diffuse wavy boundary.

Bw3—27 to 33 inches; dark grayish brown (2.5Y 4/2) sandy loam; few fine distinct yellowish brown (10YR 5/6) mottles; very weak medium subangular blocky structure; very friable; few black (10YR 2/1) and reddish brown (5YR 4/4) concretions (manganese and iron oxides); few coarse fragments (less than 5 percent); neutral; clear smooth boundary.

2C1—33 to 41 inches; dark grayish brown (2.5Y 4/2) loamy sand; single grained; loose; few reddish brown (5YR 4/4) concretions (iron oxides); about 5 percent gravel; mostly shale coarse fragments; slight effervescence; mildly alkaline; clear smooth boundary.

2C2—41 to 60 inches; dark grayish brown (2.5Y 4/2) and dark brown (10YR 3/3) gravelly sand; loose; few reddish brown (5YR 4/4) concretions (iron oxide); strong effervescence; mildly alkaline.

The thickness of the solum and the depth to calcareous sand and gravel range from 24 to 36 inches. The A horizon ranges from about 10 to 20 inches in thickness. It is black (10YR 2/1) or very dark brown (10YR 2/2) in the upper part and very dark grayish brown (10YR 3/2 or 2.5Y 3/2) or very dark gray (10YR 3/1) in the lower part. It is loam or sandy loam. The B horizon commonly has hue of 2.5Y, value of 4 or 5, and chroma of 2 or 3, but the range includes hue of 10YR, value of 4 or 5, and chroma of 2. Some pedons have a BC horizon, which is loamy sand or sand and has some gravel.

The 2C horizon typically is loamy sand or loamy coarse sand and has a gravel content of 5 to 30 percent. It has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 2 to 6. It generally has slight or strong effervescence, but it is leached in the upper few inches in some pedons.

Mayer Series

The Mayer series consists of poorly drained, calcareous soils on stream terraces and glacial outwash plains. These soils formed in loamy sediments overlying sand and gravel. Permeability is moderate in the solum and rapid in the substratum. The native vegetation was prairie grasses. Slopes range from 0 to 2 percent.

Typical pedon of Mayer loam, 0 to 2 percent slopes; 1,200 feet north and 30 feet west of the southeast corner of sec. 29, T. 98 N., R. 24 W.

Ap—0 to 9 inches; black (N 2/0) loam, black (10YR 2/1) dry; weak fine and medium granular structure; friable; few fine roots; few clear quartz grains; strong effervescence; moderately alkaline; abrupt smooth boundary.

A1—9 to 16 inches; black (N 2/0) loam, black (10YR 2/1) dry; weak fine and medium granular structure; friable; few fine roots; few clear quartz grains; strong effervescence; moderately alkaline; abrupt smooth boundary.

A2—16 to 22 inches; black (10YR 2/1) and very dark gray (10YR 3/1) loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; few fine distinct olive

(5Y 4/3) and few medium distinct light olive brown (2.5Y 5/4) mottles; weak fine subangular blocky structure parting to weak fine and medium granular; friable; few fine roots; few fine tubular pores; strong effervescence; moderately alkaline; clear smooth boundary.

Bg1—22 to 28 inches; dark grayish brown (2.5Y 4/2) loam; common fine faint olive (5Y 5/4) and common medium distinct olive (5Y 5/3) mottles; weak medium subangular blocky structure; friable; common fine pebbles; strong effervescence; moderately alkaline; clear wavy boundary.

Bg2—28 to 33 inches; dark grayish brown (2.5Y 4/2) and olive (5Y 5/3) loam; few fine distinct strong brown (7.5YR 5/6) mottles; weak medium and coarse subangular blocky structure; friable; common fine and medium pebbles; common fine yellowish red (5YR 5/6) and few black (N 2/0) concretions (iron and manganese oxides); few fine soft rounded masses of calcium carbonate; strong effervescence; moderately alkaline; clear wavy boundary.

2Cg1—33 to 46 inches; olive gray (5Y 5/2) and olive (5Y 5/3) gravelly sand; single grained; loose; 20 to 25 percent gravel; few fine yellowish red (5YR 4/6) concretions (iron oxide); few calcium carbonate coatings on the larger stones; violent effervescence; moderately alkaline; clear wavy boundary.

2Cg2—46 to 51 inches; olive gray (5Y 5/2) gravelly sand; single grained; loose; few calcium carbonate coatings on large stones; violent effervescence; moderately alkaline; clear wavy boundary.

2Cg3—51 to 60 inches; olive gray (5Y 5/2) gravelly sand; few fine distinct olive yellow (2.5Y 6/6) mottles; single grained; loose; about 30 percent gravel; few fine yellowish red (5YR 4/6) concretions (iron oxide); few calcium carbonate coatings on the larger stones; violent effervescence; moderately alkaline.

The thickness of the solum and the depth to the 2C horizon range from 24 to 36 inches. The A horizon is loam, clay loam, or sandy clay loam. It has hue of 10YR, 2.5Y, or 5Y, value of 2 or 3, and chroma of 1, or it is neutral in hue and has value of 2 or 3 and chroma of 0. It is about 14 to 24 inches thick. The Bg horizon is dominantly clay loam or loam but is sandy loam or sandy clay loam in the lower part in some pedons. It has hue of 2.5Y or 5Y or is neutral in hue. It has value of 4 or 5 and generally has chroma of 0 to 2. In some pedons, however, the lower part has subhorizons with chroma higher than 2.

The 2Cg horizon has hue of 2.5Y or 5Y and value and chroma of 2 to 6. It is coarse sand, sand, loamy coarse sand, loamy sand, or the gravelly analogs of these textures. It is commonly stratified.

Minnetonka Series

The Minnetonka series consists of poorly drained, slowly permeable soils on glacial lake plains and moraines. These soils formed in glaciolacustrine sediments. The native vegetation was mixed deciduous trees and water-tolerant prairie grasses. Slopes range from 0 to 2 percent.

Typical pedon of Minnetonka silty clay loam, 0 to 2 percent slopes; 2,600 feet west and 2,620 feet south of the northeast corner of sec. 2, T. 98 N., R. 23 W.

Ap—0 to 7 inches; black (10YR 2/1) and very dark gray (10YR 3/1) silty clay loam, grayish brown (10YR 5/2) dry; weak fine and medium granular structure; friable; medium acid; abrupt smooth boundary.

EB—7 to 12 inches; very dark grayish brown (10YR 3/2) silty clay loam, gray (10YR 5/1) dry; very dark gray (10YR 3/1) coatings on faces of peds; weak medium prismatic structure parting to weak fine subangular blocky; friable; common silt coatings, light brownish gray (10YR 6/2) dry; medium acid; clear smooth boundary.

Bt—12 to 19 inches; black (10YR 2/1 and 5Y 2/1) silty clay; mixed with a few very dark gray (5Y 3/1) streaks and pockets; moderate fine and very fine angular and subangular blocky structure; firm; thin continuous to thick patchy clay films; medium acid; clear smooth boundary.

Btg1—19 to 27 inches; olive gray (5Y 5/2 and 4/2) silty clay; common fine faint olive (5Y 5/3) mottles; moderate medium and coarse prismatic structure parting to moderate fine and medium angular blocky; firm; few thin to thick continuous black (5Y 2/1) and very dark gray (5Y 3/1) clay films on faces of peds; few black (N 2/0) and very dark gray (5Y 3/1) fillings in root channels; few strong brown (7.5YR 5/6) concretions (iron and manganese oxides); medium acid; clear smooth boundary.

Btg2—27 to 33 inches; olive gray (5Y 5/2 and 4/2) silty clay; few fine faint olive (5Y 5/3) mottles; moderate medium and coarse prismatic structure parting to weak medium subangular blocky; firm; thick continuous very dark gray (5Y 3/1) and black (5Y 2/1) clay films; many black (N 2/0) fillings in root channels and pores; few fine tubular pores; common reddish brown (5YR 5/4) concretions (iron oxide); slightly acid; gradual smooth boundary.

Btg3—33 to 47 inches; olive gray (5Y 5/2) silty clay loam; mixed with some olive gray (5Y 4/2) streaks and pockets; common fine distinct yellowish brown (10YR 5/8) mottles; moderate coarse prismatic structure; firm; many thick continuous very dark gray (5Y 3/1) and black (N 2/0) clay films on vertical faces of peds; common black (N 2/0) fillings in root channels and pores; few tubular pores; common reddish brown (5YR 5/4) and few black (10YR 2/1) concretions (iron and manganese oxides); slightly acid; gradual smooth boundary.

Cg1—47 to 55 inches; light olive gray (5Y 6/2) and olive gray (5Y 5/2) silty clay loam; common fine distinct yellowish brown (10YR 5/8) and few fine faint pale olive (5Y 6/3) mottles; massive; firm; few tubular pores; common black (N 2/0) fillings in root channels; slight effervescence; mildly alkaline; gradual smooth boundary.

Cg2—55 to 60 inches; light olive gray (5Y 6/2) silty clay loam; common fine prominent strong brown (7.5YR 5/8) and few fine faint pale olive (5Y 6/3) mottles; massive; few tubular pores; common black (N 2/0) fillings in root channels; few reddish brown (5YR 4/4) concretions (iron oxide); slight effervescence; mildly alkaline.

The thickness of the solum and the depth to free carbonates range from 28 to 52 inches. The A horizon typically is silty clay loam, but the range includes silty clay. The A or Ap horizon is black (10YR 2/1 or N 2/0). Some pedons have a thin E horizon. The E or EB horizon has value of 3 or 4 (4 or 5 dry) and chroma of 1 or 2 (moist or dry). The B horizon either has hue of 10YR, value of 2 or 3, and chroma of 1 throughout or has hue of 2.5Y or 5Y, value of 2 or 3, and chroma of 1 or 2 in the upper part and hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2 in the lower part. This horizon has distinct or prominent mottles. It is silty clay loam, silty clay, or clay. It is firm or very firm. It has thin to thick, patchy to continuous clay films.

The C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 2. It is silt loam, silty clay loam, clay, or silty clay. It is friable or firm. Some pedons have a 2C horizon, which is loam or clay loam.

Muskego Series

The Muskego series consists of very poorly drained soils in large depressions that formerly were shallow glacial lakes. These soils formed in deposits of decomposed herbaceous material underlain by limnic sediments of coprogenous earth. Permeability is moderately rapid in the upper part of the profile and slow in the lower part. Slopes are 0 to 1 percent.

Typical pedon of Muskego muck, 0 to 1 percent slopes; 1,750 feet west and 1,120 feet north of the southeast corner of sec. 22, T. 99 N., R. 25 W.

Op—0 to 9 inches; black (10YR 2/1) sapric material; less than 5 percent fiber rubbed; weak fine subangular blocky structure; very friable; neutral; clear smooth boundary.

Oa1—9 to 14 inches; black (10YR 2/1) sapric material; about 30 percent fiber, less than 5 percent rubbed; weak medium subangular blocky structure; very friable; few dark brown (7.5YR 3/2) fibers; neutral; gradual smooth boundary.

Oa2—14 to 19 inches; black (10YR 2/1) sapric material; about 50 percent fiber, 10 percent rubbed; weak medium platy structure; very friable; common dark brown (10YR 3/3 and 7.5YR 3/2) fibers; neutral; gradual smooth boundary.

Oa3—19 to 26 inches; black (10YR 2/1) sapric material; about 50 percent fiber, 5 percent rubbed; weak medium subangular blocky structure; very friable; common dark brown (7.5YR 3/2) fibers; neutral; clear smooth boundary.

C1—26 to 41 inches; black (10YR 2/1) mucky silt loam; massive; friable; common reddish brown (5YR 4/4) root channels; common snail shell fragments; strong effervescence; mildly alkaline; gradual smooth boundary.

C2—41 to 45 inches; black (10YR 2/1) mucky silt loam; massive; friable; few snail shell fragments; strong effervescence; mildly alkaline; gradual smooth boundary.

C3—45 to 53 inches; very dark gray (10YR 3/1) mucky silt loam; massive; friable; reddish brown (5YR 4/4) root channels; few snail shell fragments; strong effervescence; mildly alkaline; clear smooth boundary.

C4—53 to 60 inches; very dark gray (10YR 3/1 and 5Y 3/1) mucky silt loam that has a high content of sand; few fine distinct grayish brown (2.5Y 5/2) mottles; massive; friable; few snail shell fragments; few reddish brown (5YR 4/4) root channels; slight effervescence; mildly alkaline.

The depth to coprogenous earth commonly is 24 to 36 inches but ranges from 16 to 54 inches. The fiber is derived primarily from herbaceous plants.

The surface tier primarily is black (10YR 2/1) or very dark brown (10YR 2/2) sapric material, but some pedons grade to hemic material. The subsurface and bottom tiers have hue of 10YR or 7.5YR or are neutral in hue. They have value of 2 or 3 and chroma of 0 to 3. They consist dominantly of sapric material, but hemic material may total as much as 25 percent. The coprogenous earth has hue of 10YR, 2.5Y, or 5Y, value of 2 to 5, and chroma of 1 to 3.

Nicollet Series

The Nicollet series consists of somewhat poorly drained, moderately permeable soils on slightly convex to slightly concave slopes in the uplands. These soils formed in glacial till. The native vegetation was prairie grasses. Slopes range from 1 to 3 percent.

Typical pedon of Nicollet loam, 1 to 3 percent slopes; 360 feet north and 2,410 feet west of the southeast corner of sec. 5, T. 98 N., R. 25 W.

Ap—0 to 7 inches; black (10YR 2/1) loam, black (10YR 2/1) and very dark gray (10YR 3/1) dry; black (N

2/0) coatings on faces of peds; weak fine and very fine granular structure; friable; common fine roots; slightly acid; abrupt smooth boundary.

A1—7 to 13 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; weak fine and medium granular structure and some weak fine subangular blocky structure parting to weak fine granular; friable; common fine roots; slightly acid; clear smooth boundary.

A2—13 to 19 inches; very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; mixed with some dark brown (10YR 3/3) streaks and pockets in the lower part; black (10YR 2/1) coatings on faces of most peds; weak fine subangular blocky structure parting to weak fine and medium granular; friable; common fine roots; few fine tubular pores; slightly acid; clear smooth boundary.

Bw1—19 to 25 inches; dark grayish brown (10YR 4/2) loam; very dark gray (10YR 3/1) coatings on faces of most peds; weak fine and medium subangular blocky structure; friable; few fine roots; few fine tubular pores; neutral; clear smooth boundary.

Bw2—25 to 33 inches; dark grayish brown (2.5Y 4/2) loam; weak medium prismatic structure parting to weak fine and medium subangular blocky; friable; few fine roots; few fine tubular pores; neutral; gradual smooth boundary.

Bw3—33 to 41 inches; dark grayish brown (2.5Y 4/2) loam; few fine faint light olive brown (2.5Y 5/4) mottles; weak medium prismatic structure parting to weak fine and medium subangular blocky; friable; few fine tubular pores; few black (10YR 2/1) concretions (manganese oxide); neutral; clear smooth boundary.

BC—41 to 47 inches; dark grayish brown (2.5Y 4/2) loam; few fine prominent strong brown (7.5YR 5/6) and few fine faint yellowish brown (10YR 5/6) and dark yellowish brown (10YR 4/4) mottles; weak medium prismatic structure parting to weak medium subangular blocky; friable; few fine black (10YR 2/1) concretions (manganese oxide); few fine accumulations of calcium carbonate; slight effervescence; mildly alkaline; gradual smooth boundary.

C—47 to 60 inches; light olive brown (2.5Y 5/4) and olive (5Y 5/3) loam; common fine distinct yellowish brown (10YR 5/8) and few fine and medium prominent strong brown (7.5YR 5/6 and 5/8) mottles; massive; friable; dark brown (7.5YR 3/2) stains on some vertical cleavage faces; few fine black (10YR 2/1) and reddish brown (5YR 4/4) concretions (manganese and iron oxides); common olive gray (5Y 5/2) accumulations of calcium carbonate; slight effervescence; mildly alkaline.

The thickness of the solum and the depth to free carbonates range from 20 to 48 inches. The A horizon is black (10YR 2/1), very dark brown (10YR 2/2), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2) loam or clay loam. It is 12 to 21 inches thick. The upper part of the Bw horizon is dark grayish brown (10YR 4/2 or 2.5Y 4/2) or very dark grayish brown (10YR 3/2 or 2.5Y 3/2). The next part is dark grayish brown (10YR 4/2 or 2.5Y 4/2) or brown (10YR 4/3). The lower part of the Bw horizon and the BC horizon have hue of 2.5Y, value of 4 or 5, and chroma of 2 to 4. The C horizon is grayish brown (2.5Y 5/2), light olive brown (2.5Y 5/4), olive gray (5Y 5/2), or olive (5Y 5/3).

Okoboji Series

The Okoboji series consists of very poorly drained, moderately slowly permeable soils in upland depressions. These soils formed in glacial till sediments. The native vegetation was water-tolerant grasses. Slopes are 0 to 1 percent.

Typical pedon of Okoboji silty clay loam, 0 to 1 percent slopes; 1,860 feet east and 80 feet north of the southwest corner of sec. 10, T. 98 N., R. 26 W.

Ap—0 to 9 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak medium and fine granular structure; friable; common fine roots; mildly alkaline; abrupt smooth boundary.

A1—9 to 18 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak fine and very fine granular structure; friable; neutral; gradual smooth boundary.

A2—18 to 28 inches; black (N 2/0) silty clay loam, black (10YR 2/1) dry; weak fine and medium subangular blocky structure parting to moderate fine and very fine granular; friable; few very fine tubular pores; neutral; gradual smooth boundary.

Bg1—28 to 38 inches; very dark gray (5Y 3/1) silty clay loam, dark gray (10YR 4/1) dry; weak very fine and fine prismatic structure parting to weak fine and very fine subangular blocky and fine granular; friable; few fine tubular pores; neutral; gradual smooth boundary.

Bg2—38 to 48 inches; very dark gray (5Y 3/1) silty clay loam, dark gray (10YR 4/1) dry; few vertical olive gray (5Y 5/2) wedges in the lower part; weak fine and medium prismatic structure parting to weak fine and very fine subangular blocky; friable; few fine tubular pores; few very fine dark brown (7.5YR 4/4) concretions (iron and manganese oxides); neutral; clear wavy boundary.

Cg—48 to 60 inches; gray (5Y 5/1) and olive gray (5Y 5/2) silty clay loam; common fine distinct olive brown (2.5Y 4/4) and many fine and medium distinct yellowish brown (10YR 5/8) mottles; weak medium prismatic structure; friable; common very fine reddish brown (5YR 4/4) concretions (iron oxide); weak effervescence in spots; mildly alkaline.

The solum ranges from about 40 to 60 inches in thickness. The A horizon ranges from about 24 to 36 inches in thickness. It is black (N 2/0 or 10YR 2/1). It is silty clay loam, silt loam, or mucky silt loam. The Bg horizon is very dark gray (5Y 3/1 or 2.5Y 3/1) in the upper part and dark gray (5Y 4/1), gray (5Y 5/1), or olive gray (5Y 5/2) in the lower part. The Cg horizon is dark gray (5Y 4/1), gray (5Y 5/1), or olive gray (5Y 5/2). It typically is silty clay loam, but in some pedons it has thin layers of clay loam, loam, or silt loam.

Palms Series

The Palms series consists of very poorly drained, moderately permeable soils in depressions. These soils formed in organic material overlying silty sediments. The native vegetation was water-tolerant sedges, reeds, and grasses. Slopes are 0 to 1 percent.

Typical pedon of Palms muck, 0 to 1 percent slopes; 2,480 feet west and 190 feet north of the southeast corner of sec. 12, T. 100 N., R. 25 W.

Op—0 to 7 inches; black (N 2/0), broken face and rubbed, sapric material, black (10YR 2/1) dry; about 5 percent fibers, less than 5 percent rubbed; weak fine and very fine granular structure; slightly sticky; herbaceous fibers; common fine roots; neutral; abrupt smooth boundary.

Oa1—7 to 16 inches; black (N 2/0) sapric material, black (10YR 2/1) dry; less than 5 percent fiber rubbed; massive parting to weak platylike layers of organic material, some of which are separated by silt particles; slightly sticky; herbaceous fibers; many fine roots; common dusky red (2.5YR 3/2) fragments of undecayed organic matter; neutral; clear smooth boundary.

Oa2—16 to 24 inches; black (N 2/0) sapric material, black (10YR 2/1) dry; less than 5 percent fiber rubbed; weak fine and medium subangular blocky structure parting to weak fine granular; very friable; many fine roots; few dusky red (2.5YR 3/2) streaks of undecomposed organic matter; neutral; gradual smooth boundary.

Oa3—24 to 29 inches; black (N 2/0) sapric material, very dark gray (10YR 3/1) dry; less than 5 percent fiber rubbed; weak medium subangular blocky structure parting to weak fine granular; very friable; few tubular pores; neutral; clear wavy boundary.

C1—29 to 35 inches; black (10YR 2/1) mucky silt loam, very dark gray (10YR 3/1) dry; few fine faint olive (5Y 4/3) mottles; weak medium prismatic structure parting to weak fine subangular blocky; friable; common dark brown (7.5YR 4/4) stains in root channels; few tubular pores; neutral; abrupt wavy boundary.

C2—35 to 60 inches; olive gray (5Y 5/2) silt loam; common medium prominent reddish brown (5YR 4/4) mottles at a depth of about 48 inches; massive; friable; common reddish brown (5YR 4/4) organic fillings in root channels; few fine tubular pores; few very dark gray (5Y 3/1) stains along vertical cleavages; few soft powdery masses of calcium carbonate; strong effervescence; mildly alkaline.

The Oa horizon typically is about 20 to 45 inches thick but in some pedons is as much as 49 inches thick. It is black (N 2/0, 10YR 2/1, or 5Y 2/1) or very dark brown (10YR 2/2). The C horizon has hue of 10YR, 2.5Y, or 5Y, value of 3 to 6, and chroma of 1 or 2. It is dominantly loam, silt loam, mucky silt loam, silty clay loam, or clay loam. In some pedons, however, it has thin strata of coarse silt.

