United States
Department of
Agriculture

Soil
Conservation
Service

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

Soil Survey of Dickinson County, Iowa

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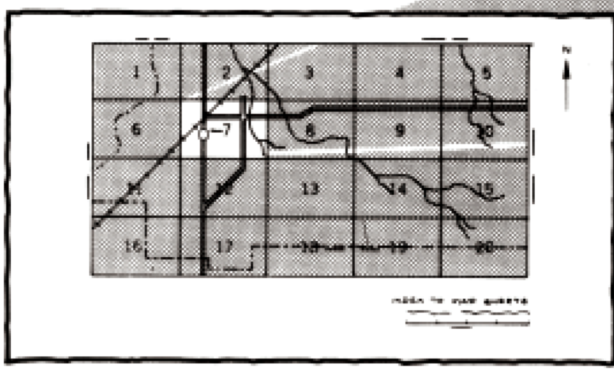

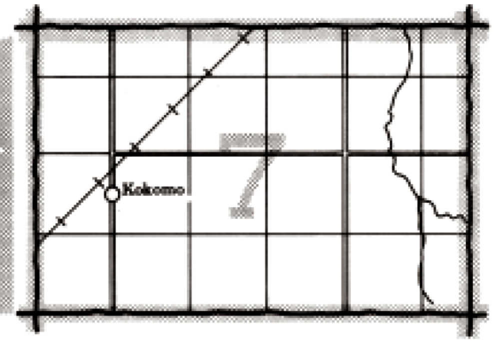

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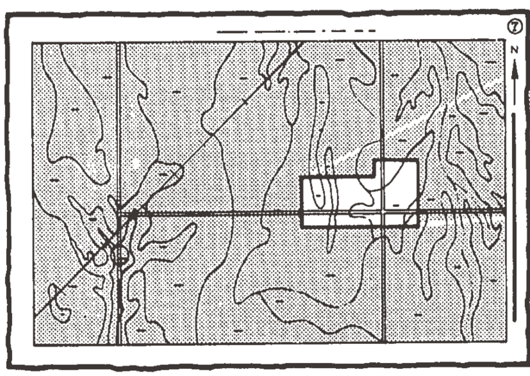