Ridgeport Series

The Ridgeport series consists of somewhat excessively drained soils on glacial outwash plains and stream terraces. These soils formed in loamy material over calcareous sand and gravel. Permeability is moderately rapid in the upper part of the profile and very rapid in the lower part. The native vegetation was prairie grasses. Slopes range from 0 to 5 percent.

Typical pedon of Ridgeport sandy loam, 0 to 2 percent slopes; 860 feet south and 500 feet west of the northeast corner of sec. 20, T. 100 N., R. 23 W.

Ap—0 to 9 inches; very dark brown (10YR 2/2) sandy loam, dark gray (10YR 4/1) dry; black (10YR 2/1) coatings on faces of peds; weak fine granular structure; friable; common fine roots; slightly acid; abrupt smooth boundary.

A—9 to 13 inches; very dark brown (10YR 2/2) sandy loam, dark gray (10YR 4/1) dry; black (10YR 2/1) coatings on faces of peds; weak fine subangular blocky structure parting to weak fine and medium granular; friable; few fine roots; slightly acid; clear smooth boundary.

BA—13 to 19 inches; very dark grayish brown (10YR 3/2), dark brown (10YR 3/3), and brown (10YR 4/3) sandy loam; very dark brown (10YR 2/2) coatings on faces of some peds; weak fine and medium subangular blocky structure parting to weak fine and medium granular; friable; few fine roots; slightly acid; clear smooth boundary.

Bw1—19 to 25 inches; brown (10YR 4/3) and dark brown (10YR 3/3) sandy loam; few dark yellowish brown (10YR 3/4) peds; weak fine subangular blocky structure; friable; few fine roots; slightly acid; clear smooth boundary.

Bw2—25 to 31 inches; dark brown (10YR 3/3) and brown (10YR 4/3) sandy loam; few dark yellowish brown (10YR 4/4) peds; weak fine subangular blocky structure; friable; few coarse fragments; neutral; clear smooth boundary.

Bw3—31 to 38 inches; dark yellowish brown (10YR 4/4) sandy loam; dark brown (10YR 3/3) coatings on faces of peds; weak fine and medium subangular blocky structure; very friable; few coarse fragments; neutral; abrupt smooth boundary.

2C1—38 to 47 inches; dark yellowish brown (10YR 4/4) and brown (10YR 4/3) loamy sand; single grained; loose; about 5 percent gravel; few shale fragments; neutral; clear wavy boundary.

2C2—47 to 60 inches; mixed yellowish brown (10YR 5/4) and dark yellowish brown (10YR 4/4) gravelly loamy sand; single grained; loose; about 20 percent gravel; slight effervescence; mildly alkaline.

The thickness of the solum is 30 to 40 inches. It typically is the same as the depth to loamy sand, gravelly loamy sand, gravelly sandy loam, or sand and gravel. In a few pedons, however, the solum extends a few inches into the coarse textured material.

Salida Series

The Salida series consists of excessively drained, very rapidly permeable soils on knobs, kames, and eskers in the uplands. These soils formed in loamy and sandy glacial outwash. The native vegetation was prairie grasses. Slopes range from 2 to 18 percent.

The Salida soils in Winnebago County are taxadjuncts because the control section has fewer coarse fragments than is definitive for the Salida series.

Typical pedon of Salida gravelly sandy loam, 9 to 18 percent slopes; 1,060 feet west and 1,100 feet north of the southeast corner of sec. 15, T. 98 N., R. 23 W.

Ap—0 to 9 inches; very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) gravelly sandy loam, dark grayish brown (10YR 4/2) and brown (10YR 4/3) dry; very dark brown (10YR 2/2) coatings on faces of some peds; weak medium and coarse granular structure; very friable; slight effervescence; moderately alkaline; abrupt smooth boundary.

Bw—9 to 13 inches; dark brown (10YR 3/3) and brown (10YR 4/3) gravelly loamy sand; weak medium and fine subangular blocky structure and some weak coarse granular structure; very friable; common very dark grayish brown (10YR 3/2) tongues; few black (10YR 2/1) concretions (manganese oxide); few soft rounded masses of calcium carbonate; slight effervescence; mildly alkaline; clear wavy boundary.

C1—13 to 20 inches; dark yellowish brown (10YR 3/4 and 4/4) and brown (10YR 4/3) very gravelly sand; single grained; loose; slightly cemented in spots; few fine reddish brown (5YR 4/4) concretions (iron oxide); few soft powdery masses of calcium carbonate on the larger gravel-sized particles; strong effervescence; moderately alkaline; gradual wavy boundary.

C2—20 to 47 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) gravelly sand; single grained; loose; slightly cemented in spots; few reddish brown (5YR 4/4) concretions (iron oxide); few soft powdery masses of calcium carbonate on the larger gravel-sized particles; strong effervescence; moderately alkaline; gradual wavy boundary.

C3—47 to 60 inches; pale brown (10YR 6/3) gravelly sand; single grained; loose; few fine reddish brown (5YR 4/4) concretions (iron oxide); slight effervescence; moderately alkaline.

The thickness of the solum ranges from 7 to 20 inches. The depth to free carbonates is less than 14 inches. Most pedons are calcareous throughout.

The A horizon is about 7 to 10 inches thick. It is very dark brown (10YR 2/2), very dark grayish brown (10YR 3/2), dark brown (10YR 3/3), or brown (10YR 4/3). The Bw horizon has hue of 10YR and value and chroma of 3 or 4. It is gravelly sand or gravelly loamy sand. The C horizon has hue of 10YR, value of 3 to 6, and chroma of 2 to 4. In some pedons it has strata that vary in content of gravel.

Shorewood Series

The Shorewood series consists of somewhat poorly drained, slowly permeable soils on slightly concave to slightly convex slopes in the uplands. These soils formed in clayey and silty glaciolacustrine sediments over glacial till. The native vegetation was mixed prairie grasses and deciduous trees. Slopes range from 1 to 3 percent.

Typical pedon of Shorewood silty clay loam, 1 to 3 percent slopes; 1,900 feet east and 40 feet north of the southwest corner of sec. 27, T. 100 N., R. 23 W.

Ap—0 to 10 inches; black (10YR 2/1) silty clay loam (33.4 percent clay), dark gray (10YR 4/1) dry; weak fine granular structure; friable; medium acid; clear smooth boundary.

A—10 to 15 inches; black (10YR 2/1) silty clay loam (35 percent clay), dark gray (10YR 4/1) dry; very dark grayish brown (10YR 3/2) streaks and pockets in the lower part; weak very thin platy structure parting to moderate very fine and fine subangular blocky; friable; many gray (10YR 5/1) silt coatings on faces of peds; few very fine concretions (iron oxide); medium acid; gradual smooth boundary.

Bt1—15 to 21 inches; dark grayish brown (2.5Y 4/2) silty clay loam (39 percent clay); mixed with some black (10YR 2/1) material in the upper part; moderate fine and very fine subangular blocky structure; friable; few thin discontinuous very dark grayish brown (2.5Y 3/2) clay films on vertical faces of peds; many silt coatings on faces of peds, gray (10YR 5/1) dry; few fine roots; few dark concretions (iron and manganese oxides); medium acid; clear smooth boundary.

Bt2—21 to 29 inches; dark grayish brown (2.5Y 4/2) silty clay (45 percent clay); few fine faint grayish brown (2.5Y 5/2) mottles; weak fine and medium prismatic structure parting to moderate fine subangular blocky; firm; common faint discontinuous very dark grayish brown (2.5Y 3/2) clay films; few white (N 8/0) silt coatings on faces of peds; common fine reddish brown (5YR 4/3 and 4/4) and black (10YR 2/1) concretions (iron and manganese oxides); slightly acid; gradual smooth boundary.

BC—29 to 42 inches; dark grayish brown (2.5Y 4/2) and grayish brown (2.5Y 5/2) silty clay (45 percent clay); weak medium prismatic structure; firm; common faint discontinuous dark olive gray (5Y 3/2) and distinct discontinuous black (N 2/0) clay films on faces of peds; dark brown (7.5YR 3/2) and black (N 2/0) fillings in old root channels; few dark brown (7.5YR 3/2) fillings in some of the smaller root pores; few reddish brown (5YR 4/4) and black (10YR 2/1) concretions (iron and manganese oxides); slightly acid; clear smooth boundary.

C—42 to 60 inches; grayish brown (2.5Y 5/2) and light olive brown (2.5Y 5/4) silty clay loam (39 percent clay); mostly massive but some weak fine prismatic structure in the upper part; friable; black (10YR 2/1 and N 2/0) fillings in root channels; common large concretions (iron oxide); common streaks of calcium carbonate on cleavage faces, apparent when dry; strong effervescence; mildly alkaline.

The thickness of the solum and the depth to free carbonates range from 28 to 48 inches. The mollic epipedon is 10 to 22 inches thick.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. Some pedons have a thin E horizon, which commonly is indistinct. The B horizon has hue of 2.5Y or 10YR and chroma of 2 or 3. It has value of 3 or 4 in the upper part and value of 4 or 5 in the lower part. It typically is silty clay loam or silty clay, but in some pedons it is silt loam or clay loam below a depth of 30 inches. The C horizon has hue of 2.5Y, value of 5, and chroma of 2 to 4. It is silty clay, silty clay loam, or silt loam. Some pedons have a 2C horizon, which is loam or clay loam. The silty sediments typically are about 4 to 8 feet thick but are only about 30 inches thick in a few pedons.

Spillville Series

The Spillville series consists of moderately well drained, moderately permeable soils on foot slopes and alluvial fans. These soils formed in loamy colluvium. The native vegetation was prairie grasses. Slopes range from 2 to 5 percent.

Typical pedon of Spillville loam, 2 to 5 percent slopes; 1,620 feet west and 200 feet south of the northeast corner of sec. 6, T. 99 N., R. 24 W.

Ap—0 to 10 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; black (10YR 2/1) and very dark gray (10YR 3/1) coatings on faces of peds; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A1—10 to 24 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure parting to weak fine and medium granular; friable; neutral; gradual smooth boundary.

A2—24 to 34 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak fine and medium subangular blocky structure parting to weak medium granular; friable; neutral; gradual smooth boundary.

A3—34 to 42 inches; black (10YR 2/1) and very dark grayish brown (10YR 3/2) loam, dark gray (10YR 4/1) and grayish brown (10YR 5/2) dry; weak medium prismatic structure parting to weak fine and medium subangular; friable; neutral; gradual smooth boundary.

AC—42 to 60 inches; very dark grayish brown (10YR 3/2) loam, grayish brown (10YR 5/2) dry; black (10YR 2/1) and very dark gray (10YR 3/1) coatings on faces of peds; mixed with yellowish brown (10YR 5/6) streaks, mostly in the lower part; few fine distinct olive brown (2.5Y 4/4) mottles in the upper part; weak medium prismatic structure parting to weak fine and medium subangular blocky; friable; neutral.

The thickness of the solum ranges from about 30 to more than 60 inches. The depth to carbonates typically is more than 48 inches, but a few pedons are calcareous at a depth of about 40 inches.

The A horizon is commonly black (10YR 2/1), very dark brown (10YR 2/2), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2). It is 30 to 56 inches thick. The C horizon commonly has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 1 or 2. It typically is loam but is sandy loam in some pedons.

Storden Series

The Storden series consists of well drained, moderately permeable soils on sharply convex knobs and on side slopes in the rolling uplands. These soils formed in glacial till. The native vegetation was prairie grasses. Slopes range from 2 to 20 percent.

Typical pedon of Storden loam, 5 to 9 percent slopes, moderately eroded; 80 feet west and 410 feet north of the southeast corner of sec. 24, T. 99 N., R. 24 W.

Ap—0 to 8 inches; mixed brown (10YR 5/3) and very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) and pale brown (10YR 6/3) dry; streaks and pockets of light olive brown (2.5Y 5/4) loam; weak fine subangular blocky structure; friable; few small pebbles; mildly alkaline; strong effervescence; clear wavy boundary.

C1—8 to 24 inches; light olive brown (2.5Y 5/4) loam; massive; friable; few fine reddish brown (5YR 4/4) concretions (iron oxide); few fine accumulations of calcium carbonate; few small pebbles; mildly alkaline; violent effervescence; clear smooth boundary.

C2—24 to 38 inches; light olive brown (2.5Y 5/4) loam; few fine distinct yellowish brown (10YR 5/8) and few fine faint grayish brown (2.5Y 5/2) mottles; massive; friable; few fine reddish brown (5YR 4/4) concretions (iron oxide); few fine accumulations of calcium carbonate; few small pebbles; mildly alkaline; violent effervescence; clear wavy boundary.

C3—38 to 60 inches; light olive brown (2.5Y 5/4) loam; few fine distinct yellowish brown (10YR 5/8) and few fine faint light yellowish brown (2.5Y 6/4) and grayish brown (2.5Y 5/2) mottles; massive; friable; few fine reddish brown (5YR 4/4) concretions (iron oxide); few fine accumulations of calcium carbonate; few small pebbles and shale fragments; mildly alkaline; violent effervescence.

The thickness of the solum generally is the same as the thickness of the A horizon. This horizon is about 3 to 10 inches thick. It is very dark brown (10YR 2/2), very dark gray (10YR 3/1), very dark grayish brown (10YR 3/2), or dark brown (10YR 3/3) loam. Pedons in eroded areas typically have an Ap horizon, which is mixed dark brown (10YR 3/3), brown (10YR 4/3 or 5/3), very dark grayish brown (10YR 3/2), or dark grayish brown (10YR 4/2). The C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 3 to 6. It is strongly or violently effervescent.

Vinje Series

The Vinje series consists of well drained soils on convex slopes in the uplands. These soils formed in silty glaciolacustrine sediments and in the underlying glacial till or till-like sediments. Permeability is moderately slow in the solum and moderate in the substratum. The native vegetation was prairie grasses. Slopes range from 2 to 14 percent.

Typical pedon of Vinje silty clay loam, 2 to 5 percent slopes; 1,770 feet south and 1,360 feet west of the northeast corner of sec. 6, T. 100 N., R. 23 W.

Ap—0 to 7 inches; very dark brown (10YR 2/2) silty clay loam, very dark grayish brown (10YR 3/2) dry; black (10YR 2/1) coatings on faces of peds; weak fine granular structure; friable; slightly acid; abrupt smooth boundary.

A—7 to 13 inches; very dark brown (10YR 2/2) silty clay loam, very dark grayish brown (10YR 3/2) dry; black (10YR 2/1) coatings on faces of peds; weak fine granular structure; friable; slightly acid; clear smooth boundary.

Bw1—13 to 17 inches; dark brown (10YR 4/3) silty clay loam; very dark grayish brown (10YR 3/2) coatings on faces of some peds; moderate fine subangular blocky structure parting to weak fine granular; friable; slightly acid; clear smooth boundary.

Bw2—17 to 24 inches; dark yellowish brown (10YR 4/4) silty clay loam; dark brown (10YR 3/3) coatings on faces of peds; moderate fine subangular blocky structure; friable; few faint thin discontinuous very dark grayish brown (10YR 3/2) clay films; slightly acid; clear smooth boundary.

Bw3—24 to 34 inches; dark yellowish brown (10YR 4/4) silty clay loam; brown (10YR 4/3) coatings on faces of some peds; few fine distinct grayish brown (2.5Y 5/2) mottles; moderate fine and very fine subangular blocky structure; friable; slightly acid; clear smooth boundary.

BC—34 to 41 inches; grayish brown (2.5Y 5/2) and olive brown (2.5Y 4/4) silty clay loam; weak medium prismatic structure parting to weak medium subangular blocky; friable; common fine distinct yellowish red (5YR 4/6) concretions and stains (iron oxide); slightly acid; clear wavy boundary.

C—41 to 47 inches; grayish brown (2.5Y 5/2) silt loam; common fine distinct yellowish red (5YR 5/8) and common fine faint light olive brown (2.5Y 5/4) mottles; some weak medium prismatic structure parting to weak medium subangular blocky; friable; few fine pores; few black (10YR 2/1) stains on faces of peds; violent effervescence; moderately alkaline; clear wavy boundary.

2C—47 to 60 inches; grayish brown (2.5Y 5/2) and yellowish brown (10YR 5/4) loam; common fine distinct strong brown (7.5YR 5/6) mottles; massive; friable; few fine pores; common yellowish red (5YR 4/6) concretions and stains on faces of peds and surrounding fine pores (iron oxide); violent effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates typically are 34 to 50 inches but range from 30 to 58 inches. The clay content averages about 35 percent throughout the solum but ranges from about 32 to 45 percent in individual horizons. The sand content ranges from about 5 to 25 percent. The sand is dominantly fine or very fine. The lacustrine sediments have no coarse sand or larger fragments, but small fragments of shale and coarse fragments make up as much as 5 percent of the 2C horizon in some pedons. The mollic epipedon is 10 to 20 inches thick.

The Ap and A horizons typically are black (10YR 2/1) to very dark grayish brown (10YR 3/2). The B horizon typically has hue of 10YR, value of 3 to 5, and chroma of 3 or 4, but the lower part has hue of 2.5Y and value of 4 or 5. This horizon typically is silty clay loam but in some pedons is silt loam, loam, or clay loam in the lower part. The C and 2C horizons have hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 2 to 4. The C horizon is silt loam or silty clay loam and formed in lacustrine sediments. The 2C horizon is loam or clay loam and formed in glacial till.

Waldorf Series

The Waldorf series consists of poorly drained, moderately slowly permeable soils in nearly level areas on hummocks and in the adjacent swales. These soils formed in silty and clayey glaciolacustrine sediments. The native vegetation was water-tolerant grasses. Slopes range from 0 to 2 percent.

Typical pedon of Waldorf silty clay loam, 0 to 2 percent slopes; 1,230 feet west and 2,430 feet south of the northeast corner of sec. 26, T. 100 N., R. 23 W.

Ap—0 to 7 inches; black (N 2/0) silty clay loam (39 percent clay), black (10YR 2/1) dry; weak fine granular structure; friable; neutral; abrupt smooth boundary.

A1—7 to 15 inches; black (N 2/0) silty clay (41.5 percent clay), black (10YR 2/1) dry; moderate fine and very fine granular structure; friable; neutral; clear smooth boundary.

A2—15 to 19 inches; black (5Y 2/1) silty clay (44.5 percent clay), very dark gray (10YR 3/1) dry; black (N 2/0) coatings on faces of peds; moderate fine and very fine granular structure; friable; neutral; clear smooth boundary.

Bg1—19 to 27 inches; dark gray (5Y 4/1) silty clay (43.3 percent clay); very dark gray (5Y 3/1) coatings on faces of peds; moderate fine subangular blocky structure; friable; neutral; clear smooth boundary.

Bg2—27 to 36 inches; olive gray (5Y 5/2) silty clay (43.5 percent clay); few fine distinct light olive brown (2.5Y 5/4) mottles; moderate fine subangular blocky structure; friable; neutral; clear smooth boundary.

Bg3—36 to 44 inches; olive gray (5Y 5/2) silty clay (41.5 percent clay); common fine distinct light olive brown (2.5Y 5/4 and 5/6) mottles; weak fine prismatic structure parting to weak fine subangular blocky; friable; neutral; abrupt wavy boundary.

Cg1—44 to 49 inches; olive gray (5Y 5/2) silty clay loam (39.6 percent clay); common fine distinct light olive brown (2.5Y 5/4 and 5/6) mottles; massive; friable; common reddish brown (5YR 4/4) concretions (iron oxide); mildly alkaline; weak effervescence; clear smooth boundary.

Cg2—49 to 60 inches; olive gray (5Y 5/2) silty clay loam (35.6 percent clay); massive; friable; common medium prominent reddish brown (5YR 4/4) concretions (iron oxide); moderately alkaline; strong effervescence.

The thickness of the solum ranges from 26 to 48 inches. The depth to free carbonates ranges from 26 to 55 inches. The mollic epipedon is 16 to 24 inches thick. The 10- to 40-inch control section has a clay content of 40 to 50 percent.

The A horizon has hue of 10YR, 2.5Y, or 5Y or is neutral in hue. It has value of 2 or 3 and chroma of 0 or 1. It is silty clay loam or silty clay. The B horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. It typically is silty clay, but silty clay loam and clay are within the range. The C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 1 or 2 and commonly has mottles. It typically is silty clay loam, silty clay, or clay, but silt loam is within the range.

Wapsie Series

The Wapsie series consists of well drained soils in outwash areas or glacial meltwater channels on uplands. These soils formed in loamy alluvium overlying sandy alluvium. Permeability is moderate in the solum and very rapid in the substratum. The native vegetation was mixed grasses and trees. Slopes range from 0 to 9 percent.

Typical pedon of Wapsie loam, 2 to 5 percent slopes; 2,500 feet north and 380 feet east of the southwest corner of sec. 23, T. 99 N., R. 23 W.

Ap—0 to 8 inches; very dark brown (10YR 2/2) loam, dark grayish brown (10YR 4/2) and brown (10YR 4/3) dry; mixed with some dark yellowish brown (10YR 4/4) streaks and pockets of subsoil material; weak fine and medium granular structure; friable; medium acid; abrupt smooth boundary.

Bt1—8 to 16 inches; dark yellowish brown (10YR 4/4) loam; dark brown (10YR 3/3) and dark yellowish brown (10YR 3/4) coatings on faces of peds; weak medium subangular blocky structure; friable; few thin discontinuous clay films on faces of peds; medium acid; gradual smooth boundary.

Bt2—16 to 22 inches; dark yellowish brown (10YR 4/4) sandy clay loam; dark brown (10YR 3/3) and dark yellowish brown (10YR 3/4) coatings on faces of peds; weak medium and coarse subangular blocky structure; friable; few thin discontinuous clay films on faces of peds; slightly acid; gradual smooth boundary.

Bt3—22 to 30 inches; dark yellowish brown (10YR 4/4) sandy clay loam; discontinuous dark yellowish brown (10YR 3/4) coatings on faces of peds; weak coarse subangular blocky structure; friable; few thin discontinuous clay films on faces of peds; slightly acid; gradual wavy boundary.

2C1—30 to 36 inches; dark yellowish brown (10YR 4/4 and 4/6) and yellowish brown (10YR 5/4) gravelly loamy sand; single grained; loose; very friable; slight effervescence; mildly alkaline; gradual wavy boundary.

2C2—36 to 60 inches; yellowish brown (10YR 5/4 and 5/6) gravelly sand; single grained; loose; slight effervescence; mildly alkaline.

The thickness of the solum ranges from about 18 to 36 inches. It typically is about the same as the depth to sand and gravel.

The A horizon is very dark brown (10YR 2/2), very dark gray (10YR 3/1), or very dark grayish brown (10YR 3/2). It is loam or silt loam that has a high content of sand. It is 6 to 10 inches thick. Some pedons have an E horizon, which is dark grayish brown (10YR 4/2) or grayish brown (10YR 5/2) and generally is mixed with darker material. The Bt horizon is dark yellowish brown (10YR 4/4), brown (10YR 4/3), or yellowish brown (10YR 5/4 or 5/6). It typically is loam in the upper part and loam or sandy clay loam in the lower part. In some pedons, however, the lower part is sandy loam.

The 2C horizon typically is yellowish brown (10YR 5/4 or 5/6), but in a few pedons it has hue of 7.5YR. Some pedons have a 2BC horizon. The 2BC and 2C horizons are gravelly loamy sand, gravelly sand, or sand. They have some gravel.

Webster Series

The Webster series consists of poorly drained, moderately permeable soils in upland swales. These soils formed in glacial sediments and glacial till. The native vegetation was water-tolerant grasses. Slopes range from 0 to 2 percent.

Typical pedon of Webster clay loam, 0 to 2 percent slopes; 220 feet north and 1,580 feet east of the southwest corner of sec. 5, T. 98 N., R. 25 W.

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

A—9 to 17 inches; black (N 2/0) clay loam, very dark gray (10YR 3/1) dry; weak fine and medium granular structure; friable; neutral; gradual smooth boundary.

AB—17 to 23 inches; black (10YR 2/1) clay loam, very dark gray (10YR 3/1) and dark gray (10YR 4/1) dry; mixed with very dark gray (10YR 3/1) streaks and pockets in the lower part; few fine distinct olive gray (5Y 5/2) mottles in the lower part; weak fine granular and subangular blocky structure; friable; neutral; clear smooth boundary.

Bg1—23 to 31 inches; dark gray (5Y 4/1) and olive gray (5Y 5/2) clay loam; mixed with very dark gray (10YR 3/1) streaks and pockets in the upper part; weak fine subangular blocky structure; friable; neutral; clear smooth boundary.

Bg2—31 to 39 inches; olive gray (5Y 5/2) clay loam; mixed with few dark gray (5Y 4/1) streaks and pockets; few fine distinct strong brown (7.5YR 5/6) and common fine faint olive (5Y 5/3) mottles; weak fine subangular blocky structure; friable; few dark brown (7.5YR 3/2) and black (10YR 2/1) concretions (iron and manganese oxides); slight effervescence in spots; neutral; gradual smooth boundary.

Bg3—39 to 46 inches; olive gray (5Y 5/2) loam; few fine distinct yellowish brown (10YR 5/8) mottles; weak fine subangular blocky structure; friable; many tubular pores; common dark brown (7.5YR 3/2) and black (10YR 2/1) concretions (iron and manganese oxides); common accumulations of calcium carbonate; few very dark gray (5Y 3/1) wormcasts; slight effervescence; mildly alkaline; gradual smooth boundary.

Cg—46 to 60 inches; light olive gray (5Y 6/2) loam; common fine distinct yellowish brown (10YR 5/8) and few fine distinct strong brown (7.5YR 5/6) mottles; massive; friable; many tubular pores; dark brown (7.5YR 3/2) and black (10YR 2/1) concretions (iron and manganese oxides); common accumulations of calcium carbonate; strong effervescence; mildly alkaline.

The thickness of the solum ranges from 24 to 50 inches. It commonly is the same as the depth to free carbonates, but some pedons have a BC horizon that contains free carbonates.

The Ap and A horizons are black (N 2/0 or 10YR 2/1). The AB horizon is black (N 2/0 or 10YR 2/1) or very dark gray (10YR 3/1). The A and AB horizons are clay loam or silty clay loam. The depth to the B horizon is 14 to 24 inches. The Bg and BC horizons are dark grayish brown (2.5Y 4/2), dark gray (5Y 4/1), gray (5Y 5/1), or olive gray (5Y 5/2). They are clay loam or silty clay loam. The colors in the Cg horizon generally are similar to those in the B horizon, but the range includes light olive gray (5Y 6/2) and olive (5Y 5/3).

Formation of the Soils

In this section, the factors that have affected the formation of soils in Winnebago County are described and the processes of horizon differentiation are explained.

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, or lay of the land; and the length of time that the forces of soil formation have acted on the soil material (*10*). Human activities also affect soil formation.

The active factors of soil formation are climate and plant and animal life. These factors act on the parent material and slowly change it into a natural body that has genetically related horizons. The effects of plant and animal life are conditioned by relief. The parent material affects the kind of soil profile that forms and in extreme cases determines it almost entirely. Finally, time is needed for a soil to form in the parent material. Some time is always needed for the differentiation of soil horizons.

The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effects 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 soils in Winnebago County formed in material that was transported from the site of the parent rock and redeposited at a new location through the actions of glacial ice, water, wind, and gravity.

The parent materials in the county are glacial till, glacial outwash, alluvium, organic deposits, wind- or water-deposited sandy material, and glaciolacustrine sediment. The bedrock beneath these materials has been buried so deeply that it has had no influence on the soils. The glacial drift is about 150 feet deep over bedrock throughout most of the county (*16*). The bedrock topography ranges from about 1,050 feet above mean sea level in the western part of the county to about 1,150 feet in the eastern part (*6*).

Glacial till is unsorted sediment in which particles range in size from clay to boulders (*19*). It is the most important parent material in the county. The earliest glaciations in Iowa began sometime before 2.2 million years ago (*4, 5*). The county was probably glaciated several times during the earliest pre-Illinoian stages (*4*), but deposits from these earlier glaciations were either removed by later glacial erosion or are now deeply buried beneath younger deposits.

Glacial deposits of the youngest glacial stage, the Wisconsinan, make up most of the surface and near-surface parent materials in the uplands. They were deposited by the Des Moines Lobe of the continental ice sheet approximately 12,000 to 14,000 years ago (*12, 19*). The upland topography and parent materials vary throughout the county as a result of this glaciation. A broad belt of hummocky topography in the Altamont-Bemis Moraine complex is in the eastern part of the county (*11*). It extends along the southern edge of the county for about 4 miles west of Forest City. Similar hummocky topography of the Algona Moraine is in a belt 5 to 7 miles wide on the west side of Lime Creek.

The hummocky topography of these end moraines formed primarily through supraglacial deposition (*11*). As a result, the parent material in the uplands varies locally. Most areas are dominated by glacial till. The till is a heterogeneous mixture, indicating its glacial origin, and shows little evidence of sorting or stratification. Kamelike knobs and glacial eskers are common landforms in these areas (fig. 14). Salida soils formed in sandy deposits in many of these areas. Storden, Clarion, Hayden, Lester, and Le Sueur soils formed in the glacial till.

To the west of the Algona Moraine, in the western two-thirds of the county, the uplands generally have a low-relief topography of swells and swales. Clarion, Nicollet, and Storden are the major soils that formed in glacial till on these uplands.

Outwash deposited by glacial meltwater streams is an important geologic deposit in the county. Sand and gravel are deposited along the margin of the Algona Moraine, which in places borders Lime Creek (*19*). The most extensive deposits are near Scarville and Leland and west of Forest City. Other deposits are associated with the Altamont-Bemis Moraine complex south of Rice

Figure 14.—An area of Salida gravelly sandy loam, 9 to 18 percent slopes, on a glacial esker.

Lake. Similar deposits of lesser extent and depth are in scattered areas in other parts of the county, commonly adjacent to the smaller streams. Mayer, Linder, Ridgeport, Hanska, and Wapsie soils formed in outwash material.

Alluvium is sediment that has been deposited along major and minor streams and drainageways and at the base of some steep slopes. It varies widely in texture because of differences in the source material and in the manner in which it was deposited. In Winnebago County the main source of alluvium is glacial till.

Some of the alluvial material has been transported only short distances. This material is called local alluvium or colluvium. It retains many of the characteristics of the soils from which it was washed. The sloping Spillville soils, for example, are at the base of slopes below soils that formed in glacial till.

Colo silty clay loam, channeled, is the main alluvial soil along the Winnebago River. Coarser textured alluvium mainly occurs only as narrow bands in scattered areas adjacent to the river. These areas were too small to be separated in mapping. Along the smaller streams in the county, the main soil that formed in alluvium is Coland clay loam.

Organic material accumulated in old lakebeds or swamps that supported a heavy growth of aquatic plants and other vegetation that grew under excessively wet conditions. The vegetation partly decomposed and accumulated in fairly thick beds under water. In places the deposits are more than 20 feet thick. Glacial till or finer textured local alluvium generally underlies the organic material. In places layers of mineral soil material separate layers of organic material. Boots, Blue Earth, Houghton, Palms, and Muskego soils formed in organic material. In Blue Earth and Muskego soils, the organic material has been modified by aquatic animal life.

Wind- or water-deposited sandy material in Winnebago County was probably deposited mainly by water. In most areas, however, it has been reworked to some extent by the wind. Dickinson and Dickman soils formed in these deposits.

Glaciolacustrine sediment, which is dominantly fine textured, is the parent material of a number of soils in the county. The older sediment was deposited in lakes on the glacial surface, whereas the younger sediment was deposited in small lakes or marshes on the modern land surface. These small lakes and marshes have subsequently been drained.

Ranging from about 3 to more than 9 feet in thickness, the glaciolacustrine sediment caps various knobs of the Altamont-Bemis Moraine complex in the eastern part of the county. It has a consistent two-fold stratigraphy. The upper part is massive, fine textured material in which modern soils formed. The lower part is a thin layer of stratified sand that has a pebble band. Glacial till and other glacial deposits underlie the glaciolacustrine sediment. Collinwood, Kilkenny, Shorewood, and Vinje soils formed in areas where this sediment mantles knobs or hummocks.

Fine textured lacustrine sediment is deposited in closed depressions and in swales between knobs throughout the county, particularly on the Altamont-Bemis and Algona Moraines in the eastern third of the county. These deposits formed in shallow lakes and marshes, which have been drained. The deposits typically are 8 to 10 feet thick but may be as much as about 20 feet thick. Even though they are fine grained, they are noticeably stratified. Waldorf and Minnetonka soils formed in the lacustrine sediment. The sloping Coland soils formed on foot slopes around depressions containing lacustrine or organic sediment.

Climate

Winnebago County has a midcontinental, subhumid climate. The eastern part of the county has a slightly longer growing season and receives more rainfall than the western part (*24*).

Climate influences the formation of soils in many ways. Rainfall affects the extent of leaching in soils and helps to determine the kind of vegetation that grows on the soils. Temperature affects the growth of plants, the activity of micro-organisms, and the rate of chemical actions in the soils. Temperature and moisture conditions affect the rate at which parent material weathers. The amount and seasonal distribution of precipitation help to determine the depth to which calcium carbonates, other soluble minerals, and clay are moved downward through the soil and the rate of erosion. Precipitation also affects the depth to the water table in poorly drained and somewhat poorly drained soils. The depth to the water table, in turn, affects the depth of development in the subsoil. In areas where the water table is near the surface most of the year, the subsoil does not develop to so great a depth as the subsoil in areas where the water table is lower.

Soils form more rapidly in a warm climate than in a cold climate. They also form more rapidly in a wet climate than in a dry climate. Except for climatic differences resulting from topography, the soils in Winnebago County formed under about the same climate. The climate has not been the same, however, during the entire period of soil formation.

The formation of the soils in Winnebago County began about 13,000 years ago, after the glaciation in Iowa ended and a warming trend began (*21*). The climate in northern Iowa since that time has varied considerably (*3, 31*). From before 13,000 to about 11,000 years ago, the climate was cool and the vegetation was dominantly a coniferous forest of spruce. As the climate warmed, deciduous vegetation invaded and persisted until about 9,000 years ago. After this time, the climate became warmer and drier. Prairie vegetation became dominant in Iowa by about 8,000 years ago. During the past 8,000 years, the climate has fluctuated to a minor extent. During some periods it was similar to the present climate, and during other periods it was warmer and drier. During the past 3,000 years, it has been generally similar to the present climate (*13*).

The climate in the part of Winnebago County east of the Winnebago River has been conducive to mixed prairie grasses and deciduous forest. In this part of the county, numerous large depressions or bogs that were not drained until recent times helped to provide a more humid environment, which favored deciduous trees. Along with the Winnebago River, they also tended to impede prairie fires, which would have hindered or prevented the growth of trees.

In the rest of the county, most of the soils do not have characteristics indicating that they were ever forested. Evidently, the rapid geologic erosion that accompanied major climatic changes removed the soils that formed under forest vegetation. Therefore, the soil landscapes generally are less than 8,000 years old. Most of the soil features relating to the prairie environment have developed during the last 3,000 years of relative erosional stability (*31*). Clarion, Nicollet, Webster, Okoboji, and other soils formed under prairie vegetation.

The effect of climate on soils is modified by local conditions, such as relief. For example, the microclimate in areas of the low lying, poorly drained Webster and Canisteo soils is cooler and wetter than that in areas of the well drained adjacent soils, such as Clarion. The microclimate in areas of Storden and other soils on the steeper slopes is drier than that in areas of the adjacent Clarion soils on gentle slopes. South- and west-facing slopes generally are slightly warmer and less humid than nearby areas. These variations account for some of the differences among soils within the same general climatic region. Partly because of these microclimatic conditions, areas in the eastern part of the county and areas adjacent to Myre Slough and Lake Harmon support native trees.

Plant and Animal Life

Vegetation and animal life are important factors of soil formation. Vegetation is especially important. Many changes in vegetation took place in Winnebago County during the postglacial period. Forest vegetation dominated by spruce grew on the soils until about 11,000 years ago. It was followed by deciduous forest, which lasted until about 9,000 years ago. Then, prairie vegetation began to dominate (*3, 31*). For the past 8,000 years, the soils have been influenced by both prairie grasses and deciduous trees. Big bluestem and little bluestem were probably the main prairie grasses. The main trees were oak, hickory, ash, elm, and maple.

Variations in the kinds of vegetation commonly cause marked differences among soils (*15*). As plants grow and die, their remains are added to the soil. Burrowing animals, earthworms, bacteria, protozoa, other microbes, and fungi help to convert these 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. Humus gives the surface soil its dark color.

Large burrowing animals, such as badgers, foxes, and pocket gophers, significantly affect soil formation in small areas. Small animals, such as earthworms, also influence soil formation. They move up and down in soils as the soil moisture and temperature change. In many soils in the county, earthworms have moved material from one horizon to another.

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 trees have a thinner, lighter colored surface layer because the organic matter, derived mainly from leaves, accumulated only on the surface. Soils that formed under mixed grasses and timber are intermediate in color.

Dark soils, such as Webster, Nicollet, and Clarion soils, formed more recently under prairie vegetation. Lester soils formed under mixed grasses and timber and are typically lighter colored in the surface layer than the Webster, Nicollet, and Clarion soils. Hayden soils formed under timber and have a thin, light colored surface layer.

Relief

Relief is an important cause of differences among soils. It indirectly influences soil formation through its effect on drainage, runoff, and erosion. More water runs off the surface of the steeper areas, and less soaks into the soil. As a result, less leaching of carbonates occurs and less clay is moved from the surface layer into the subsoil. Also, the hazard of erosion is more severe on the steeper slopes. Much of the acreage in Winnebago County is nearly level to moderately sloping, but many areas are strongly sloping to steep.

The topography in Winnebago County is geologically immature, as is evidenced by a large number of small depressions or potholes, other depressions, and the lack of minor upland streams. The county has three main types of moraine topography. One type is a series of flat-topped, smooth-sided slopes that have many small depressions and an indistinct drainage pattern. This kind of topography generally has low relief. It is prevalent in most of the western two-thirds of the county. Clarion, Nicollet, Webster, Canisteo, and Okoboji are the major soils on this topography.

Another dominant kind of topography is along the lateral front of the Algona Moraine. It is in a belt, 5 to 7 miles wide, that extends northeast to southwest on the west side of Lime Creek. It consists of high-relief hummocks or high hills that have steep side slopes dissected to some extent by upland drainageways. Clarion and Storden soils are dominant in this area.

The third type of topography is in the eastern part of the county. It generally is hummocky and has high relief. The landscape is one of relatively broad, flat-topped hummocks and ridges that have low areas or swales between knobs. The low areas and swales commonly interconnect relatively large depressional areas of organic soils. Much of the acreage probably was an area of ice-walled lakes at the time of glaciation (*11*). In this area the soils formed in glaciolacustrine sediments. Examples are Collinwood, Shorewood, Vinje, Kilkenny, and Waldorf soils. In other areas of this topography, Hayden and Lester soils are dominant.

Variations in relief are a major reason for the differing soil properties among some of the soils in the county. Topography affects the color, the thickness of the solum, and the horizonation of the soils, as is evident in Storden, Clarion, and Nicollet soils, which formed in the same kind of parent material and under similar vegetation. These soils differ from each other because of variations in topography. The thickness and color of the surface layer and the thickness of the solum are related to the slope. The surface layer is thicker and darker in the less sloping areas. Storden soils are typically on the steepest slopes, Clarion soils on the intermediate slopes, and Nicollet soils in nearly level areas. The solum typically is thinnest in the Storden soils and thickest in the Nicollet soils.

Topography affects the color of the subsoil through its effect on drainage and soil aeration. A well drained soil generally has a brown subsoil because iron compounds are oxidized and well distributed throughout the horizon. The sloping Clarion soils are an example. On the other hand, soils in nearly level or depressional areas are wet and commonly have a gray or mottled subsoil because of poor aeration and restricted drainage. Webster soils are an example.

Colo and Coland soils are on bottom land. Although they are nearly level, their microrelief affects runoff, the depth to the water table, and the rate at which they receive new sediment.

Time

Geologically, the soils in Winnebago County are young. The radiocarbon technique for determining the age of carbonaceous material found in till has made it possible to determine the approximate age of soils and Pleistocene deposits in Iowa. Published studies provide information about the age of soils in Iowa (*18, 19, 20, 21*).

The radiocarbon technique indicates that the most recent Wisconsinan glaciation in north-central Iowa occurred 14,000 to 12,000 years ago (*4, 19*). The soils in Winnebago County formed after this glaciation. Soil formation began at widely differing times, depending on the local landscape evolution.

In much of Iowa, including Winnebago County, erosion has beveled the side slopes of uplands, and in places soil material has been removed and deposited on lower lying slopes (*19, 21*). This sediment accumulated as local alluvium on foot slopes. The sloping Spillville soils formed in this alluvium. The uplands have an older surface on the summits than on the side slopes. The side slopes are less than 13,000 years old and in places less than 3,000 years old (*31*).

Clarion, Storden, and other soils on side slopes are subject to geologic erosion, which continually exposes fresh material. As a result, the age of these soils ranges from that of the parent material to that of the most recent sediment.

The soils that formed in glacial outwash on terraces, such as Linder and Ridgeport soils, are less than 13,000 years old (*19*). The age of the soils that formed in alluvium ranges from that of the recently deposited material in areas of Spillville loam and Colo silty clay loam, channeled, to that of the slightly older sediment in which Coland clay loam formed. The older sediment is less than about 13,000 years old and is probably much younger.

Human Activities

Important changes have taken place in the soils since Winnebago County was settled. Breaking the prairie sod and draining some of the many depressions and small lakes affected the protective cover.

The most drastic changes are those caused by water erosion. Cultivation increases the runoff rate and thus the susceptibility to erosion, which removes topsoil, organic matter, and plant nutrients. Sheet or rill erosion, the most prevalent kind of erosion in the county, removes only a fraction of an inch at a time. Plowing and cultivation generally destroy the evidence of this loss. Over a period of years, however, much eroded soil is deposited on the lower slopes and foot slopes. The sloping Spillville soils formed in this eroded material. In other areas shallow and deep gullies have formed. As the land was brought under cultivation, the runoff rate increased and the rate at which water moved into the soil decreased. As a result, accelerated erosion has removed part or all of the original surface layer from sloping soils in some areas (fig. 15).