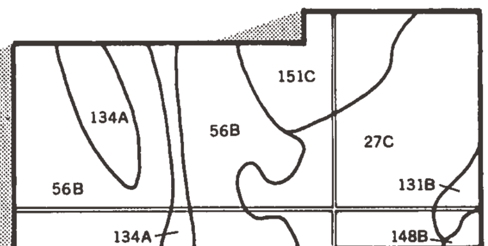

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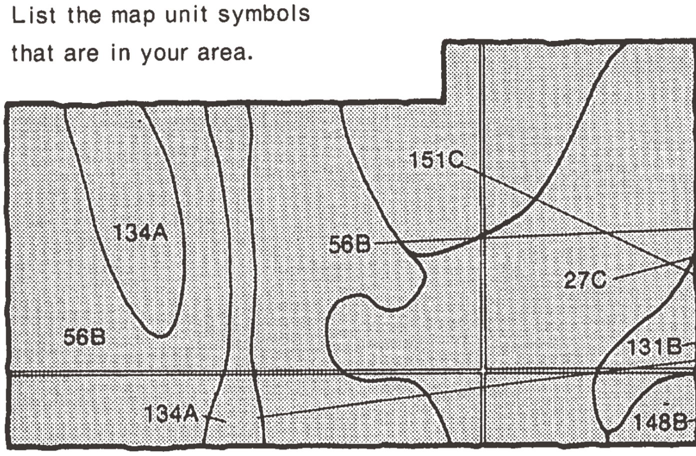
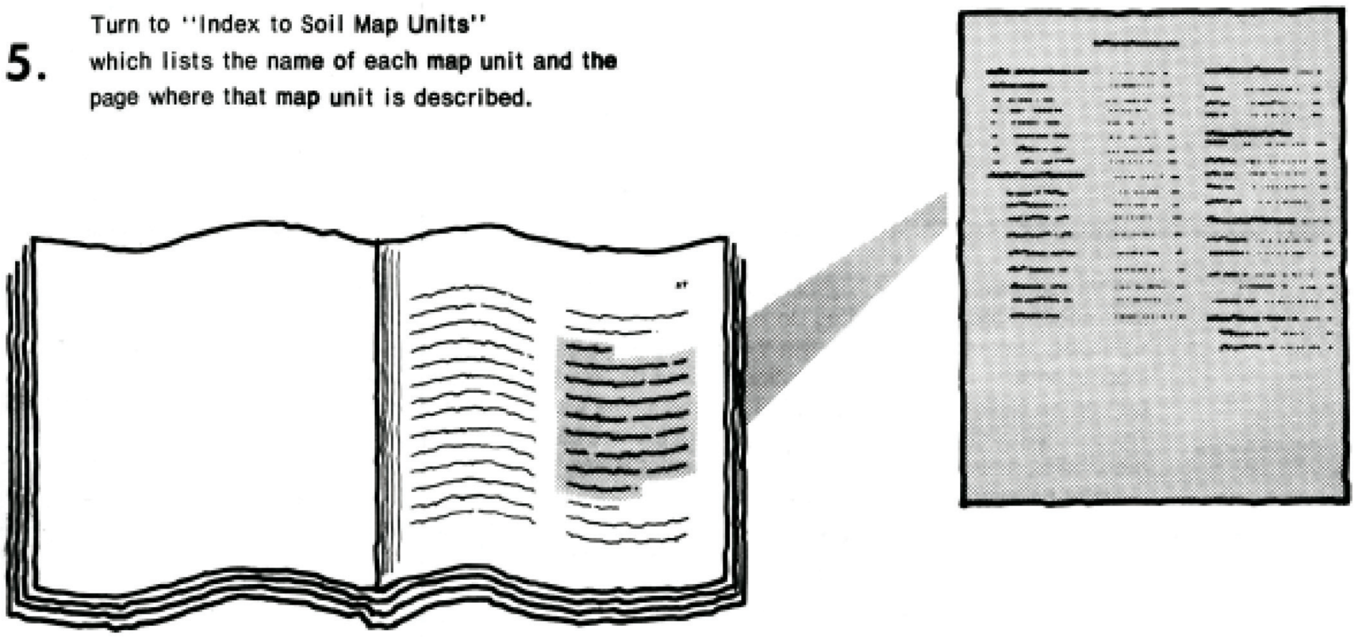