Erosion has changed not only the thickness of the surface layer but also its structure. In severely eroded areas the plow layer consists of the upper part of the subsoil mixed with the remaining surface layer or, in the

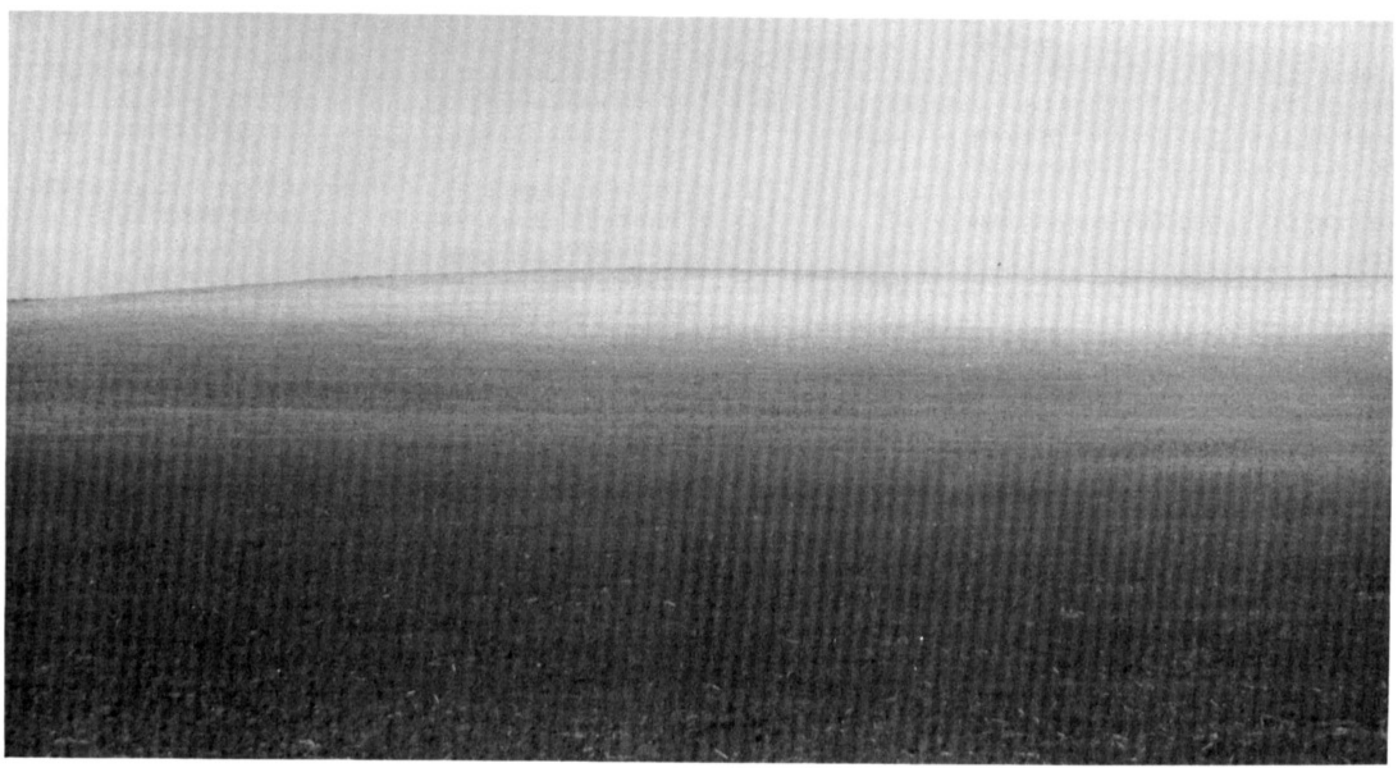

Figure 15.—An area of Storden loam, 14 to 20 percent slopes, moderately eroded, where erosion has removed the original surface soil, exposing the yellowish brown and light olive brown substratum. Spillville loam, 2 to 5 percent slopes, is in the foreground.

Storden soils, the upper part of the substratum mixed with small amounts of the remaining surface layer.

Erosion and cultivation also reduce the organic matter content, available water capacity, and fertility level of the soil. Even in areas that are not subject to erosion, compaction by heavy machinery reduces the thickness of the surface layer and alters the soil structure. The granular structure so apparent in virgin grassland breaks down somewhat under intensive cropping. As a result, the surface becomes hard when dry.

Erosion is one of the main reasons for the reduction of the organic matter content in soils. As much as a third of the organic matter, however, is lost through causes other than erosion (*27*). Cultivation and cropping reduce the content and in places redistribute the organic matter. Maintaining as high a content as was originally present under native grasses generally is not feasible. The content should be high enough, however, to maintain crop production.

On the other hand, human activities have increased the productivity of soils, decreased soil loss, and reclaimed areas that otherwise are not suitable for crops or pasture. For example, terraces and similar measures have slowed runoff and thus have helped to control erosion. Flooding has been controlled in areas where streams have been straightened and deepened and obstacles to floodwater have been removed. As a result of these measures, some areas along streams are better suited to cultivated crops. Drainage ditches have provided outlets for tile drains and drained depressions and small lakes. They have improved the suitability for most agricultural uses, but they have also destroyed the native habitat for some wildlife species. Applications of commercial fertilizer and lime have corrected deficiencies in plant nutrients, so that some soils are more productive than they were in their natural state.

Processes of Horizon Differentiation

Soil horizons are faintly or moderately expressed in most of the soils in Winnebago County. Storden, Webster, and Canisteo soils have faint horizons; Clarion and Nicollet soils have intermediate horizons; and Hayden and Lester soils have somewhat more prominent horizons. Some soils have a marked difference in texture between the solum and an underlying 2C horizon. Examples are soils that formed in outwash, such as Mayer and Linder soils, and soils that formed in two kinds of parent material, such as Kilkenny and Vinje soils.

Horizon differentiation results from soil-forming processes. These processes are the accumulation of organic matter, leaching of calcium carbonates and other bases, the accumulation of calcium carbonates, the formation and translocation of silicate clay minerals, and the reduction and transfer of iron (*26*). Each of these processes helps to determine the kind of soil horizons that form and the rate of soil formation. As most soils form, organic matter is added, soluble salts or bases and carbonates are removed, clay is transferred from the surface downward, and primary minerals are transformed into secondary minerals that can be used by plants. In general, these processes tend to promote horizon differentiation, but some changes tend to offset or retard it. The processes and resulting changes proceed simultaneously in soils, and thus the ultimate nature of the profile is governed by the balance of these processes within the soil.

In most of the soils in Winnebago County, some organic matter has accumulated in the A horizon. The accumulation of organic matter is one of the first evidences of horizon differentiation. In soils that formed in organic deposits, the A horizon has a very high organic matter content. Examples are Palms and Houghton soils. Some mineral soils have a high organic matter content and a thick A horizon. Examples are Okoboji, Webster, Canisteo, and Colo soils. Clarion soils have a moderate organic matter content. Storden and Hayden are examples of soils that have a low organic matter content and a faint, thin A horizon.

Leaching of calcium carbonates and other bases has occurred in many soils in Winnebago County. Leaching generally occurs before and during the translocation of silicate clay minerals. Percolating water removes soluble salts and calcium carbonates from the upper horizons. The depth to which calcium carbonates precipitate generally is an indication of the usual depth to which water percolates or the depth to the water table in part of the year. A B horizon forms as carbonates are moved downward. This leaching has occurred to a moderate depth in Clarion and Nicollet soils. Hayden, Dundas, and Lester soils generally are more strongly leached and to a somewhat greater depth. The removal of calcium carbonates has progressed much more slowly, or not at all, in Storden soils because erosion removes most of the surface layer and organic matter as the soils form. Thus, only minimal horizonation has occurred.

Horizons are faintly expressed in Harps and Canisteo soils. Carbonates have accumulated in the upper horizons, partly because of the upward movement of water in the profile, which retards leaching and transformations, resulting in weakly developed upper horizons. The calcium carbonate equivalent in Harps soils ranges from about 15 to 40 percent.

The formation and translocation of silicate clay minerals have contributed to the development of more prominent horizons in Hayden, Lester, and Dundas soils. The B horizon of these soils has more clay than the A horizon, and in many areas dark clay coatings are on faces of peds and in and along root channels. In places an eluviated E horizon has platy structure, has less clay than the A or B horizon, and is lighter in color, especially when the soil is dry. The leaching of bases and the translocation of clay have been more dominant processes of horizonation in these soils than the accumulation of organic matter. The depth to which clay is moved is related to the depth of water percolation during the growing season (*22*).

Transfers of compounds from lower horizons to upper horizons also occur. For example, phosphorus is removed from the subsoil by plant roots, is transferred to the parts of the plants above ground, and subsequently is returned to the surface in plant residue.

Transformations occur in all horizons, but the rate of transformation is most rapid in the surface layer. During the growing season, organic matter is broken down and transformed into simpler chemical compounds and elements. Also, primary minerals are transformed into secondary mineral elements. As a result of most transformations, the elements are more available to plants. For example, if the pH level is near 7, the primary mineral apatite is weathered to secondary phosphorus compounds that plants can use (*7, 23*). At a higher pH level, however, this transformation is slowed and other phosphorus compounds that are not available to plants are formed. As a result, soils with a pH of more than 7, such as Harps and Canisteo soils, have a lower supply of available phosphorus than soils that have a pH level near 7, such as Nicollet and Webster soils.

Gleying, or the reduction and transfer of iron, is evident in poorly drained and very poorly drained soils (*25*). Okoboji, Webster, Canisteo, and Harps soils, for example, have a gleyed B horizon. The iron in this horizon is transformed from an oxidized form to a reduced form that is soluble and can be moved with water. This process results in gray or olive colors. In places these 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.
Bisequum. Two sequences of soil horizons, each of which consists of an illuvial horizon and the overlying eluvial horizons.
Bottom land. The normal flood plain of a stream, subject to flooding.
Boulders. Rock fragments larger than 2 feet (60 centimeters) in diameter.
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.
Cation. An ion carrying a positive charge of electricity. The common soil cations are calcium, potassium, magnesium, sodium, and hydrogen.
Cation-exchange capacity. The total amount of exchangeable cations that can be held by the soil, expressed in terms of milliequivalents per 100 grams of soil at neutrality (pH 7.0) or at some other stated pH value. The term, as applied to soils, is synonymous with base-exchange capacity, but is more precise in meaning.
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.
Claypan. A slowly permeable soil horizon that contains much more clay than the horizons above it. A claypan is commonly hard when dry and plastic or stiff when wet.
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.

Compressible (in tables). Excessive decrease in volume of soft soil under load.

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.

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.

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.

Field moisture capacity. The moisture content of a soil, expressed as a percentage of the ovendry weight, after the gravitational, or free, water has drained away; the field moisture content 2 or 3 days after a soaking rain; also called *normal field capacity, normal moisture capacity,* or *capillary capacity.*

Fine textured soil. Sandy clay, silty clay, and clay.

First bottom. The normal flood plain of a stream, subject to frequent or occasional flooding.

Foot slope. The inclined surface at the base of a hill.

Fragile (in tables). A soil that is easily damaged by use or disturbance.

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 meltwater.

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 meltwater. 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.

Green manure crop (agronomy). A soil-improving crop grown to be plowed under in an early stage of maturity or soon after maturity.

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.

Hardpan. A hardened or cemented soil horizon, or layer. The soil material is sandy, loamy, or clayey and is cemented by iron oxide, silica, calcium carbonate, or other substance.

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.

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.

Landslide. The rapid downhill movement of a mass of soil and loose rock, generally when wet or saturated. The speed and distance of movement, as well as the amount of soil and rock material, vary greatly.

Leaching. The removal of soluble material from soil or other material by percolating water.

Liquid limit. The moisture content at which the soil passes from a plastic to a liquid state.

Loam. Soil material that is 7 to 27 percent clay particles, 28 to 50 percent silt particles, and less than 52 percent sand particles.

Loess. Fine grained material, dominantly of silt-sized particles, deposited by wind.

Low strength. The soil is not strong enough to support loads.

Medium textured soil. Very fine sandy loam, loam, silt loam, or silt.

Metamorphic rock. Rock of any origin altered in mineralogical composition, chemical composition, or structure by heat, pressure, and movement. Nearly all such rocks are crystalline.

Mineral soil. Soil that is mainly mineral material and low in organic material. Its bulk density is more than that of organic soil.

Miscellaneous area. An area that has little or no natural soil and supports little or no vegetation.

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).

Muck. Dark colored, finely divided, well decomposed organic soil material. (See Sapric soil material.)

Munsell notation. A designation of color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color of 10YR hue, value of 6, and chroma of 4.

Neutral soil. A soil having a pH value between 6.6 and 7.3. (See Reaction, soil.)

Nutrient, plant. Any element taken in by a plant essential to its growth. Plant nutrients are mainly nitrogen, phosphorus, potassium, calcium, magnesium, sulfur, iron, manganese, copper, boron, and zinc obtained from the soil and carbon, hydrogen, and oxygen obtained from the air and water.

Organic matter. Plant and animal residue in the soil in various stages of decomposition.

Outwash 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).

Ped. An individual natural soil aggregate, such as a granule, a prism, or a block.

Pedon. The smallest volume that can be called "a soil." A pedon is three dimensional and large enough to permit study of all horizons. Its area ranges from about 10 to 100 square feet (1 square meter to 10 square meters), depending on the variability of the soil.

Percolation. The downward movement of water through the soil.

Percs slowly (in tables). The slow movement of water through the soil adversely affecting the specified use.

Permeability. The quality of the soil that enables water to move downward through the profile. Permeability is measured as the number of inches per hour that water moves downward through the saturated soil. Terms describing permeability are:

Very slow	less than 0.06 inch
Slow	0.06 to 0.2 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.

Plowpan. A compacted layer formed in the soil directly below the plowed layer.

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.

Productivity, soil. The capability of a soil for producing a specified plant or sequence of plants under specific management.

Profile, soil. A vertical section of the soil extending through all its horizons and into the parent material.

Reaction, soil. A measure of acidity or alkalinity of a soil, expressed in pH values. A soil that tests to pH 7.0 is described as precisely neutral in reaction because it is neither acid nor alkaline. The degree of acidity or alkalinity is expressed as—

	pH
Extremely acid	below 4.5
Very strongly acid	4.5 to 5.0
Strongly acid	5.1 to 5.5
Medium acid	5.6 to 6.0
Slightly acid	6.1 to 6.5
Neutral	6.6 to 7.3
Mildly alkaline	7.4 to 7.8
Moderately alkaline	7.9 to 8.4
Strongly alkaline	8.5 to 9.0
Very strongly alkaline	9.1 and higher

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.

Rock fragments. Rock or mineral fragments having a diameter of 2 millimeters or more; for example, pebbles, cobbles, stones, and boulders.

Rooting depth (in tables). Shallow root zone. The soil is shallow over a layer that greatly restricts roots.

Root zone. The part of the soil that can be penetrated by plant 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.

Sandstone. Sedimentary rock containing dominantly sand-size particles.

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.

Shale. Sedimentary rock formed by the hardening of a clay deposit.

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.

Siltstone. Sedimentary rock made up of dominantly silt-sized particles.

Similar soils. Soils that share limits of diagnostic criteria, behave and perform in a similar manner, and have similar conservation needs or management requirements for the major land uses in the survey area.

Slickensides. Polished and grooved surfaces produced by one mass sliding past another. In soils, slickensides may occur at the bases of slip surfaces on the steeper slopes; on faces of blocks, prisms, and columns; and in swelling clayey soils, where there is marked change in moisture content.

Slick spot. A small area of soil having a puddled, crusted, or smooth surface and an excess of exchangeable sodium. The soil is generally silty or clayey, is slippery when wet, and is low in productivity.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multipled 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 ensure satisfactory performance of the soil for a specific use.

Sloughed till. Water-saturated till that has flowed slowly downhill from its original place of deposit by glacial ice. It may rest on other till, on glacial outwash, or on a glaciolacustrine deposit.

Slow refill (in tables). The slow filling of ponds, resulting from restricted permeability in the soil.

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.

Stone line. A concentration of coarse fragments in a soil. Generally it is indicative of an old weathered surface. In a cross section, the line may be one fragment or more thick. It generally overlies material that weathered in place and is overlain by recent sediment of variable thickness.

Stones. Rock fragments 10 to 24 inches (25 to 60 centimeters) in diameter.

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 grained* (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 about 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. It 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.

Toe slope. The outermost inclined surface at the base of a hill; part of a foot slope.

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.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Valley fill. In glaciated regions, material deposited in stream valleys by glacial meltwater. In nonglaciated regions, alluvium deposited by heavily loaded streams.

Variegation. Refers to patterns of contrasting colors assumed to be inherited from the parent material rather than to be the result of poor drainage.

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 distributed over a wide range in size or diameter. Such soil normally can be easily increased in density and bearing properties by compaction. Contrasts with poorly graded soil.

Wilting point (or permanent wilting point). The moisture content of soil, on an 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

[Recorded in the period 1951-79 at Forest City, Iowa]

Month	Temperature						Precipitation				
	Average daily maximum	Average daily minimum	Average	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----	22.3	3.1	12.7	45	-26	0	0.87	0.36	1.30	3	9.7
February---	29.0	9.6	19.3	50	-20	0	.90	.26	1.42	3	7.5
March------	39.6	21.0	30.3	71	-10	21	2.06	.94	3.04	5	11.1
April------	57.4	35.5	46.5	86	15	73	2.97	1.65	4.12	7	1.7
May--------	71.1	47.3	59.2	91	28	303	3.92	2.42	5.25	8	.0
June-------	80.1	56.6	68.4	95	40	552	4.76	2.67	6.59	7	.0
July-------	83.8	61.4	72.6	96	47	701	4.42	1.92	6.54	6	.0
August-----	81.9	59.0	70.5	94	44	636	4.28	1.76	6.41	6	.0
September--	73.2	49.6	61.4	91	32	342	2.90	1.03	4.43	5	.0
October----	62.5	39.1	50.8	87	19	147	1.96	.55	3.11	5	.1
November---	43.0	24.9	34.0	69	-4	0	1.36	.37	2.17	4	4.2
December---	28.9	11.9	20.4	55	-21	0	1.03	.47	1.50	3	8.6
Yearly:											
Average--	56.1	34.9	45.5	---	---	---	---	---	---	---	---
Extreme--	---	---	---	98	-26	---	---	---	---	---	---
Total----	---	---	---	---	---	2,775	31.43	24.25	37.37	62	42.9

* 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 degrees F).

TABLE 2.--FREEZE DATES IN SPRING AND FALL

[Recorded in the period 1951-79 at Forest City, Iowa]

Probability	Temperature		
	24^{o} F or lower	28^{o} F or lower	32^{o} F or lower
Last freezing temperature in spring:			
1 year in 10 later than--	May 12	May 24	June 8
2 years in 10 later than--	Apr. 30	May 11	May 25
5 years in 10 later than--	Apr. 5	Apr. 14	Apr. 27
First freezing temperature in fall:			
1 year in 10 earlier than--	Sept. 27	Sept. 13	Sept. 2
2 years in 10 earlier than--	Oct. 9	Sept. 26	Sept. 16
5 years in 10 earlier than--	Nov. 1	Oct. 20	Oct. 11

TABLE 3.--GROWING SEASON

[Recorded in the period 1951-79 at Forest City, Iowa]

Probability	Daily minimum temperature during growing season		
	Higher than 24^{o} F	Higher than 28^{o} F	Higher than 32^{o} F
	Days	Days	Days
9 years in 10	181	157	138
8 years in 10	187	165	144
5 years in 10	200	179	156
2 years in 10	214	193	169
1 year in 10	222	202	176

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS

Map symbol	Soil name	Acres	Percent
6	Okoboji silty clay loam, 0 to 1 percent slopes	14,660	5.7
28B	Dickman sandy loam, 2 to 7 percent slopes	890	0.3
55	Nicollet loam, 1 to 3 percent slopes	26,885	10.5
62C2	Storden loam, 5 to 9 percent slopes, moderately eroded	850	0.3
62D2	Storden loam, 9 to 14 percent slopes, moderately eroded	1,230	0.5
62E2	Storden loam, 14 to 20 percent slopes, moderately eroded	805	0.3
73B	Salida gravelly sandy loam, 2 to 7 percent slopes	425	0.2
73E	Salida gravelly sandy loam, 9 to 18 percent slopes	280	0.1
90	Okoboji mucky silt loam, 0 to 1 percent slopes	5,100	2.0
95	Harps loam, 1 to 3 percent slopes	10,040	3.9
107	Webster clay loam, 0 to 2 percent slopes	21,340	8.3
135	Coland clay loam, 0 to 2 percent slopes	2,340	0.9
135B	Coland clay loam, 2 to 5 percent slopes	975	0.4
138B	Clarion loam, 2 to 5 percent slopes	22,690	8.8
138C	Clarion loam, 5 to 9 percent slopes	295	0.1
138C2	Clarion loam, 5 to 9 percent slopes, moderately eroded	17,080	6.7
138D2	Clarion loam, 9 to 14 percent slopes, moderately eroded	1,530	0.6
150	Hanska loam, 0 to 2 percent slopes	1,010	0.4
168B	Hayden loam, 2 to 5 percent slopes	735	0.3
168C	Hayden loam, 5 to 9 percent slopes	430	0.2
168D2	Hayden loam, 9 to 14 percent slopes, moderately eroded	385	0.1
168E	Hayden loam, 14 to 25 percent slopes	210	0.1
175B	Dickinson fine sandy loam, 2 to 5 percent slopes	770	0.3
221	Palms muck, 0 to 1 percent slopes	4,830	1.9
224	Linder loam, 0 to 2 percent slopes	1,445	0.6
236B	Lester loam, 2 to 5 percent slopes	3,870	1.5
236C2	Lester loam, 5 to 9 percent slopes, moderately eroded	3,395	1.3
236D2	Lester loam, 9 to 14 percent slopes, moderately eroded	1,900	0.7
236E2	Lester loam, 14 to 18 percent slopes, moderately eroded	730	0.3
236F	Lester loam, 18 to 30 percent slopes	310	0.1
307	Dundas silt loam, 0 to 2 percent slopes	695	0.3
321	Boots muck, 0 to 1 percent slopes	930	0.4
325	Le Sueur loam, 1 to 3 percent slopes	2,760	1.1
349	Darfur loam, 0 to 1 percent slopes	380	0.1
384	Collinwood silty clay loam, 0 to 2 percent slopes	915	0.4
384B	Collinwood silty clay loam, 2 to 5 percent slopes	515	0.2
386	Cordova loam, 0 to 2 percent slopes	1,795	0.7
390	Waldorf silty clay loam, 0 to 2 percent slopes	3,700	1.4
485B	Spillville loam, 2 to 5 percent slopes	4,010	1.6
507	Canisteo clay loam, 0 to 2 percent slopes	42,829	16.5
511	Blue Earth mucky silt loam, 0 to 1 percent slopes	805	0.3
583	Minnetonka silty clay loam, 0 to 2 percent slopes	1,580	0.6
585B	Coland-Spillville complex, 0 to 5 percent slopes	410	0.2
621	Houghton muck, 0 to 1 percent slopes	3,945	1.5
638B2	Clarion-Storden loams, 2 to 5 percent slopes, moderately eroded	3,465	1.3
638C2	Clarion-Storden loams, 5 to 9 percent slopes, moderately eroded	4,260	1.7
638D2	Clarion-Storden loams, 9 to 14 percent slopes, moderately eroded	3,915	1.5
638E2	Clarion-Storden loams, 14 to 18 percent slopes, moderately eroded	530	0.2
655	Crippin loam, 1 to 3 percent slopes	2,520	1.0
658	Mayer loam, 0 to 2 percent slopes	2,985	1.2
777	Wapsie loam, 0 to 2 percent slopes	305	0.1
777B	Wapsie loam, 2 to 5 percent slopes	930	0.4
777C	Wapsie loam, 5 to 9 percent slopes	620	0.2
787B	Vinje silty clay loam, 2 to 5 percent slopes	1,025	0.4
787C2	Vinje silty clay loam, 5 to 9 percent slopes, moderately eroded	1,045	0.4
787D2	Vinje silty clay loam, 9 to 14 percent slopes, moderately eroded	515	0.2
811	Muskego muck, 0 to 1 percent slopes	2,380	0.9
823	Ridgeport sandy loam, 0 to 2 percent slopes	1,870	0.7
823B	Ridgeport sandy loam, 2 to 5 percent slopes	1,585	0.6
836B	Kilkenny clay loam, 2 to 5 percent slopes	3,030	1.2
836C2	Kilkenny clay loam, 5 to 9 percent slopes, moderately eroded	3,535	1.4
836D2	Kilkenny clay loam, 9 to 14 percent slopes, moderately eroded	2,335	0.9
836E2	Kilkenny clay loam, 14 to 18 percent slopes, moderately eroded	535	0.2

TABLE 4.--ACREAGE AND PROPORTIONATE EXTENT OF THE SOILS--Continued

Map symbol	Soil name	Acres	Percent
836F	Kilkenny clay loam, 18 to 35 percent slopes	405	0.2
855	Shorewood silty clay loam, 1 to 3 percent slopes	1,945	0.8
1133	Colo silty clay loam, channeled, 0 to 2 percent slopes	1,435	0.6
2811	Muskego muck, ponded, 0 to 1 percent slopes	1,280	0.5
5010	Pits, sand and gravel	165	0.1
5040	Orthents, loamy	440	0.2
	Water	945	0.4
	Total	256,704	100.0

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
55	Nicollet loam, 1 to 3 percent slopes
95	Harps loam, 1 to 3 percent slopes (where drained)
107	Webster clay loam, 0 to 2 percent slopes (where drained)
135	Coland clay loam, 0 to 2 percent slopes (where drained)
135B	Coland clay loam, 2 to 5 percent slopes (where drained)
138B	Clarion loam, 2 to 5 percent slopes
150	Hanska loam, 0 to 2 percent slopes (where drained)
168B	Hayden loam, 2 to 5 percent slopes
175B	Dickinson fine sandy loam, 2 to 5 percent slopes
224	Linder loam, 0 to 2 percent slopes
236B	Lester loam, 2 to 5 percent slopes
307	Dundas silt loam, 0 to 2 percent slopes (where drained)
325	Le Sueur loam, 1 to 3 percent slopes
349	Darfur loam, 0 to 1 percent slopes (where drained)
384	Collinwood silty clay loam, 0 to 2 percent slopes
384B	Collinwood silty clay loam, 2 to 5 percent slopes
386	Cordova loam, 0 to 2 percent slopes (where drained)
390	Waldorf silty clay loam, 0 to 2 percent slopes (where drained)
485B	Spillville loam, 2 to 5 percent slopes
507	Canisteo clay loam, 0 to 2 percent slopes (where drained)
583	Minnetonka silty clay loam, 0 to 2 percent slopes (where drained)
585B	Coland-Spillville complex, 0 to 5 percent slopes (where drained)
638B2	Clarion-Storden loams, 2 to 5 percent slopes, moderately eroded
655	Crippin loam, 1 to 3 percent slopes
658	Mayer loam, 0 to 2 percent slopes (where drained)
777	Wapsie loam, 0 to 2 percent slopes
777B	Wapsie loam, 2 to 5 percent slopes
787B	Vinje silty clay loam, 2 to 5 percent slopes
836B	Kilkenny clay loam, 2 to 5 percent slopes
855	Shorewood silty clay loam, 1 to 3 percent slopes

TABLE 6.--LAND CAPABILITY CLASSES AND 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	Land capability	Corn	Soybeans	Oats	Bromegrass-alfalfa hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
		Bu	Bu	Bu	Tons	AUM*	AUM*	AUM*
6--------------- Okoboji	IIIw	115	37	80	3.4	3.3	4.3	7.3
28B------------- Dickman	IIIe	65	24	53	3.1	1.2	3.6	3.9
55-------------- Nicollet	I	150	50	80	5.0	3.5	5.4	6.5
62C2------------ Storden	IIIe	115	36	80	4.5	3.0	4.8	5.0
62D2------------ Storden	IIIe	106	33	74	4.2	2.5	4.3	4.5
62E2------------ Storden	IVe	89	28	62	3.5	2.2	3.8	4.2
73B------------- Salida	IVs	40	14	30	2.4	1.5	2.9	3.7
73E------------- Salida	VIe	---	---	---	2.0	1.0	2.5	3.0
90-------------- Okoboji	IIIw	115	37	80	3.4	3.3	4.3	7.3
95-------------- Harps	IIw	125	40	87	3.8	3.3	5.0	6.6
107------------- Webster	IIw	145	46	102	4.4	4.2	6.6	7.3
135------------- Coland	IIw	136	44	95	4.1	4.1	6.0	7.6
135B------------ Coland	IIe	130	43	93	4.0	4.0	5.9	7.5
138B------------ Clarion	IIe	145	46	101	6.1	4.2	6.7	7.6
138C------------ Clarion	IIIe	140	44	98	5.9	3.8	6.3	7.3
138C2----------- Clarion	IIIe	136	41	95	5.7	3.8	6.2	7.1
138D2----------- Clarion	IIIe	127	37	89	5.3	3.7	5.5	6.5
150------------- Hanska	IIw	90	28	60	3.5	2.7	4.0	5.2
168B------------ Hayden	IIe	127	41	89	5.3	3.5	5.6	6.5

See footnotes at end of table.

TABLE 6.--LAND CAPABILITY CLASSES AND YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Land capability	Corn	Soybeans	Oats	Bromegrass-alfalfa hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
		Bu	Bu	Bu	Tons	AUM*	AUM*	AUM*
168C----------- Hayden	IIIe	122	39	85	5.1	3.5	5.3	6.5
168D2---------- Hayden	IIIe	109	35	76	4.6	3.0	4.9	6.0
168E----------- Hayden	VIe	---	---	---	4.0	3.0	4.3	4.5
175B----------- Dickinson	IIe	109	33	65	3.0	2.7	4.8	5.0
221------------ Palms	IIIw	105	34	70	---	---	---	---
224------------ Linder	IIs	100	32	70	3.0	2.3	3.7	4.1
236B----------- Lester	IIe	136	44	95	5.7	3.5	5.9	6.5
236C2---------- Lester	IIIe	127	41	89	5.3	3.5	5.6	6.5
236D2---------- Lester	IIIe	118	38	83	5.0	3.2	5.3	6.2
236E2---------- Lester	IVe	101	32	74	4.6	3.0	4.0	5.8
236F----------- Lester	VIe	---	---	---	3.0	3.0	2.1	4.5
307------------ Dundas	IIw	101	32	71	3.0	2.4	3.9	4.3
321------------ Boots	IIIw	83	24	58	---	---	---	---
325------------ Le Sueur	I	141	45	80	4.5	3.3	5.8	6.7
349------------ Darfur	IIw	118	38	70	3.5	3.5	4.4	5.2
384------------ Collinwood	IIw	129	41	85	4.0	3.5	5.1	6.0
384B----------- Collinwood	IIe	126	40	80	4.0	3.5	5.1	6.0
386------------ Cordova	IIw	136	44	90	4.0	3.6	5.3	6.0
390------------ Waldorf	IIw	111	36	78	3.3	3.1	4.8	6.0
485B----------- Spillville	IIe	156	52	94	6.2	4.1	7.2	8.5
507------------ Canisteo	IIw	139	44	91	3.5	3.0	4.5	5.2

See footnotes at end of table.

TABLE 6.--LAND CAPABILITY CLASSES AND YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Land capability	Corn	Soybeans	Oats	Bromegrass-alfalfa hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
		Bu	Bu	Bu	Tons	AUM*	AUM*	AUM*
511------------- Blue Earth	IIIw	82	26	57	---	---	---	---
583------------- Minnetonka	IIw	109	36	75	3.3	3.0	5.1	6.0
585B------------ Coland-Spillville	IIw	144	47	95	5.0	4.1	6.5	8.0
621------------- Houghton	IIIw	95	29	---	---	---	---	---
638B2----------- Clarion-Storden	IIe	132	42	83	5.1	3.7	5.8	6.6
638C2----------- Clarion-Storden	IIIe	123	39	75	4.6	3.3	5.5	6.1
638D2----------- Clarion-Storden	IIIe	114	36	73	4.4	3.1	5.1	5.9
638E2----------- Clarion-Storden	IVe	97	30	60	3.9	2.7	4.6	5.0
655------------- Crippin	I	150	48	105	6.0	4.2	6.5	7.1
658------------- Mayer	IIw	105	34	70	3.0	3.2	4.2	5.0
777------------- Wapsie	IIs	95	29	57	3.0	2.7	4.3	5.0
777B------------ Wapsie	IIe	92	28	55	2.9	2.6	4.1	4.8
777C------------ Wapsie	IIIe	87	27	52	2.7	2.3	3.8	4.5
787B------------ Vinje	IIe	122	44	85	5.1	3.8	6.1	7.1
787C2----------- Vinje	IIIe	113	39	79	4.8	3.6	5.8	6.8
787D2----------- Vinje	IIIe	104	33	73	4.4	3.2	5.4	6.2
811------------- Muskego	IIIw	106	35	70	3.0	3.7	---	---
823------------- Ridgeport	IIIs	78	25	55	3.3	1.7	3.2	3.6
823B------------ Ridgeport	IIIe	75	24	53	3.2	1.5	3.1	3.5
836B------------ Kilkenny	IIe	116	37	81	4.5	4.7	5.8	6.7

See footnotes at end of table.

TABLE 6.--LAND CAPABILITY CLASSES AND YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Land capability	Corn	Soybeans	Oats	Bromegrass-alfalfa hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
		Bu	Bu	Bu	Tons	AUM*	AUM*	AUM*
836C2----------- Kilkenny	IIIe	107	34	75	4.5	4.2	5.2	6.0
836D2----------- Kilkenny	IVe	98	31	69	4.1	3.0	4.2	5.0
836E2----------- Kilkenny	VIe	81	26	57	3.4	2.6	3.9	4.8
836F------------ Kilkenny	VIe	---	---	---	3.0	3.2	3.3	4.5
855------------- Shorewood	IIw	123	37	86	4.2	3.5	5.6	6.7
1133------------ Colo	Vw	---	---	---	---	3.0	---	---
2811------------ Muskego	VIIw	---	---	---	---	---	---	---
5010**. 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.--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 height, in feet, of--				
	<8	8-15	16-25	26-35	>35
6. Okoboji	---	Redosier dogwood	Black ash, tall purple willow.	Black willow, white willow, golden willow.	---
28B. Dickman	Siberian peashrub	Eastern redcedar, Tatarian honeysuckle, lilac.	Green ash, honeylocust, red pine, jack pine, Austrian pine, Russian-olive.	Eastern white pine, Siberian elm.	---
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, 62E2. Storden	American plum	Eastern redcedar, hackberry, Tatarian honeysuckle, Siberian peashrub.	Honeylocust, green ash, Russian-olive.	Siberian elm	---
73B, 73E. Salida					
90. Okoboji	---	Redosier dogwood	Black ash, tall purple willow.	Black willow, white willow, golden willow.	---
95. Harps	---	Tatarian honeysuckle, northern white-cedar, Siberian peashrub, lilac.	Hackberry, white spruce, eastern redcedar, bur oak.	Golden willow, honeylocust, green ash.	Eastern cottonwood.
107. Webster	---	Redosier dogwood, American plum, Tatarian honeysuckle.	Hackberry, Amur maple, northern white-cedar, tall purple willow, white spruce.	Golden willow, green ash.	Eastern cottonwood, silver maple.
135. Coland	---	Redosier dogwood, Tatarian honeysuckle, American plum.	White spruce, hackberry, northern white-cedar, tall purple willow, Amur maple.	Golden willow, green ash.	Eastern cottonwood, silver maple.
135B. Coland	---	Redosier dogwood, American plum, Tatarian honeysuckle.	Hackberry, Amur maple, northern white-cedar, tall purple willow, white spruce.	Golden willow, green ash.	Eastern cottonwood, silver maple.
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.	---

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of-- <8	8-15	16-25	26-35	>35
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.
168B, 168C, 168D2, 168E------ Hayden	---	Redosier dogwood, gray dogwood, Siberian peashrub, lilac.	Hackberry, eastern redcedar, Russian-olive, Amur maple, northern white-cedar, blue spruce.	Eastern white pine, green ash.	---
175B------ Dickinson	Lilac------	Eastern redcedar, Russian-olive, Tatarian honeysuckle, Siberian peashrub.	Eastern white pine, green ash, Norway spruce, honeylocust, red pine, Amur maple, hackberry.	---	---
221------ Palms	Vanhoutte spirea	Silky dogwood, common ninebark, nannyberry viburnum, American cranberrybush.	---	---	Imperial Carolina poplar.
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.
236B, 236C2, 236D2, 236E2, 236F------ Lester	---	Redosier dogwood, Siberian peashrub, lilac, gray dogwood.	Hackberry, eastern redcedar, northern white-cedar, Amur maple, Russian-olive, blue spruce.	Eastern white pine, green ash.	---
307------ Dundas	---	Tatarian honeysuckle, lilac, redosier dogwood.	Northern white-cedar, white spruce, hackberry, Amur maple, tall purple willow.	Golden willow, green ash.	Eastern cottonwood, silver maple.
321------ Boots	Vanhoutte spirea	Nannyberry viburnum, silky dogwood, common ninebark, American cranberrybush.	Northern white-cedar, Manchurian crabapple, white spruce.	Eastern white pine, Norway spruce, green ash.	Imperial Carolina poplar.
325------ Le Sueur	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, blue spruce, Amur maple.	Austrian pine, eastern white pine, green ash, hackberry.	Silver maple.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
349. Darfur	---	Redosier dogwood, Tatarian honeysuckle, American plum.	Northern white-cedar, white spruce, tall purple willow, Amur maple, hackberry.	Golden willow, green ash.	Eastern cottonwood, silver maple.
384, 384B. Collinwood	---	Northern white-cedar, Siberian peashrub, Tatarian honeysuckle, lilac, eastern redcedar.	White spruce, Austrian pine, hackberry, Russian-olive, bur oak.	Eastern white pine, green ash.	---
386. Cordova	---	Tatarian honeysuckle, American plum, redosier dogwood.	Northern white-cedar, white spruce, hackberry, tall purple willow, Amur maple.	Green ash, golden willow.	Eastern cottonwood, silver maple.
390. Waldorf	---	Redosier dogwood, Tatarian honeysuckle, American plum.	Northern white-cedar, white spruce, Amur maple, tall purple willow, hackberry.	Golden willow, green ash.	Eastern cottonwood, silver maple.
485B. Spillville	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, blue spruce, Amur maple.	Hackberry, eastern white pine, Austrian pine, green ash.	Silver maple.
507. Canisteo	---	Siberian peashrub, Tatarian honeysuckle, lilac, northern white-cedar.	Hackberry, bur oak, white spruce, eastern redcedar.	Golden willow, honeylocust, green ash.	Eastern cottonwood.
511. Blue Earth	Vanhoutte spirea	Silky dogwood, common ninebark, nannyberry viburnum, American cranberrybush.	Northern white-cedar, Manchurian crabapple, white spruce.	Eastern white pine, Norway spruce, green ash.	Imperial Carolina poplar.
583. Minnetonka	---	Tatarian honeysuckle, American plum, redosier dogwood.	Northern white-cedar, white spruce, hackberry, tall purple willow, Amur maple.	Green ash, golden willow.	Eastern cottonwood, silver maple.
585B*:					
Coland	---	Redosier dogwood, Tatarian honeysuckle, American plum.	White spruce, hackberry, northern white-cedar, tall purple willow, Amur maple.	Golden willow, green ash.	Eastern cottonwood, silver maple.

See footnote at end of table.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
585B*: Spillville	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, blue spruce, Amur maple.	Hackberry, eastern white pine, Austrian pine, green ash.	Silver maple.
621 Houghton	Vanhoutte spirea	Silky dogwood, common ninebark, nannyberry viburnum, American cranberrybush.	Northern white-cedar, Manchurian crabapple, white spruce.	Eastern white pine, Norway spruce, green ash.	Imperial Carolina poplar.
638B2*, 638C2*, 638D2*, 638E2*: 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.	---
Storden	American plum	Eastern redcedar, hackberry, Tatarian honeysuckle, Siberian peashrub.	Honeylocust, green ash, Russian-olive.	Siberian elm	---
655 Crippin	---	Northern white-cedar, Tatarian honeysuckle, Siberian peashrub, lilac.	Hackberry, white spruce, eastern redcedar, bur oak.	Golden willow, green ash, honeylocust.	Eastern cottonwood.
658 Mayer	---	Tatarian honeysuckle, northern white-cedar, Siberian peashrub, lilac.	Hackberry, bur oak, white spruce, eastern redcedar.	Golden willow, green ash, honeylocust.	Eastern cottonwood.
777, 777B, 777C Wapsie	Lilac, Tatarian honeysuckle, Siberian peashrub.	Eastern redcedar, Manchurian crabapple, hackberry.	Russian-olive, jack pine, green ash, bur oak, eastern white pine, honeylocust.	---	---
787B, 787C2, 787D2 Vinje	Gray dogwood, silky dogwood.	Redosier dogwood, Tatarian honeysuckle, American plum.	Amur maple, eastern redcedar, Russian-olive.	Red pine, Norway spruce, hackberry.	Silver maple.
811 Muskego	Vanhoutte spirea	Nannyberry viburnum, silky dogwood, common ninebark, American cranberrybush.	White spruce, Manchurian crabapple, northern white-cedar.	Eastern white pine, Norway spruce, green ash.	Imperial Carolina poplar.

See footnote at end of table.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average height, in feet, of--				
	<8	8-15	16-25	26-35	>35
823, 823B----------- Ridgeport	Tatarian honeysuckle, lilac, Siberian peashrub.	Eastern redcedar, hackberry, Manchurian crabapple.	Eastern white pine, jack pine, honeylocust, Russian-olive, bur oak, green ash.	---	---
836B, 836C2, 836D2, 836E2, 836F------------- Kilkenny	---	Redosier dogwood, gray dogwood, Siberian peashrub, lilac.	Northern white-cedar, blue spruce, hackberry, Amur maple, eastern redcedar.	Austrian pine, eastern white pine, green ash.	---
855--------------- Shorewood	---	Northern white-cedar, Siberian peashrub, Tatarian honeysuckle, lilac, eastern redcedar.	White spruce, Austrian pine, hackberry, bur oak, Russian-olive.	Eastern white pine, green ash.	---
1133-------------- Colo	---	Redosier dogwood, American plum, Tatarian honeysuckle.	White fir, white spruce, hackberry, Amur maple, tall purple willow.	Green ash, golden willow.	Silver maple, eastern cottonwood.
2811-------------- Muskego	Vanhoutte spirea	Silky dogwood, common ninebark, nannyberry viburnum, American cranberrybush.	Northern white-cedar, Manchurian crabapple, white spruce.	Eastern white pine, Norway spruce, green ash.	Imperial Carolina poplar.
5010*. Pits					
5040*. Orthents					

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 8.--RECREATIONAL DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
6----------------------- Okoboji	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
28B--------------------- Dickman	Slight----------	Slight----------	Moderate: slope.	Slight----------	Moderate: droughty.
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.
62E2-------------------- Storden	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
73B--------------------- Salida	Slight----------	Slight----------	Severe: small stones.	Slight----------	Severe: droughty.
73E--------------------- Salida	Moderate: slope.	Moderate: slope.	Severe: slope, small stones.	Slight----------	Severe: droughty.
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.
135--------------------- Coland	Severe: flooding, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, flooding.
135B-------------------- Coland	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
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.
150--------------------- Hanska	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
168B-------------------- Hayden	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
168C-------------------- Hayden	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.

TABLE 8.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
168D2: Hayden	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
168E: Hayden	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
175B: Dickinson	Slight	Slight	Moderate: slope.	Slight	Slight.
221: Palms	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: ponding, excess humus.
224: Linder	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Slight	Slight.
236B: Lester	Slight	Slight	Moderate: slope.	Slight	Slight.
236C2: Lester	Slight	Slight	Severe: slope.	Slight	Slight.
236D2: Lester	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
236E2, 236F: Lester	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
307: Dundas	Severe: wetness.	Moderate: wetness, percs slowly.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
321: Boots	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding, excess humus.
325: Le Sueur	Moderate: wetness.	Moderate: wetness.	Moderate: slope, wetness.	Slight	Slight.
349: Darfur	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
384: Collinwood	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Slight	Slight.
384B: Collinwood	Moderate: wetness.	Moderate: wetness.	Moderate: slope, wetness.	Slight	Slight.
386: Cordova	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
390: Waldorf	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.
485B: Spillville	Slight	Slight	Moderate: slope.	Slight	Slight.
507: Canisteo	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.

TABLE 8.--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.
583------------------- Minnetonka	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.
585B*:					
Coland---------------	Severe: flooding, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, flooding.
Spillville-----------	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
621------------------- Houghton	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.
638B2*:					
Clarion--------------	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
Storden--------------	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
638C2*:					
Clarion--------------	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
Storden--------------	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
638D2*:					
Clarion--------------	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: slope.
Storden--------------	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: slope.
638E2*:					
Clarion--------------	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
Storden--------------	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
655------------------- Crippin	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Slight----------	Slight.
658------------------- Mayer	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
777------------------- Wapsie	Slight----------	Slight----------	Slight----------	Slight----------	Slight.
777B------------------ Wapsie	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
777C------------------ Wapsie	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.

See footnote at end of table.