Symbols

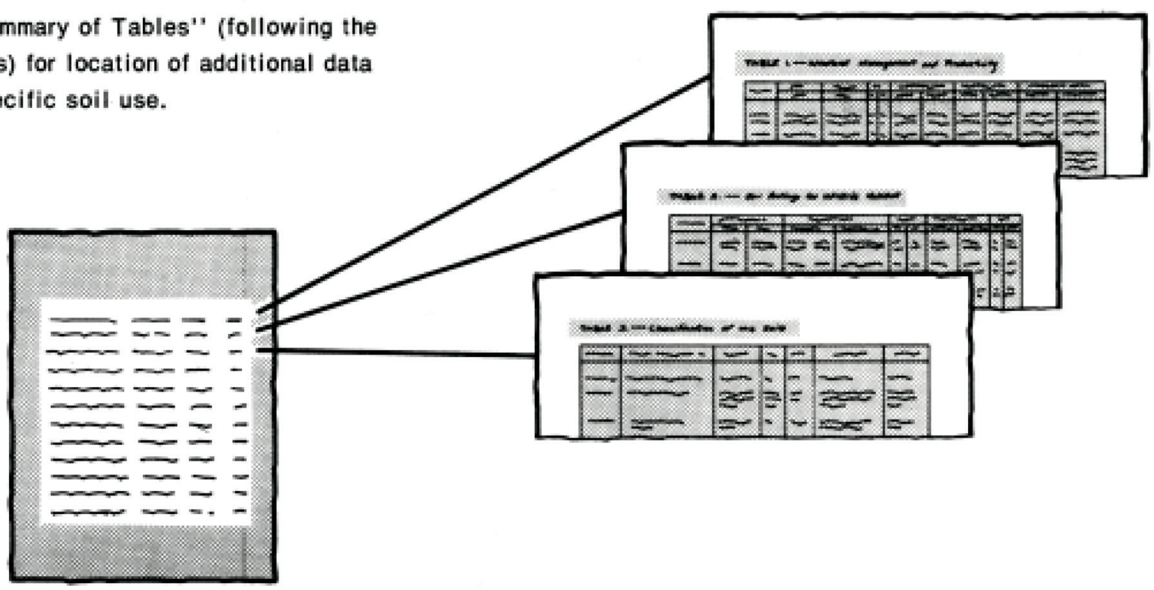
27C
56B
131B
134A
148B
151C

THIS SOIL SURVEY

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



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



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

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

This survey was made cooperatively by the Soil Conservation Service; the Iowa Agriculture and Home Economics Experiment Station; the Cooperative Extension Service, Iowa State University; and the Department of Soil Conservation, State of Iowa. It is part of the technical assistance furnished to the Dickinson County Soil Conservation District. Funds appropriated by Dickinson County were used to defray part of the cost of the survey.

Major fieldwork for this soil survey was completed in 1976-79. Soil names and descriptions were approved in 1980. Unless otherwise indicated, statements in this publication refer to conditions in the survey area in 1979.

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

Cover: West Okoboji Lake. Clarion and Estherville soils are in the foreground.

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Preface

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

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

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

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

Soil Survey of
Dickinson County, Iowa

By Wayne N. Dankert, Soil Conservation Service

Fieldwork by Wayne N. Dankert, Laurence T. Hanson, and Ronald L. Reckner, 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

DICKINSON COUNTY is in northwestern Iowa. It is in the first tier of counties south of Minnesota and in the third column of counties east of the Big Sioux River, which is the Iowa-South Dakota boundary (fig. 1). It has a total area of 257,920 acres, or 403 square miles, of which 15,485 acres is water. Spirit Lake, the county seat, is in the north-central part of the county.

According to the 1980 census, the population of Dickinson County is about 15,630. The population of Spirit Lake, the largest town, is about 3,975. That of Milford is about 2,076, and that of Arnolds Park and of Lake Park is 1,100. The population of Terril, Orleans, Okoboji, West Okoboji, Wahpeton, and Superior ranges from about 200 to 600.

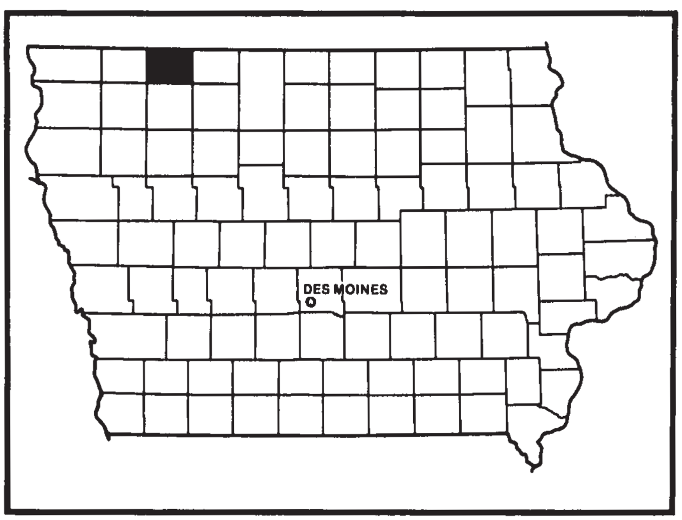


Figure 1.—Location of Dickinson County in Iowa.

The landscape varies throughout the county. In the southwestern part it is characterized by a well defined surface drainage pattern. In most of the county, however, it is characterized by a poorly defined surface drainage pattern and many depressions and sloughs. Most of the soils are deep, are loamy or silty, and are nearly level to gently sloping. The elevation ranges from about 1,275 to 1,575 feet above sea level.

Farming is the main enterprise in the county. Corn and soybeans are the main crops. Industry is important in the vicinity of Spirit Lake and Milford. Tourism is important in the vicinity of the Iowa Great Lakes.

This survey updates the soil survey of Dickinson County published in 1923 (*8*). It provides additional information and larger maps, which show the soils in greater detail.

General Nature of the County

The climate, history and development, and transportation facilities of Dickinson County are briefly described in this section. The climate and distribution of soils have affected the pattern of development in the county and the kinds of cultural features and their locations.