TABLE 8.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
787B------------------ Vinje	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: slope, percs slowly.	Slight----------	Slight.
787C2----------------- Vinje	Moderate: percs slowly.	Moderate: percs slowly.	Severe: slope.	Slight----------	Slight.
787D2----------------- Vinje	Moderate: slope, percs slowly.	Moderate: slope, percs slowly.	Severe: slope.	Slight----------	Moderate: slope.
811------------------- Muskego	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding, excess humus.
823------------------- Ridgeport	Slight----------	Slight----------	Slight----------	Slight----------	Slight.
823B------------------ Ridgeport	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
836B------------------ Kilkenny	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: slope, percs slowly.	Slight----------	Slight.
836C2----------------- Kilkenny	Moderate: percs slowly.	Moderate: percs slowly.	Severe: slope.	Slight----------	Slight.
836D2----------------- Kilkenny	Moderate: slope, percs slowly.	Moderate: slope, percs slowly.	Severe: slope.	Slight----------	Moderate: slope.
836E2----------------- Kilkenny	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
836F------------------ Kilkenny	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
855------------------- Shorewood	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: slope, percs slowly.	Slight----------	Slight.
1133------------------ Colo	Severe: flooding, wetness.	Moderate: flooding, wetness.	Severe: wetness, flooding.	Moderate: flooding, wetness.	Severe: flooding.
2811------------------ Muskego	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding, excess humus.
5010*. Pits					
5040*. Orthents					

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 9.--WILDLIFE HABITAT

[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
6----------------- Okoboji	Fair	Fair	Fair	Fair	Very poor.	Good	Good	Fair	Fair	Good.
28B--------------- Dickman	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
55---------------- Nicollet	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
62C2, 62D2, 62E2--- Storden	Fair	Good	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
73B--------------- Salida	Poor	Poor	Poor	Poor	Poor	Very poor.	Very poor.	Poor	Poor	Very poor.
73E--------------- Salida	Very poor.	Poor	Poor	Poor	Poor	Very poor.	Very poor.	Very poor.	Poor	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.
135--------------- Coland	Good	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.
135B-------------- Coland	Good	Fair	Good	Fair	Poor	Fair	Poor	Fair	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.
150--------------- Hanska	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
168B-------------- Hayden	Good	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
168C, 168D2-------- Hayden	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
168E-------------- Hayden	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
175B-------------- Dickinson	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
221--------------- Palms	Good	Poor	Poor	Poor	Poor	Good	Good	Fair	Poor	Good.

TABLE 9.--WILDLIFE HABITAT--Continued

Soil name and map symbol	Potential for habitat elements: Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Potential as habitat for--: Openland wildlife	Woodland wildlife	Wetland wildlife
224----------------- Linder	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
236B---------------- Lester	Good	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
236C2, 236D2, 236E2------------- Lester	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
236F---------------- Lester	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
307----------------- Dundas	Good	Good	Good	Good	Fair	Good	Good	Good	Good	Good.
321----------------- Boots	Good	Poor	Poor	Poor	Poor	Good	Good	Poor	Poor	Good.
325----------------- Le Sueur	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
349----------------- Darfur	Fair	Fair	Fair	Fair	Fair	Good	Good	Fair	Fair	Good.
384, 384B----------- Collinwood	Fair	Fair	Fair	Good	Good	Poor	Fair	Fair	Good	Poor.
386----------------- Cordova	Good	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.
390----------------- Waldorf	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
485B---------------- Spillville	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
507----------------- Canisteo	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
511----------------- Blue Earth	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Poor	Good.
583----------------- Minnetonka	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
585B*:										
Coland------------	Good	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.
Spillville---------	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
621----------------- Houghton	Fair	Poor	Poor	Fair	Fair	Good	Good	Poor	Poor	Good.
638B2*:										
Clarion-----------	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
Storden-----------	Good	Good	Good	Fair	Poor	Very poor.	Very poor.	Good	Fair	Very poor.

See footnote at end of table.

TABLE 9.--WILDLIFE HABITAT--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
638C2*, 638D2*: Clarion	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
Storden	Fair	Good	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
638E2*: Clarion	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
Storden	Fair	Good	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
655 Crippin	Good	Good	Good	Good	Fair	Fair	Poor	Good	Good	Poor.
658 Mayer	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
777, 777B Wapsie	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
777C Wapsie	Fair	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
787B Vinje	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
787C2, 787D2 Vinje	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
811 Muskego	Good	Poor	Poor	Poor	Poor	Good	Good	Poor	Poor	Good.
823, 823B Ridgeport	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
836B Kilkenny	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
836C2, 836D2, 836E2 Kilkenny	Fair	Good	Good	Good	Good	Poor	Very poor.	Fair	Good	Very poor.
836F Kilkenny	Poor	Fair	Good	Good	Good	Very poor.	Very poor.	Poor	Good	Very poor.
855 Shorewood	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
1133 Colo	Good	Fair	Good	Fair	Poor	Good	Good	Fair	Fair	Good.
2811 Muskego	Very poor.	Very poor.	Very poor.	Very poor.	Very poor.	Good	Good	Very poor.	Very poor.	Good.
5010*. Pits										
5040*. Orthents										

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 10.--BUILDING SITE DEVELOPMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation]

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
6----------------- Okoboji	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.
28B--------------- Dickman	Severe: cutbanks cave.	Slight---------	Slight---------	Moderate: slope.	Slight---------	Moderate: droughty.
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.
62E2-------------- Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
73B--------------- Salida	Severe: cutbanks cave.	Slight---------	Slight---------	Moderate: slope.	Slight---------	Severe: droughty.
73E--------------- Salida	Severe: cutbanks cave.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	Severe: droughty.
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.
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.
135B-------------- Coland	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: low strength, frost action.	Moderate: wetness.
138B-------------- Clarion	Slight---------	Slight---------	Slight---------	Slight---------	Moderate: frost action.	Slight.
138C, 138C2------- Clarion	Slight---------	Slight---------	Slight---------	Moderate: slope.	Moderate: frost action.	Slight.

TABLE 10.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
138D2: Clarion	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
150: Hanska	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action.	Moderate: wetness.
168B: Hayden	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Slight.
168C: Hayden	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength.	Slight.
168D2: Hayden	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: slope, shrink-swell.	Severe: slope.	Severe: low strength.	Moderate: slope.
168E: Hayden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope.
175B: Dickinson	Severe: cutbanks cave.	Slight	Slight	Slight	Moderate: frost action.	Slight.
221: Palms	Severe: excess humus, ponding.	Severe: ponding, low strength.	Severe: ponding, low strength.	Severe: ponding, low strength.	Severe: ponding, frost action, subsides.	Severe: ponding, excess humus.
224: Linder	Severe: cutbanks cave, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Severe: frost action.	Slight.
236B: Lester	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Slight.
236C2: Lester	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength.	Slight.
236D2: Lester	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: slope, shrink-swell.	Severe: slope.	Severe: low strength.	Moderate: slope.
236E2, 236F: Lester	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope.
307: Dundas	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
321: Boots	Severe: excess humus, ponding.	Severe: ponding, low strength.	Severe: ponding, low strength.	Severe: ponding, low strength.	Severe: ponding, frost action.	Severe: ponding, excess humus.
325: Le Sueur	Severe: wetness.	Moderate: wetness, shrink-swell.	Severe: wetness.	Moderate: wetness, shrink-swell.	Severe: frost action, low strength.	Slight.

TABLE 10.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
349 Darfur	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action.	Moderate: wetness.
384, 384B Collinwood	Severe: wetness.	Severe: shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell.	Severe: low strength, frost action.	Slight.
386 Cordova	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action, low strength.	Moderate: wetness.
390 Waldorf	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: low strength, wetness, frost action.	Severe: wetness.
485B Spillville	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness, shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Slight.
507 Canisteo	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
511 Blue Earth	Severe: excess humus, ponding.	Severe: ponding, low strength.	Severe: ponding.	Severe: ponding, low strength.	Severe: low strength, ponding, frost action.	Severe: ponding.
583 Minnetonka	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: low strength, wetness, frost action.	Severe: wetness.
585B*:						
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.
621 Houghton	Severe: ponding, excess humus.	Severe: ponding, low strength.	Severe: ponding, low strength.	Severe: ponding, low strength.	Severe: ponding, low strength, frost action.	Severe: excess humus, ponding.
638B2*:						
Clarion	Slight	Slight	Slight	Slight	Moderate: frost action.	Slight.
Storden	Slight	Slight	Slight	Slight	Moderate: frost action.	Slight.
638C2*:						
Clarion	Slight	Slight	Slight	Moderate: slope.	Moderate: frost action.	Slight.

See footnote at end of table.

TABLE 10.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
638C2*: Storden	Slight	Slight	Slight	Moderate: slope.	Moderate: frost action.	Slight.
638D2*: Clarion	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
Storden	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
638E2*: Clarion	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
655 Crippin	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Severe: frost action, low strength.	Slight.
658 Mayer	Severe: wetness, cutbanks cave.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action.	Moderate: wetness.
777, 777B Wapsie	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Slight.
777C Wapsie	Severe: cutbanks cave.	Slight	Slight	Moderate: slope.	Slight	Slight.
787B Vinje	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Slight.
787C2 Vinje	Moderate: too clayey.	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength.	Slight.
787D2 Vinje	Moderate: too clayey, slope.	Moderate: shrink-swell, slope.	Moderate: slope, shrink-swell.	Severe: slope.	Severe: low strength.	Moderate: slope.
811 Muskego	Severe: excess humus, ponding.	Severe: ponding, low strength.	Severe: ponding, low strength.	Severe: ponding, low strength.	Severe: subsides, ponding, frost action.	Severe: ponding, excess humus.
823, 823B Ridgeport	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Slight.
836B Kilkenny	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Slight.
836C2 Kilkenny	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength.	Slight.
836D2 Kilkenny	Moderate: slope.	Moderate: shrink-swell, slope.	Moderate: slope, shrink-swell.	Severe: slope.	Severe: low strength.	Moderate: slope.

See footnote at end of table.

TABLE 10.--BUILDING SITE DEVELOPMENT--Continued

Soil name and map symbol	Shallow excavations	Dwellings without basements	Dwellings with basements	Small commercial buildings	Local roads and streets	Lawns and landscaping
836E2, 836F------- Kilkenny	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: low strength, slope.	Severe: slope.
855--------------- Shorewood	Moderate: too clayey, wetness.	Severe: shrink-swell.	Moderate: wetness, shrink-swell.	Severe: shrink-swell.	Severe: low strength, frost action, shrink-swell.	Slight.
1133-------------- Colo	Severe: wetness.	Severe: flooding, shrink-swell, wetness.	Severe: flooding, shrink-swell, wetness.	Severe: flooding, shrink-swell, wetness.	Severe: flooding, low strength, frost action.	Severe: flooding.
2811-------------- Muskego	Severe: excess humus, ponding.	Severe: ponding, low strength.	Severe: ponding, low strength.	Severe: ponding, low strength.	Severe: ponding, frost action, subsides.	Severe: ponding, excess humus.
5010*. Pits						
5040*. Orthents						

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 11.--SANITARY FACILITIES

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "good," and other terms. Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation]

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
6: Okoboji	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding, too clayey.	Severe: ponding.	Poor: too clayey, hard to pack, ponding.
28B: Dickman	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
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.
62E2: Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
73B: Salida	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
73E: Salida	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
90: Okoboji	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding, too clayey.	Severe: ponding.	Poor: too clayey, 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.
135: Coland	Severe: flooding, wetness.	Severe: seepage, flooding, wetness.	Severe: flooding, seepage, wetness.	Severe: flooding, wetness.	Poor: hard to pack, wetness.
135B: Coland	Severe: wetness.	Severe: seepage, wetness.	Severe: seepage, wetness.	Severe: wetness.	Poor: hard to pack, wetness.
138B: Clarion	Slight	Moderate: slope, seepage.	Slight	Slight	Good.

TABLE 11.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
138C, 138C2 Clarion	Slight	Severe: slope.	Slight	Slight	Good.
138D2 Clarion	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
150 Hanska	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, wetness.
168B Hayden	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
168C Hayden	Moderate: percs slowly.	Severe: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
168D2 Hayden	Moderate: percs slowly, slope.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
168E Hayden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
175B Dickinson	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
221 Palms	Severe: subsides, ponding.	Severe: seepage, excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding, seepage.	Poor: ponding, excess humus.
224 Linder	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, small stones, too sandy.
236B Lester	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Fair: too clayey.
236C2 Lester	Moderate: percs slowly.	Severe: slope.	Moderate: too clayey.	Slight	Fair: too clayey.
236D2 Lester	Moderate: percs slowly, slope.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Fair: too clayey, slope.
236E2, 236F Lester	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
307 Dundas	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: hard to pack, wetness.
321 Boots	Severe: ponding.	Severe: seepage, excess humus.	Severe: seepage, ponding.	Severe: seepage, ponding.	Poor: ponding, excess humus.
325 Le Sueur	Severe: wetness.	Severe: wetness.	Moderate: wetness, too clayey.	Moderate: wetness.	Fair: too clayey, wetness.

TABLE 11.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
349----------------- Darfur	Severe: wetness.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: too sandy, wetness.
384----------------- Collinwood	Severe: wetness, percs slowly.	Slight-----------	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack.
384B---------------- Collinwood	Severe: wetness, percs slowly.	Moderate: slope.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack.
386----------------- Cordova	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
390----------------- Waldorf	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.
485B---------------- Spillville	Severe: wetness.	Severe: seepage, wetness.	Severe: seepage, wetness.	Severe: wetness.	Fair: wetness.
507----------------- Canisteo	Severe: wetness.	Severe: seepage, wetness.	Severe: wetness.	Severe: seepage, wetness.	Poor: wetness.
511----------------- Blue Earth	Severe: ponding.	Severe: ponding.	Severe: ponding, excess humus.	Severe: ponding.	Poor: hard to pack, ponding.
583----------------- Minnetonka	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: hard to pack, wetness.
585B*:					
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.
621----------------- Houghton	Severe: ponding, percs slowly.	Severe: seepage, ponding, excess humus.	Severe: ponding, excess humus.	Severe: ponding, seepage.	Poor: ponding, excess humus.
638B2*:					
Clarion------------	Slight-----------	Moderate: slope, seepage.	Slight-----------	Slight-----------	Good.
Storden------------	Slight-----------	Moderate: seepage, slope.	Slight-----------	Slight-----------	Good.

See footnote at end of table.

TABLE 11.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
638C2*:					
Clarion	Slight	Severe: slope.	Slight	Slight	Good.
Storden	Slight	Severe: slope.	Slight	Slight	Good.
638D2*:					
Clarion	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
Storden	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
638E2*:					
Clarion	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
655 Crippin	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
658 Mayer	Severe: wetness, poor filter.	Severe: wetness, seepage.	Severe: wetness, seepage, too sandy.	Severe: wetness, seepage.	Poor: wetness, too sandy, seepage.
777, 777B Wapsie	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
777C Wapsie	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
787B Vinje	Severe: percs slowly.	Moderate: seepage, slope.	Severe: too clayey.	Slight	Poor: too clayey, hard to pack.
787C2 Vinje	Severe: percs slowly.	Severe: slope.	Severe: too clayey.	Slight	Poor: too clayey, hard to pack.
787D2 Vinje	Severe: percs slowly.	Severe: slope.	Severe: too clayey.	Moderate: slope.	Poor: too clayey, hard to pack.
811 Muskego	Severe: ponding, percs slowly.	Severe: seepage, excess humus, ponding.	Severe: ponding, excess humus.	Severe: seepage, ponding.	Poor: hard to pack, ponding.
823, 823B Ridgeport	Severe: poor filter.	Severe: seepage.	Severe: seepage.	Severe: seepage.	Poor: thin layer.
836B Kilkenny	Severe: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight	Poor: hard to pack.
836C2 Kilkenny	Severe: percs slowly.	Severe: slope.	Moderate: too clayey.	Slight	Poor: hard to pack.

See footnote at end of table.

TABLE 11.--SANITARY FACILITIES--Continued

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
836D2----------------- Kilkenny	Severe: percs slowly.	Severe: slope.	Moderate: slope, too clayey.	Moderate: slope.	Poor: hard to pack.
836E2, 836F--------- Kilkenny	Severe: percs slowly, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: hard to pack, slope.
855----------------- Shorewood	Severe: wetness, percs slowly.	Severe: wetness.	Severe: too clayey.	Slight-----------	Poor: too clayey.
1133---------------- Colo	Severe: wetness, flooding.	Severe: wetness, flooding.	Severe: wetness, flooding.	Severe: wetness, flooding.	Poor: wetness, hard to pack.
2811---------------- Muskego	Severe: ponding, percs slowly.	Severe: seepage, excess humus, ponding.	Severe: ponding, excess humus.	Severe: seepage, ponding.	Poor: hard to pack, ponding.
5010*. Pits					
5040*. Orthents					

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 12.--CONSTRUCTION MATERIALS

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "good," "fair," and other terms. Absence of an entry indicates that the soil was not rated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation]

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
6 Okoboji	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
28B Dickman	Good	Probable	Improbable: too sandy.	Poor: thin layer.
55 Nicollet	Fair: wetness, low strength.	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.
62E2 Storden	Fair: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
73B, 73E Salida	Good	Probable	Probable	Poor: small stones, area reclaim, too sandy.
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.	Good.
107 Webster	Fair: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Good.
135, 135B Coland	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
138B, 138C, 138C2 Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
138D2 Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: slope.
150 Hanska	Fair: wetness.	Probable	Improbable: too sandy.	Fair: thin layer.
168B, 168C Hayden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.

TABLE 12.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
168D2 Hayden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones, slope.
168E Hayden	Fair: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
175B Dickinson	Good	Probable	Improbable: too sandy.	Good.
221 Palms	Poor: wetness.	Improbable: excess fines, excess humus.	Improbable: excess fines, excess humus.	Poor: wetness, excess humus.
224 Linder	Fair: wetness.	Probable	Improbable: too sandy.	Poor: small stones, area reclaim.
236B, 236C2 Lester	Fair: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
236D2 Lester	Fair: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones, slope.
236E2, 236F Lester	Fair: slope, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
307 Dundas	Fair: wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
321 Boots	Poor: wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: excess humus, wetness.
325 Le Sueur	Fair: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Good.
349 Darfur	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: thin layer.
384, 384B Collinwood	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
386 Cordova	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
390 Waldorf	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
485B Spillville	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
507 Canisteo	Fair: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.

See footnote at end of table.

TABLE 12.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
511------------------- Blue Earth	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
583------------------- Minnetonka	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer, wetness.
585B*:				
Coland---------------	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
Spillville-----------	Good-----------------	Improbable: excess fines.	Improbable: excess fines.	Good.
621------------------- Houghton	Poor: wetness, low strength.	Improbable: excess humus.	Improbable: excess humus.	Poor: wetness, excess humus.
638B2*, 638C2*:				
Clarion--------------	Good-----------------	Improbable: excess fines.	Improbable: excess fines.	Good.
Storden--------------	Good-----------------	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
638D2*:				
Clarion--------------	Good-----------------	Improbable: excess fines.	Improbable: excess fines.	Fair: slope.
Storden--------------	Good-----------------	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones, slope.
638E2*:				
Clarion--------------	Fair: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
Storden--------------	Fair: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
655------------------- Crippin	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
658------------------- Mayer	Fair: wetness.	Probable-------------	Probable-------------	Fair: area reclaim, thin layer.
777, 777B, 777C------- Wapsie	Good-----------------	Probable-------------	Probable-------------	Fair: small stones, area reclaim, thin layer.
787B, 787C2, 787D2---- Vinje	Fair: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
811------------------- Muskego	Poor: wetness, low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: excess humus, wetness.

See footnote at end of table.

TABLE 12.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
823, 823B Ridgeport	Good	Probable	Improbable: too sandy.	Fair: small stones, area reclaim, thin layer.
836B, 836C2 Kilkenny	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
836D2 Kilkenny	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones, slope.
836E2 Kilkenny	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
836F Kilkenny	Poor: low strength, slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
855 Shorewood	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
1133 Colo	Poor: shrink-swell, low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
2811 Muskego	Poor: wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: excess humus, wetness.
5010*. Pits				
5040*. Orthents				

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 13.--WATER MANAGEMENT

[Some terms that describe restrictive soil features are defined in the Glossary. See text for definitions of "slight," "moderate," and "severe." Absence of an entry indicates that the soil was not evaluated. The information in this table indicates the dominant soil condition but does not eliminate the need for onsite investigation]

Soil name and map symbol	Limitations for--			Features affecting--		
	Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Drainage	Terraces and diversions	Grassed waterways
6----------------- Okoboji	Moderate: seepage.	Severe: ponding.	Severe: slow refill.	Ponding, frost action.	Erodes easily, ponding.	Wetness, erodes easily.
28B--------------- Dickman	Severe: seepage.	Severe: seepage.	Severe: no water.	Deep to water	Too sandy, soil blowing.	Droughty.
55---------------- Nicollet	Moderate: seepage.	Moderate: piping.	Moderate: deep to water, slow refill.	Frost action---	Wetness---------	Favorable.
62C2-------------- Storden	Moderate: seepage, slope.	Moderate: piping.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
62D2, 62E2-------- Storden	Severe: slope.	Moderate: piping.	Severe: no water.	Deep to water	Slope, erodes easily.	Slope, erodes easily.
73B--------------- Salida	Severe: seepage.	Severe: seepage.	Severe: no water.	Deep to water	Too sandy------	Droughty.
73E--------------- Salida	Severe: seepage, slope.	Severe: seepage.	Severe: no water.	Deep to water	Slope, too sandy.	Slope, droughty.
90---------------- Okoboji	Moderate: seepage.	Severe: ponding.	Severe: slow refill.	Ponding, frost action.	Erodes easily, ponding.	Wetness, erodes easily.
95---------------- Harps	Moderate: seepage.	Severe: wetness.	Moderate: slow refill.	Frost action---	Wetness---------	Wetness.
107--------------- Webster	Moderate: seepage.	Severe: wetness.	Moderate: slow refill.	Frost action---	Wetness---------	Wetness.
135--------------- Coland	Moderate: seepage.	Severe: wetness.	Moderate: slow refill.	Flooding, frost action.	Wetness---------	Wetness.
135B-------------- Coland	Moderate: seepage, slope.	Severe: wetness.	Moderate: slow refill.	Frost action, slope.	Wetness---------	Wetness.
138B, 138C, 138C2- Clarion	Moderate: seepage, slope.	Severe: piping.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
138D2------------- Clarion	Severe: slope.	Severe: piping.	Severe: no water.	Deep to water	Slope, erodes easily.	Slope, erodes easily.
150--------------- Hanska	Severe: seepage.	Severe: seepage, wetness.	Severe: cutbanks cave.	Frost action, cutbanks cave.	Wetness, too sandy.	Wetness.
168B, 168C-------- Hayden	Moderate: seepage, slope.	Slight---------	Severe: no water.	Deep to water	Favorable------	Favorable.
168D2, 168E------- Hayden	Severe: slope.	Slight---------	Severe: no water.	Deep to water	Slope----------	Slope.

TABLE 13.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Features affecting-- Drainage	Terraces and diversions	Grassed waterways
175B: Dickinson	Severe: seepage.	Severe: seepage.	Severe: no water.	Deep to water	Soil blowing, too sandy.	Favorable.
221: Palms	Severe: seepage.	Severe: excess humus, ponding.	Severe: slow refill.	Ponding, subsides.	Ponding, soil blowing.	Wetness.
224: Linder	Severe: seepage.	Severe: seepage, piping.	Severe: cutbanks cave.	Frost action, cutbanks cave.	Wetness, too sandy.	Droughty.
236B, 236C2: Lester	Moderate: seepage, slope.	Severe: thin layer.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
236D2, 236E2, 236F: Lester	Severe: slope.	Severe: thin layer.	Severe: no water.	Deep to water	Slope, erodes easily.	Slope, erodes easily.
307: Dundas	Moderate: seepage.	Severe: wetness.	Severe: slow refill.	Frost action	Wetness	Wetness.
321: Boots	Severe: seepage.	Severe: excess humus, ponding.	Moderate: slow refill.	Ponding, subsides.	Ponding, soil blowing.	Wetness.
325: Le Sueur	Moderate: seepage.	Moderate: wetness.	Severe: no water.	Frost action	Wetness	Favorable.
349: Darfur	Severe: seepage.	Severe: seepage, piping, wetness.	Severe: cutbanks cave.	Frost action, cutbanks cave.	Wetness, too sandy.	Wetness.
384: Collinwood	Slight	Severe: hard to pack.	Severe: slow refill.	Percs slowly, frost action.	Wetness, percs slowly.	Percs slowly.
384B: Collinwood	Moderate: slope.	Severe: hard to pack.	Severe: slow refill.	Percs slowly, frost action, slope.	Wetness, percs slowly.	Percs slowly.
386: Cordova	Moderate: seepage.	Severe: wetness.	Severe: slow refill.	Frost action	Wetness	Wetness.
390: Waldorf	Moderate: seepage.	Severe: hard to pack, wetness.	Severe: slow refill.	Frost action	Wetness	Wetness.
485B: Spillville	Moderate: seepage, slope.	Moderate: thin layer, piping, wetness.	Moderate: deep to water, slow refill.	Deep to water	Favorable	Favorable.
507: Canisteo	Severe: seepage.	Severe: wetness.	Moderate: slow refill.	Frost action	Wetness	Wetness.
511: Blue Earth	Moderate: seepage.	Severe: piping, excess humus, ponding.	Severe: slow refill.	Ponding, frost action.	Ponding	Wetness.

TABLE 13.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Features affecting-- Drainage	Terraces and diversions	Grassed waterways
583 Minnetonka	Moderate: seepage.	Severe: piping, hard to pack, wetness.	Severe: no water.	Percs slowly, frost action.	Wetness	Wetness, percs slowly.
585B*:						
Coland	Moderate: seepage, slope.	Severe: wetness.	Moderate: slow refill.	Flooding, slope, frost action.	Wetness	Wetness.
Spillville	Moderate: seepage, slope.	Moderate: thin layer, piping, wetness.	Moderate: deep to water, slow refill.	Deep to water	Favorable	Favorable.
621 Houghton	Severe: seepage.	Severe: excess humus, ponding.	Severe: slow refill.	Frost action, subsides, ponding.	Ponding, soil blowing.	Wetness.
638B2*, 638C2*:						
Clarion	Moderate: seepage, slope.	Severe: piping.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
Storden	Moderate: seepage, slope.	Moderate: piping.	Severe: no water.	Deep to water	Erodes easily	Erodes easily.
638D2*, 638E2*:						
Clarion	Severe: slope.	Severe: piping.	Severe: no water.	Deep to water	Slope, erodes easily.	Slope, erodes easily.
Storden	Severe: slope.	Moderate: piping.	Severe: no water.	Deep to water	Slope, erodes easily.	Slope, erodes easily.
655 Crippin	Moderate: seepage.	Moderate: wetness, piping.	Moderate: slow refill, deep to water.	Frost action	Wetness, erodes easily.	Erodes easily.
658 Mayer	Severe: seepage.	Severe: seepage, wetness.	Severe: cutbanks cave.	Frost action, cutbanks cave.	Wetness, too sandy.	Wetness.
777, 777B, 777C Wapsie	Severe: seepage.	Severe: seepage.	Severe: no water.	Deep to water	Too sandy	Favorable.
787B, 787C2 Vinje	Moderate: seepage, slope.	Moderate: hard to pack.	Severe: no water.	Deep to water	Favorable	Favorable.
787D2 Vinje	Severe: slope.	Moderate: hard to pack.	Severe: no water.	Deep to water	Slope	Slope.
811 Muskego	Severe: seepage.	Severe: excess humus, ponding.	Severe: slow refill.	Ponding, percs slowly.	Ponding, soil blowing, percs slowly.	Wetness, percs slowly.
823, 823B Ridgeport	Severe: seepage.	Severe: piping.	Severe: no water.	Deep to water	Soil blowing	Rooting depth.
836B, 836C2 Kilkenny	Moderate: seepage, slope.	Severe: hard to pack.	Severe: no water.	Deep to water	Favorable	Favorable.

See footnote at end of table.

TABLE 13.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for-- Pond reservoir areas	Embankments, dikes, and levees	Aquifer-fed excavated ponds	Features affecting-- Drainage	Terraces and diversions	Grassed waterways
836D2, 836E2, 836F------------- Kilkenny	Severe: slope.	Severe: hard to pack.	Severe: no water.	Deep to water	Slope----------	Slope.
855--------------- Shorewood	Moderate: seepage.	Moderate: piping.	Severe: no water.	Deep to water	Erodes easily	Erodes easily, percs slowly.
1133-------------- Colo	Moderate: seepage.	Severe: wetness.	Moderate: slow refill.	Flooding, frost action.	Wetness---------	Wetness.
2811-------------- Muskego	Severe: seepage.	Severe: piping, excess humus, ponding.	Severe: slow refill.	Ponding, subsides, frost action.	Ponding---------	Wetness.
5010*. Pits						
5040*. Orthents						

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 14.--ENGINEERING INDEX PROPERTIES

[The symbol < means less than; > means more than. Absence of an entry indicates that data were not estimated]

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
6---------------- Okoboji	0-9	Silty clay loam	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	9-38	Silty clay loam, silty clay.	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	38-60	Silty clay loam, silty clay.	CH	A-7	0	95-100	95-100	90-100	80-95	55-65	30-40
28B-------------- Dickman	0-12	Sandy loam-------	SM, SM-SC, SC	A-2, A-4	0	95-100	95-100	55-95	25-40	20-30	2-8
	12-47	Sandy loam, loamy fine sand.	SM, SM-SC, SC	A-2, A-4	0	95-100	85-100	55-95	25-45	15-25	2-8
	47-60	Stratified fine sand to coarse sand.	SP-SM	A-3, A-2	0	95-100	75-100	50-80	5-10	---	NP
55--------------- Nicollet	0-19	Loam-------------	ML, CL	A-6, A-7	0-5	95-100	90-100	85-98	55-85	35-50	10-25
	19-47	Clay loam, loam, silty clay loam.	CL	A-6, A-7	0-5	95-100	90-100	80-95	55-80	35-50	15-25
	47-60	Loam, clay loam	CL	A-6	0-5	95-100	90-100	75-90	50-75	30-40	15-25
62C2, 62D2, 62E2- Storden	0-8	Loam-------------	ML, CL	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	A-4, A-6	0-5	95-100	85-97	70-85	55-70	20-40	5-15
73B, 73E--------- Salida	0-9	Gravelly sandy loam.	SM, SP-SM	A-2, A-1	0-5	85-95	60-75	30-60	12-20	---	NP
	9-13	Gravelly loamy sand, gravelly coarse sand, gravelly loamy coarse sand.	SP, SW, GP, GP-GM	A-1	0-5	50-90	40-60	10-30	0-5	---	NP
	13-60	Very gravelly coarse sand, very gravelly sand.	SP, SW, GP, GP-GM	A-1	0-5	20-70	10-60	5-30	0-5	---	NP
90--------------- Okoboji	0-17	Mucky silt loam	OH, MH	A-7	0	100	100	95-100	90-95	60-95	10-30
	17-44	Silty clay loam, silty clay.	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	44-60	Silty clay loam, silty clay.	CH	A-7	0	95-100	95-100	90-100	80-95	55-65	30-40
95--------------- Harps	0-16	Loam-------------	CL, CH	A-6, A-7	0-5	95-100	95-100	80-90	65-80	30-55	15-35
	16-40	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
	40-60	Loam, sandy clay loam.	CL	A-6	0-5	95-100	90-100	70-80	50-75	25-40	10-25
107-------------- Webster	0-23	Clay loam--------	CL, CH	A-7, A-6	0-5	95-100	95-100	85-95	70-90	35-60	15-30
	23-46	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
	46-60	Loam, sandy loam, clay loam.	CL	A-6	0-5	95-100	90-100	75-85	50-75	30-40	10-20
135-------------- Coland	0-9	Clay loam--------	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	9-48	Clay loam, silty clay loam.	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	48-60	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
135B------------- Coland	0-36	Clay loam--------	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	36-60	Clay loam, silty clay loam.	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30

TABLE 14.--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	
138B, 138C, 138C2, 138D2----Clarion	0-17	Loam-------------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	17-30	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	30-60	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
150--------------Hanska	0-17	Loam-------------	ML, CL, CL-ML	A-4	0	95-100	95-100	80-95	50-65	<25	2-10
	17-38	Sandy loam, coarse sandy loam, loam.	SM, SM-SC, SC	A-4	0	95-100	95-100	65-80	35-50	<20	2-8
	38-60	Sand, coarse sand	SP-SM	A-3, A-1, A-2	0	95-100	85-100	45-70	5-10	<20	NP
168B, 168C, 168D2, 168E-----Hayden	0-8	Loam-------------	CL-ML, CL	A-4	0	100	98-100	85-98	50-80	20-30	4-10
	8-45	Clay loam, loam	CL	A-7, A-6	0	95-100	90-100	80-95	55-75	30-50	15-26
	45-60	Loam, sandy loam, fine sandy loam.	CL, SC	A-6, A-4	0-5	95-100	90-100	75-90	35-70	20-35	8-15
175B-------------Dickinson	0-15	Fine sandy loam	SM, SC, SM-SC	A-4, A-2	0	100	100	85-95	30-50	15-30	NP-10
	15-32	Fine sandy loam, sandy loam.	SM, SC, SM-SC	A-4	0	100	100	85-95	35-50	15-30	NP-10
	32-60	Loamy sand, loamy fine sand, fine sand.	SM, SP-SM, SM-SC	A-2, A-3	0	100	100	80-95	5-20	10-20	NP-5
221--------------Palms	0-29	Sapric material	PT	A-8	---	---	---	---	---	---	---
	29-60	Silt loam, fine sandy loam, mucky silt loam.	CL-ML, CL	A-4, A-6	0	85-100	80-100	70-95	50-90	25-40	5-20
224--------------Linder	0-13	Loam-------------	CL, SC	A-4, A-6	0	100	95-100	80-95	35-80	25-40	8-15
	13-33	Sandy loam-------	SC, SM-SC	A-2, A-4	0	95-100	80-100	45-75	30-45	20-30	5-10
	33-60	Gravelly sand, gravelly loamy sand, loamy coarse sand.	SP, SP-SM	A-1	0-5	75-95	30-95	25-50	2-12	---	NP
236B, 236C2, 236D2, 236E2, 236F------------Lester	0-7	Loam-------------	ML, CL	A-6, A-4	0-5	95-100	90-100	80-95	50-70	30-40	5-15
	7-21	Clay loam, loam	CL	A-7, A-6	0-5	95-100	90-100	80-95	55-75	35-50	15-25
	21-60	Loam, clay loam	CL, CL-ML	A-6, A-4	0-5	95-100	90-100	75-90	50-70	20-40	5-20
307--------------Dundas	0-22	Silt loam--------	ML, CL	A-6, A-4	0	100	95-98	85-97	60-80	30-40	6-16
	22-45	Clay loam, silty clay loam, sandy clay loam.	CL, CH	A-6, A-7	0-2	97-100	90-98	85-97	50-90	35-60	15-30
	45-60	Clay loam, loam, fine sandy loam.	CL, SC	A-6	0-2	95-100	90-98	80-95	35-70	30-40	10-20
321--------------Boots	0-7	Sapric material	PT	A-8	0	---	---	---	---	---	---
	7-60	Hemic material, sapric material.	PT	A-8	0	---	---	---	---	---	---
325--------------Le Sueur	0-14	Loam-------------	CL, ML, CL-ML	A-6, A-4	0	95-100	95-100	90-100	70-85	20-40	5-15
	14-35	Clay loam, loam, silty clay loam.	CL	A-6, A-7	0	95-100	95-100	85-100	60-80	35-50	15-25
	35-60	Loam-------------	CL-ML, CL	A-6, A-4	0-5	95-100	90-100	80-95	55-75	20-40	5-20

TABLE 14.--ENGINEERING INDEX PROPERTIES--Continued

Soil name and map symbol	Depth	USDA texture	Classification		Fragments > 3 inches	Percentage passing sieve number--				Liquid limit	Plasticity index
			Unified	AASHTO		4	10	40	200		
	In				Pct					Pct	
349 Darfur	0-18	Loam	OL, ML	A-4	0	100	100	100	60-80	25-40	NP-10
	18-28	Sandy loam, loam, loamy fine sand.	SM	A-4	0	100	100	70-100	35-50	20-30	NP-5
	28-60	Stratified fine sand to fine sandy loam.	SM	A-2, A-4	0	100	100	50-100	15-40	---	---
384, 384B Collinwood	0-19	Silty clay loam	CL, CH, ML, MH	A-7	0	100	100	95-100	90-95	40-55	15-25
	19-40	Silty clay, clay, silty clay loam.	MH, CH	A-7	0	100	100	95-100	90-95	50-65	20-35
	40-60	Silty clay, clay, silty clay loam.	CH, CL	A-7	0	100	100	95-100	90-95	40-60	15-30
386 Cordova	0-21	Loam, clay loam	OL, ML, MH, OH	A-6, A-7	0	95-100	95-100	90-100	70-85	38-60	12-25
	21-39	Silty clay loam, clay loam.	CL	A-7	0	90-100	90-100	85-95	65-90	40-50	20-30
	39-60	Clay loam, loam	CL	A-6	0-5	90-100	90-100	80-95	55-70	30-40	12-20
390 Waldorf	0-19	Silty clay loam, silty clay.	ML, MH	A-7	0	100	100	95-100	90-100	45-65	14-30
	19-44	Silty clay, silty clay loam.	MH	A-7	0	100	100	95-100	95-100	50-70	20-35
	44-60	Silty clay loam, silty clay, silt loam.	MH, CL, ML, CH	A-7, A-6	0	100	100	95-100	90-100	35-65	11-30
485B Spillville	0-42	Loam	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
	42-60	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
507 Canisteo	0-14	Clay loam	OL, CL	A-7	0	98-100	95-100	85-98	60-90	40-50	15-20
	14-46	Clay loam, loam, silty clay loam.	CL	A-6, A-7	0	98-100	90-100	85-95	65-85	38-50	25-35
	46-60	Clay loam, loam	CL	A-6	0-5	95-100	90-98	80-95	50-75	30-40	12-20
511 Blue Earth	0-8	Mucky silt loam	OL, ML	A-5	0	95-100	95-100	85-95	80-95	41-50	2-8
	8-60	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
583 Minnetonka	0-12	Silty clay loam	MH, ML	A-5, A-7	0	95-100	95-100	90-98	85-95	40-55	6-20
	12-55	Silty clay, silty clay loam.	MH, CH, CL, ML	A-7	0	95-100	95-100	90-98	85-95	40-65	12-35
	55-60	Silty clay loam, silt loam, clay loam.	MH, ML, CL	A-7, A-4, A-6	0	95-100	85-100	75-100	60-95	30-55	5-25
585B*:											
Coland	0-9	Clay loam	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	9-48	Clay loam, silty clay loam.	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	48-60	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	0-42	Loam	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
	42-60	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

See footnote at end of table.

TABLE 14.--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	
621-------------- Houghton	0-60	Sapric material	PT	A-8	0	---	---	---	---	---	---
638B2*, 638C2*, 638D2*, 638E2*:											
Clarion--------	0-17	Loam------------	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	17-30	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	30-60	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
Storden--------	0-8	Loam------------	ML, CL	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	A-4, A-6	0-5	95-100	85-97	70-85	55-70	20-40	5-15
655-------------- Crippin	0-20	Loam, clay loam	CL	A-6, A-7	0	95-100	95-100	80-90	60-80	30-45	10-20
	20-34	Loam, clay loam	CL	A-6	0-5	95-100	90-100	80-90	60-80	30-40	10-20
	34-60	Loam, clay loam	CL	A-6	2-5	90-100	85-100	75-90	55-80	30-40	10-20
658-------------- Mayer	0-22	Loam,-----------	CL, ML	A-6, A-4	0-2	95-100	85-100	70-90	50-85	30-40	5-15
	22-33	Loam, sandy clay loam, silt loam.	CL, SC, ML, SM	A-6, A-4	0-5	90-100	85-100	70-90	40-85	30-40	5-15
	33-60	Gravelly coarse sand, sand, coarse sand.	SP, SW, SP-SM	A-1	0-10	65-95	45-85	20-45	2-10	<20	NP
777, 777B, 777C-- Wapsie	0-8	Loam------------	CL, ML, CL-ML	A-4	0	100	90-100	70-90	50-75	25-35	5-10
	8-30	Loam, sandy loam, sandy clay loam.	CL, SC, CL-ML, SM-SC	A-4, A-6	0	85-95	80-95	70-85	40-60	20-35	5-15
	30-60	Gravelly loamy sand, gravelly sand, sand.	SW, SM, SP, SP-SM	A-1	0	60-90	60-85	20-40	3-25	---	NP
787B, 787C2, 787D2----------- Vinje	0-13	Silty clay loam	CL	A-7	0	100	100	95-100	90-95	40-55	15-25
	13-41	Silty clay, silty clay loam.	CH, CL	A-7	0	100	100	95-100	90-95	40-60	15-30
	41-60	Clay loam, silt loam, silty clay loam.	CL	A-6	0-5	90-100	85-95	75-90	45-70	25-40	10-20
811-------------- Muskego	0-26	Sapric material	PT	A-8	0	---	---	---	---	---	---
	26-60	Coprogenous earth, mucky silt loam.	OL	A-5	0	95-100	95-100	85-100	75-96	41-50	2-8
823, 823B-------- Ridgeport	0-13	Sandy loam-------	SM, SC, SM-SC	A-2, A-4	0	95-100	90-100	70-90	25-50	15-30	2-10
	13-38	Sandy loam, gravelly sandy loam.	SM, SC, SM-SC	A-2, A-4	0	95-100	85-100	65-85	20-45	15-30	2-10
	38-60	Gravelly loamy sand, loamy sand, sand.	SW, SP, SW-SM, SP-SM	A-1	0-5	80-95	75-95	35-50	2-10	<25	NP-6
836B, 836C2, 836D2, 836E2, 836F------------ Kilkenny	0-8	Clay loam--------	ML, MH	A-7	0	95-100	95-100	80-95	70-85	40-60	10-25
	8-57	Clay loam, clay, silty clay loam.	MH, CH	A-7	0	95-100	90-98	80-95	65-80	50-70	25-35
	57-60	Clay loam, loam	CL, ML	A-7, A-6	0-5	95-100	90-98	75-90	60-75	35-50	10-25

See footnote at end of table.