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 Milford, Iowa, in the period 1951 to 1977. 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 Milford on January 21, 1970, is -31 degrees. In summer the average temperature is 71 degrees, and the average daily maximum temperature is 83 degrees. The highest recorded temperature, which occurred at Milford on July 31, 1955, is 103 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 27 inches. Of this, 20 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 16 inches. The heaviest 1-day rainfall during the period of record was 6.17 inches at Milford on July 4, 1962. Thunderstorms occur on about 45 days each year, and most occur in summer.

The average seasonal snowfall is about 36 inches. The greatest snow depth at any one time during the period of record was 35 inches. On an average of 20 days, at least 1 inch of snow is on the ground. The number of such days varies greatly from year to year.

The average relative humidity in midafternoon is about 60 percent. Humidity is higher at night, and the average at dawn is about 80 percent. The sun shines 75 percent of the time possible in summer and 60 percent in winter. The prevailing wind is from the northwest. Average windspeed is highest, 12 miles per hour, in spring.

History and Development

The Oneota Indians probably occupied northwest Iowa from about 950 A.D. until they were displaced by settlers (*3*). They farmed and hunted, but they apparently were more nomadic than their contemporaries to the north and south. A site occupied by the Oneota Indians has been identified and investigated in Okoboji Township (*23*). The Oneota Indians probably became the Ioway Indian Tribe, who gave up their Iowa land by a treaty in 1830.

Dickinson County was named in honor of Daniel S. Dickinson, a United States Senator from New York. The first settlers came to the Arnolds Park area in 1856. Thirty-nine of them were killed by the Indians during the winter of 1856-57. An election to organize the county was held in August 1857. In most of the following years, the population increased but remained low until after the Indian War of 1862-63. During the grasshopper plagues of 1873-77, more than one-half of the settlers left the county. The population was 180 in 1860; 1,389 in 1870; 1,901 in 1880; and 7,995 in 1900 (*21*).

Farming was important during the early settlement of the county, but trapping was the most important nonmilitary occupation until about 1875. Prairie hay and corn were the main crops. The well drained soils, such as Clarion, Everly, and Sac, were the main soils used for farming until drainage improvement projects were begun in the early 1900's. Individual and group drainage projects have made row cropping possible on the very poorly drained and poorly drained soils, which make up about 30 percent of the acreage in the county. Drainage improvement projects are still in progress, mainly to improve the suitability for farming in cultivated areas. In recent years much of the increase in the acreage used for row crops has been on soils on bottom land, where flooding is a hazard, and on moderately sloping to strongly sloping soils on side slopes, where erosion is a hazard.

Since Dickinson County was settled, the total acreage in farms has remained fairly constant. In recent years the farms in the county have been increasing in size and decreasing in number. In 1900, the county had 995 farms (*8*). It had 1,051 in 1960; 754 in 1970; and 660 in 1980 (*9, 20, 22*). The average size of the farm was 223 acres in 1900, 223 acres in 1960, 299 acres in 1970, and 345 acres in 1980 (*8, 9, 20, 22*).

On about 85 percent of the acreage in Dickinson County, the slope is 5 percent or less. Most of the soils are well suited to crops and commonly are used for crops. Corn is the main crop, but the acreage of soybeans has increased in recent years. In 1960, soybeans were grown on about 15 percent of the farmland. By 1970, they were grown on about 35 percent of the farmland and by 1979, on 40 percent. In 1979, corn was grown on 105,000 acres; soybeans on 80,800 acres; all varieties of hay on 9,300 acres; and oats on 6,400 acres (*20*).

Much of the crop production is fed to livestock. In recent years, the number of cattle has been stable and the number of hogs farrowed, raised, and sold has increased slightly. In 1979, 30,000 fed cattle and 105,000 fed hogs were sold. In the same year, the number of beef cattle was 8,700; the number of milk cows, 700; and the number of hogs and pigs, 90,000 (*20*).

Transportation Facilities

Dickinson County is served by one federal highway, five state highways, and numerous all-weather surfaced county roads. Gravel surfaced county roads follow most section lines.

The county is served by two railway companies and two bus companies. Spirit Lake and Milford have municipal airports. Commercial charter service is available at the Spirit Lake Airport. The Dickinson County Senior Adult Transportation System provides local transportation.

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. Wilmonton-Everly-Ocheyedan association

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

This association consists of soils on upland divides, drainageways, ridges, and side slopes. The drainageways are poorly defined on the broad divides and well defined in the rest of the association. There are no perennial streams and few depressions. Slopes range from 0 to 9 percent.

This association makes up about 8 percent of the county. It is about 20 percent Wilmonton soils, 20 percent Everly soils, 10 percent Ocheyedan soils, and 50 percent minor soils (fig. 2).

The somewhat poorly drained, very gently sloping Wilmonton soils are on broad divides and at the slightly concave head of drainageways. The well drained, nearly level to moderately sloping Everly soils are on broad divides and convex ridgetops and side slopes. The well drained, nearly level to gently sloping Ocheyedan soils are on ridgetops and side slopes.

Typically, the surface layer of the Wilmonton soils is black silty clay loam about 8 inches thick. The subsurface layer is silty clay loam about 10 inches thick. It is black and very dark gray in the upper part and very dark grayish brown and very dark gray in the lower part. The subsoil is about 18 inches thick. It is dark grayish brown and light olive brown, friable clay loam in the upper part and light olive brown and brownish yellow, firm clay loam and loam in the lower part. The substratum to a depth of 60 inches is light brownish gray and mottled brownish yellow and light brownish gray, calcareous loam.

Typically, the surface layer of the Everly soils is black clay loam about 7 inches thick. The subsurface layer is black and very dark brown clay loam about 4 inches thick. The subsoil is about 25 inches thick. It is very dark grayish brown and brown, friable clay loam in the upper part; dark yellowish brown, friable clay loam in the next part; and yellowish brown, mottled, firm loam in the lower part. The substratum to a depth of 60 inches is brownish yellow, light gray, and yellowish brown, mottled, calcareous loam.

Typically, the surface layer of the Ocheyedan soils is black loam about 10 inches thick. The subsurface layer is very dark grayish brown loam about 5 inches thick. The subsoil is about 30 inches thick. It is brown and yellowish brown, friable loam in the upper part; yellowish brown, very friable sandy loam in the next part; and yellowish brown and light olive brown, friable loam and silt loam in the lower part. The substratum to a depth of 60 inches is light brownish gray and yellowish brown, mottled, calcareous silt loam and loam.

Kingston soils are the most extensive minor soils in this association. Less extensive are Fostoria, Letri, and Madelia soils. The somewhat poorly drained Fostoria and Kingston soils are on broad, plane uplands and at the head of drainageways. The Kingston soils contain less sand than the Wilmonton soils. The poorly drained Letri and Madelia soils are on plane and slightly concave, broad uplands and in upland drainageways.

This association is used mainly for row crops. Corn and soybeans are the major crops. They are the only crops on some farms. Alfalfa and oats are grown on some livestock farms. About one-third of the farms have a small acreage of permanent pasture. A few small areas support native hardwoods.

Erosion is the main concern in managing the gently sloping and moderately sloping soils for cultivated crops. A conservation tillage system that leaves crop residue on the surface, contour farming, and terraces help to prevent excessive soil losses. Forgoing fall tillage also