TABLE 14.--ENGINEERING INDEX PROPERTIES--Continued

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	
855-------------- Shorewood	0-15	Silty clay loam	CL, ML	A-6, A-7	0	100	100	90-100	85-100	35-50	12-20
	15-42	Silty clay, silty clay loam.	MH	A-7	0	100	100	90-100	85-100	55-75	20-40
	42-60	Clay loam, silty clay loam, silty clay.	CL, ML	A-6, A-7	0-5	95-100	90-100	85-100	80-95	35-50	10-20
1133------------- Colo	0-12	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-60	15-30
	12-47	Silty clay loam	CL, CH	A-7	0	100	100	90-100	90-100	40-55	20-30
	47-60	Silty clay loam, clay loam, silt loam.	CL, CH	A-7	0	100	100	95-100	80-100	40-55	15-30
2811------------- Muskego	0-26	Sapric material	PT	A-8	0	---	---	---	---	---	---
	26-60	Coprogenous earth, mucky silt loam.	OL, ML	A-5	0	95-100	95-100	85-100	75-96	41-50	2-8
5010*. Pits											
5040*. Orthents											

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS

[The symbol < means less than; > means more than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" 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
								K	T	
	In	Pct	g/cc	In/hr	In/in	pH				
6----------------	0-9	35-42	1.25-1.30	0.2-0.6	0.21-0.23	6.1-7.8	High---------	0.37	5	4
Okoboji	9-38	35-42	1.30-1.35	0.2-0.6	0.18-0.20	6.6-7.8	High---------	0.37		
	38-60	35-45	1.35-1.40	0.2-0.6	0.18-0.20	7.4-8.4	High---------	0.37		
28B--------------	0-12	6-18	1.30-1.40	2.0-6.0	0.13-0.15	5.6-6.5	Low----------	0.20	3	3
Dickman	12-47	6-18	1.35-1.50	2.0-6.0	0.12-0.14	5.6-7.3	Low----------	0.20		
	47-60	1-10	1.50-1.60	6.0-20	0.02-0.07	5.6-7.8	Low----------	0.15		
55---------------	0-19	24-35	1.15-1.25	0.6-2.0	0.17-0.22	5.6-7.3	Moderate-----	0.24	5	6
Nicollet	19-47	24-35	1.25-1.35	0.6-2.0	0.15-0.19	5.6-7.8	Moderate-----	0.32		
	47-60	22-32	1.35-1.55	0.6-2.0	0.14-0.19	7.4-8.4	Low----------	0.32		
62C2, 62D2, 62E2-	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
Storden	8-60	18-30	1.35-1.65	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37		
73B, 73E---------	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
Salida	9-13	2-8	1.50-1.65	>20	0.02-0.04	7.4-8.4	Low----------	0.10		
	13-60	0-5	1.50-1.65	>20	0.02-0.04	7.4-8.4	Low----------	0.10		
90---------------	0-17	20-26	1.20-1.25	0.6-2.0	0.24-0.26	6.1-7.8	High---------	0.37	5	6
Okoboji	17-44	35-42	1.30-1.35	0.2-0.6	0.18-0.20	6.6-7.8	High---------	0.37		
	44-60	35-45	1.35-1.40	0.2-0.6	0.18-0.20	7.4-8.4	High---------	0.37		
95---------------	0-16	25-35	1.35-1.40	0.6-2.0	0.19-0.21	7.9-8.4	Moderate-----	0.24	5	4L
Harps	16-40	18-32	1.40-1.50	0.6-2.0	0.17-0.19	7.9-8.4	Moderate-----	0.32		
	40-60	20-26	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Moderate-----	0.32		
107--------------	0-23	26-35	1.35-1.40	0.6-2.0	0.19-0.21	6.6-7.3	Moderate-----	0.24	5	6
Webster	23-46	25-35	1.40-1.50	0.6-2.0	0.16-0.18	6.6-7.8	Moderate-----	0.32		
	46-60	18-29	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Moderate-----	0.32		
135--------------	0-9	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28	5	7
Coland	9-48	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28		
	48-60	12-26	1.50-1.65	0.6-6.0	0.13-0.17	6.1-7.8	Low----------	0.28		
135B-------------	0-36	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28	5	7
Coland	36-60	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28		
138B, 138C,										
138C2, 138D2----	0-17	18-24	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.28	5	6
Clarion	17-30	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low----------	0.37		
	30-60	12-22	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37		
150--------------	0-17	6-18	1.30-1.40	2.0-6.0	0.20-0.22	6.1-7.8	Low----------	0.28	4	5
Hanska	17-38	6-18	1.35-1.50	2.0-6.0	0.10-0.13	6.1-7.3	Low----------	0.28		
	38-60	1-10	1.50-1.60	6.0-20	0.03-0.05	6.6-7.8	Low----------	0.17		
168B, 168C,										
168D2, 168E-----	0-8	10-25	1.40-1.60	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.32	5	6
Hayden	8-45	18-35	1.50-1.65	0.6-2.0	0.15-0.19	5.1-7.8	Moderate-----	0.32		
	45-60	15-27	1.65-1.80	0.6-2.0	0.14-0.19	7.4-8.4	Low----------	0.32		
175B-------------	0-15	10-18	1.50-1.55	2.0-6.0	0.12-0.15	5.6-7.3	Low----------	0.20	4	3
Dickinson	15-32	10-15	1.45-1.55	2.0-6.0	0.12-0.15	5.1-6.5	Low----------	0.20		
	32-60	4-10	1.55-1.65	6.0-20	0.08-0.10	5.1-7.3	Low----------	0.20		
221--------------	0-29	---	0.25-0.45	0.2-6.0	0.35-0.45	5.1-7.8	-------------	----	2	2
Palms	29-60	7-35	1.45-1.75	0.2-2.0	0.14-0.22	6.1-8.4	Low----------	----		

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors		Wind erodi-bility group
								K	T	
	In	Pct	g/cc	In/hr	In/in	pH				
224---------------- Linder	0-13	14-18	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.8	Low----------	0.24	4	5
	13-33	10-18	1.45-1.55	2.0-6.0	0.15-0.17	6.1-7.8	Low----------	0.24		
	33-60	2-8	1.55-1.75	>20	0.02-0.04	6.1-8.4	Low----------	0.10		
236B, 236C2, 236D2, 236E2, 236F------------ Lester	0-7	15-27	1.30-1.40	0.6-2.0	0.20-0.22	5.6-6.5	Low----------	0.28	5	6
	7-21	24-35	1.45-1.55	0.6-2.0	0.15-0.19	5.1-7.3	Moderate-----	0.28		
	21-60	20-30	1.55-1.75	0.6-2.0	0.14-0.19	6.6-8.4	Low----------	0.37		
307---------------- Dundas	0-22	10-27	1.40-1.60	0.6-2.0	0.22-0.24	5.6-7.3	Moderate-----	0.28	5	6
	22-45	20-35	1.50-1.65	0.2-0.6	0.15-0.19	5.1-7.3	Moderate-----	0.28		
	45-60	15-30	1.60-1.75	0.6-2.0	0.14-0.19	6.1-8.4	Moderate-----	0.28		
321---------------- Boots	0-7	---	0.16-0.45	0.6-6.0	0.35-0.45	5.6-7.3	-------------	----	2	2
	7-60	---	0.16-0.28	0.6-6.0	0.35-0.45	5.6-7.3	-------------	----		
325---------------- Le Sueur	0-14	20-27	1.30-1.40	0.6-2.0	0.20-0.24	5.6-7.3	Low----------	0.24	5	6
	14-35	24-35	1.30-1.45	0.6-2.0	0.15-0.19	5.1-6.5	Moderate-----	0.32		
	35-60	20-27	1.50-1.65	0.6-2.0	0.15-0.19	7.4-8.4	Moderate-----	0.32		
349---------------- Darfur	0-18	18-25	1.20-1.35	0.6-2.0	0.20-0.22	6.1-7.3	Low----------	0.20	5	5
	18-28	13-18	1.35-1.50	2.0-6.0	0.15-0.17	6.6-7.8	Low----------	0.20		
	28-60	5-15	1.45-1.60	2.0-6.0	0.08-0.10	6.6-8.4	Low----------	0.20		
384, 384B--------- Collinwood	0-19	35-45	1.20-1.30	0.2-0.6	0.14-0.17	5.6-7.3	Moderate-----	0.32	5	4
	19-40	35-60	1.25-1.35	0.06-0.6	0.13-0.16	5.6-7.8	High---------	0.32		
	40-60	35-45	1.25-1.40	0.06-0.6	0.11-0.15	7.4-8.4	High---------	0.32		
386---------------- Cordova	0-21	15-30	1.25-1.45	0.2-2.0	0.18-0.22	6.1-7.3	Moderate-----	0.28	5	6
	21-39	28-35	1.35-1.50	0.2-0.6	0.15-0.19	5.1-6.5	Moderate-----	0.28		
	39-60	18-30	1.45-1.70	0.6-2.0	0.14-0.16	6.6-8.4	Moderate-----	0.28		
390---------------- Waldorf	0-19	35-45	1.20-1.30	0.2-2.0	0.18-0.25	6.1-7.3	Moderate-----	0.28	5	4
	19-44	40-55	1.25-1.35	0.2-0.6	0.13-0.16	6.6-7.8	High---------	0.28		
	44-60	24-45	1.25-1.35	0.2-2.0	0.20-0.22	7.4-8.4	Moderate-----	0.28		
485B-------------- Spillville	0-42	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.28	5	6
	42-60	14-24	1.55-1.70	0.6-6.0	0.15-0.18	5.6-7.3	Low----------	0.28		
507---------------- Canisteo	0-14	22-32	1.25-1.35	0.6-2.0	0.18-0.22	7.4-8.4	Moderate-----	0.24	5	4L
	14-46	20-35	1.35-1.50	0.6-2.0	0.15-0.19	7.4-8.4	Moderate-----	0.32		
	46-60	22-32	1.45-1.60	0.6-2.0	0.14-0.16	7.4-8.4	Low----------	0.32		
511---------------- Blue Earth	0-8	18-32	0.20-0.80	0.6-2.0	0.18-0.24	7.4-8.4	Moderate-----	0.28	5	4L
	8-60	18-32	0.20-0.80	0.6-2.0	0.18-0.24	7.4-8.4	Low----------	0.28		
583---------------- Minnetonka	0-12	27-35	1.20-1.40	0.2-0.6	0.18-0.22	5.6-7.3	Moderate-----	0.28	5	7
	12-55	35-60	1.20-1.35	0.06-0.2	0.13-0.19	5.6-7.8	High---------	0.28		
	55-60	25-40	1.25-1.55	0.2-2.0	0.16-0.21	6.6-7.8	Moderate-----	0.28		
585B*:										
Coland-----------	0-9	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28	5	7
	9-48	27-35	1.40-1.50	0.6-2.0	0.20-0.22	6.1-7.3	High---------	0.28		
	48-60	12-26	1.50-1.65	0.6-6.0	0.13-0.17	6.1-7.8	Low----------	0.28		
Spillville-------	0-42	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate-----	0.28	5	6
	42-60	14-24	1.55-1.70	0.6-6.0	0.15-0.18	5.6-7.3	Low----------	0.28		
621---------------- Houghton	0-60	---	0.15-0.45	0.2-6.0	0.35-0.45	4.5-7.8	-------------	----	2	2

See footnote at end of table.

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS--Continued

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors		Wind erodibility group
								K	T	
	In	Pct	g/cc	In/hr	In/in	pH				
638B2*, 638C2*, 638D2*, 638E2*:										
Clarion--------	0-17	18-24	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low----------	0.28	5	6
	17-30	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low----------	0.37		
	30-60	12-22	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37		
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
	8-60	18-30	1.35-1.65	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.37		
655-------------- Crippin	0-20	22-30	1.35-1.40	0.6-2.0	0.20-0.22	6.6-8.4	Low----------	0.28	5	4L
	20-34	24-30	1.40-1.55	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.28		
	34-60	22-28	1.55-1.75	0.6-2.0	0.17-0.19	7.9-8.4	Low----------	0.37		
658-------------- Mayer	0-22	18-27	1.25-1.35	0.6-2.0	0.20-0.22	7.4-8.4	Low----------	0.28	4	4L
	22-33	18-27	1.25-1.35	0.6-2.0	0.16-0.19	7.4-8.4	Low----------	0.28		
	33-60	1-5	1.55-1.65	6.0-20	0.02-0.04	7.4-8.4	Low----------	0.15		
777, 777B, 777C-- Wapsie	0-8	12-18	1.40-1.45	0.6-2.0	0.18-0.20	5.6-7.3	Low----------	0.28	4	5
	8-30	12-18	1.45-1.50	0.6-2.0	0.15-0.17	5.6-6.5	Low----------	0.28		
	30-60	2-10	1.50-1.75	>20	0.02-0.06	5.1-7.8	Low----------	0.10		
787B, 787C2, 787D2----------- Vinje	0-13	35-40	1.25-1.30	0.2-0.6	0.21-0.23	6.1-7.3	Moderate-----	0.32	5	4
	13-41	35-45	1.30-1.45	0.2-0.6	0.20-0.22	6.1-7.3	Moderate-----	0.32		
	41-60	20-30	1.45-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Low----------	0.32		
811-------------- Muskego	0-26	2-4	0.10-0.21	0.6-6.0	0.35-0.45	5.6-7.3	-------------	----	---	2
	26-60	18-35	0.30-1.10	0.06-0.2	0.18-0.24	6.6-8.4	Moderate-----	0.28		
823, 823B-------- Ridgeport	0-13	10-18	1.50-1.55	2.0-6.0	0.14-0.17	5.6-7.3	Low----------	0.24	4	3
	13-38	10-18	1.55-1.60	2.0-6.0	0.10-0.14	5.6-7.3	Low----------	0.24		
	38-60	2-8	1.60-1.75	>20	0.03-0.05	7.4-8.4	Low----------	0.10		
836B, 836C2, 836D2, 836E2, 836F------------ Kilkenny	0-8	27-30	1.15-1.25	0.2-0.6	0.17-0.19	5.6-7.3	Moderate-----	0.28	5	6
	8-57	35-45	1.25-1.35	0.2-0.6	0.15-0.19	4.5-7.3	Moderate-----	0.28		
	57-60	25-35	1.35-1.45	0.2-2.0	0.14-0.16	5.6-7.8	Moderate-----	0.37		
855-------------- Shorewood	0-15	30-40	1.20-1.40	0.2-0.6	0.18-0.22	5.6-7.3	Moderate-----	0.37	4	7
	15-42	36-55	1.20-1.35	0.06-0.6	0.13-0.16	5.1-6.5	High---------	0.37		
	42-60	35-45	1.25-1.55	0.2-2.0	0.14-0.16	6.6-7.8	Moderate-----	0.37		
1133------------- Colo	0-12	27-32	1.28-1.32	0.6-2.0	0.21-0.23	5.6-7.3	High---------	----	---	8
	12-47	30-35	1.25-1.35	0.6-2.0	0.18-0.20	5.6-7.3	High---------	0.28		
	47-60	25-35	1.35-1.45	0.6-2.0	0.18-0.20	6.1-7.3	High---------	0.28		
2811------------- Muskego	0-26	2-4	0.10-0.21	0.2-6.0	0.35-0.45	5.6-7.3	-------------	----	---	8
	26-60	18-35	0.30-1.10	0.6-2.0	0.18-0.24	6.6-8.4	Moderate-----	0.28		
5010*. Pits										
5040*. Orthents										

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 16.--SOIL AND WATER FEATURES

["Flooding" and "water table" and terms such as "rare," "brief," "apparent," and "perched" 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 or that data were not estimated]

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months		Uncoated steel	Concrete
					Ft					
6----------------- Okoboji	B/D	None---------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Low.
28B--------------- Dickman	A	None---------	---	---	>6.0	---	---	Low------	Low------	Moderate.
55---------------- Nicollet	B	None---------	---	---	2.5-5.0	Apparent	Nov-Jul	High-----	High-----	Low.
62C2, 62D2, 62E2-- Storden	B	None---------	---	---	>6.0	---	---	Moderate	Low------	Low.
73B, 73E---------- Salida	A	None---------	---	---	>6.0	---	---	Low------	Low------	Low.
90---------------- Okoboji	B/D	None---------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Low.
95---------------- Harps	B/D	None---------	---	---	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
107--------------- Webster	B/D	None---------	---	---	1.0-2.0	Apparent	Nov-Jul	High-----	High-----	Low.
135--------------- Coland	B/D	Occasional	Brief-----	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
135B-------------- Coland	B/D	None---------	---	---	1.5-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
138B, 138C, 138C2, 138D2------------ Clarion	B	None---------	---	---	>6.0	---	---	Moderate	Low------	Low.
150--------------- Hanska	B/D	Rare---------	---	---	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
168B, 168C, 168D2, 168E------------- Hayden	B	None---------	---	---	>6.0	---	---	Moderate	Low------	Moderate.
175B-------------- Dickinson	B	None---------	---	---	>6.0	---	---	Moderate	Low------	Moderate.
221--------------- Palms	A/D	None---------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Moderate.
224--------------- Linder	B	None---------	---	---	2.0-4.0	Apparent	Nov-Jul	High-----	Moderate	Low.
236B, 236C2, 236D2, 236E2, 236F------------- Lester	B	None---------	---	---	>6.0	---	---	Moderate	Low------	Moderate.
307--------------- Dundas	B/D	None---------	---	---	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Moderate.

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months		Uncoated steel	Concrete
					Ft					
321---------------- Boots	A/D	None--------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	Moderate	Low.
325---------------- Le Sueur	B	None--------	---	---	2.0-4.0	Perched	Nov-Jul	High-----	High-----	Low.
349---------------- Darfur	B/D	None--------	---	---	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
384, 384B--------- Collinwood	C	None--------	---	---	2.0-5.0	Apparent	Nov-Jul	High-----	High-----	Low.
386---------------- Cordova	C/D	None--------	---	---	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
390---------------- Waldorf	C/D	None--------	---	---	0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
485B-------------- Spillville	B	None--------	---	---	3.0-5.0	Apparent	Nov-Jul	Moderate	High-----	Moderate.
507---------------- Canisteo	B/D	None--------	---	---	1.0-3.0	Apparent	Oct-Jul	High-----	High-----	Low.
511---------------- Blue Earth	B/D	None--------	---	---	+2-1.0	Apparent	Nov-Jul	High-----	High-----	Low.
583---------------- Minnetonka	D	None--------	---	---	0-3.0	Perched	Nov-Jul	High-----	High-----	Moderate.
585B*: Coland------------	B/D	Occasional	Brief-----	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
Spillville--------	B	None--------	---	---	3.0-5.0	Apparent	Nov-Jul	Moderate	High-----	Moderate.
621---------------- Houghton	A/D	None--------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Low.
638B2*, 638C2*, 638D2*, 638E2*: Clarion----------	B	None--------	---	---	>6.0	---	---	Moderate	Low------	Low.
Storden----------	B	None--------	---	---	>6.0	---	---	Moderate	Low------	Low.
655---------------- Crippin	B	None--------	---	---	2.0-4.0	Apparent	Nov-Jul	High-----	High-----	Low.
658---------------- Mayer	B/D	None--------	---	---	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
777, 777B, 777C--- Wapsie	B	None--------	---	---	>6.0	---	---	Low------	Low------	Moderate.
787B, 787C2, 787D2------------- Vinje	B	None--------	---	---	>6.0	---	---	Moderate	Moderate	Low.
811---------------- Muskego	A/D	None--------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	Moderate	Moderate.

See footnote at end of table.

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydro-logic group	Flooding			High water table			Potential frost action	Risk of corrosion	
		Frequency	Duration	Months	Depth	Kind	Months		Uncoated steel	Concrete
					Ft					
823, 823B--------- Ridgeport	B	None--------	---	---	>6.0	---	---	Low------	Low------	Low.
836B, 836C2, 836D2, 836E2, 836F------------- Kilkenny	B	None--------	---	---	>6.0	---	---	Moderate	Moderate	Moderate.
855--------------- Shorewood	C	None--------	---	---	3.0-5.0	Perched	Nov-Jul	High-----	High-----	Moderate.
1133-------------- Colo	B/D	Frequent----	Very brief to long.	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Moderate.
2811-------------- Muskego	D	None--------	---	---	+3-1.0	Apparent	Nov-Jul	High-----	Moderate	Moderate.
5010*. Pits										
5040*. Orthents										

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 17.--CLASSIFICATION OF THE SOILS

[An asterisk in the first column indicates that the soil is a taxadjunct to the series. See text for a description of those characteristics of the soil that are outside the range of the series]

Soil name	Family or higher taxonomic class
Blue Earth	Fine-silty, mixed (calcareous), mesic Mollic Fluvaquents
Boots	Euic, mesic Typic Medihemists
Canisteo	Fine-loamy, mixed (calcareous), mesic Typic Haplaquolls
Clarion	Fine-loamy, mixed, mesic Typic Hapludolls
Coland	Fine-loamy, mixed, mesic Cumulic Haplaquolls
Collinwood	Fine, montmorillonitic, mesic Aquic Hapludolls
Colo	Fine-silty, mixed, mesic Cumulic Haplaquolls
Cordova	Fine-loamy, mixed, mesic Typic Argiaquolls
Crippin	Fine-loamy, mixed, mesic Aquic Hapludolls
Darfur	Coarse-loamy, mixed, mesic Typic Haplaquolls
Dickinson	Coarse-loamy, mixed, mesic Typic Hapludolls
Dickman	Sandy, mixed, mesic Typic Hapludolls
Dundas	Fine-loamy, mixed, mesic Udollic Ochraqualfs
Hanska	Coarse-loamy, mixed, mesic Typic Haplaquolls
Harps	Fine-loamy, mesic Typic Calciaquolls
Hayden	Fine-loamy, mixed, mesic Typic Hapludalfs
Houghton	Euic, mesic Typic Medisaprists
Kilkenny	Fine, montmorillonitic, mesic Mollic Hapludalfs
Le Sueur	Fine-loamy, mixed, mesic Aquic Argiudolls
Lester	Fine-loamy, mixed, mesic Mollic Hapludalfs
Linder	Coarse-loamy, mixed, mesic Aquic Hapludolls
Mayer	Fine-loamy over sandy or sandy-skeletal, mixed (calcareous), mesic Typic Haplaquolls
Minnetonka	Fine, montmorillonitic, mesic Typic Argiaquolls
Muskego	Coprogenous, euic, mesic Limnic Medisaprists
Nicollet	Fine-loamy, mixed, mesic Aquic Hapludolls
Okoboji	Fine, montmorillonitic, mesic Cumulic Haplaquolls
Orthents	Fine-loamy, mixed, mesic Typic Udorthents
Palms	Loamy, mixed, euic, mesic Terric Medisaprists
Ridgeport	Coarse-loamy, mixed, mesic Typic Hapludolls
*Salida	Sandy-skeletal, mixed, mesic Entic Hapludolls
Shorewood	Fine, montmorillonitic, mesic Aquic Argiudolls
Spillville	Fine-loamy, mixed, mesic Cumulic Hapludolls
Storden	Fine-loamy, mixed (calcareous), mesic Typic Udorthents
Vinje	Fine, montmorillonitic, mesic Typic Hapludolls
Waldorf	Fine, montmorillonitic, mesic Typic Haplaquolls
Wapsie	Coarse-loamy over sandy or sandy-skeletal, mixed, mesic Mollic Hapludalfs
Webster	Fine-loamy, mixed, mesic Typic Haplaquolls

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