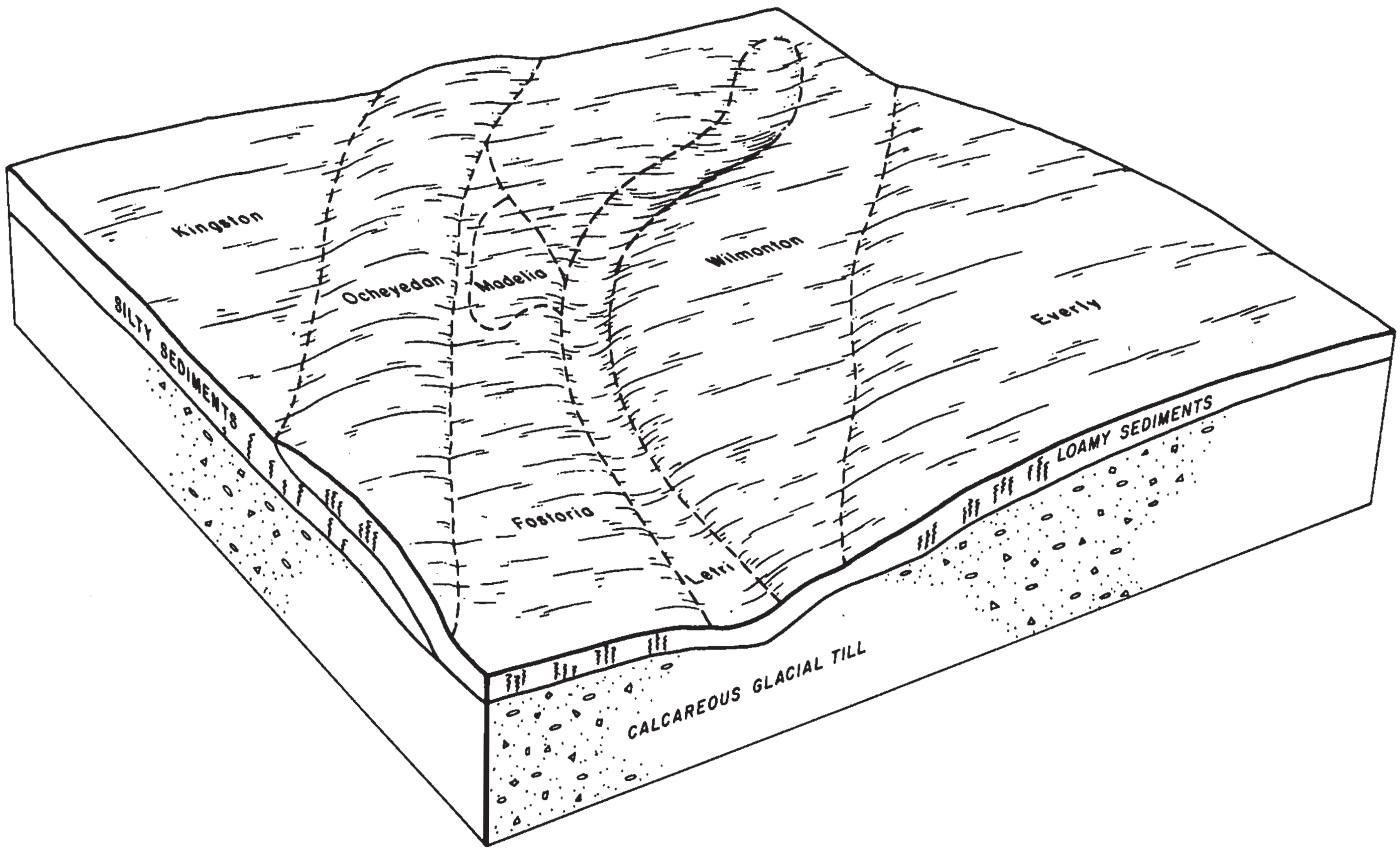


Figure 2.—Pattern of soils and parent material in the Wilmonton-Everly-Ocheyedan association.

reduces the hazard of erosion. Because the poorly drained minor soils are tile drained, they can be efficiently row cropped.

On some farms raising livestock, most commonly hogs, is a major enterprise. Livestock waste can contaminate surface water and ground water, especially in areas of the poorly drained minor soils. On most farms, however, sizable areas of well drained soils are well suited to livestock waste disposal.

2. Ransom-Sac-Primghar association

Nearly level to gently sloping, somewhat poorly drained and well drained, silty soils formed in loess or in loess and the underlying glacial till; on uplands

This association consists of soils on upland divides, drainageways, ridges, and side slopes. The drainageways are poorly defined in the level areas and well defined in the gently sloping areas. There are no perennial streams and few depressions, but the Little Sioux River borders this association for several miles. Slopes generally range from 0 to 5 percent.

This association makes up about 4 percent of the county. It is about 37 percent Ransom soils, 29 percent Sac soils, 21 percent Primghar soils, and 13 percent minor soils (fig. 3).

The somewhat poorly drained, very gently sloping Ransom soils are on broad divides and the slightly concave, lower side slopes. The well drained, gently sloping Sac soils are on convex upland ridgetops and side slopes. The somewhat poorly drained, nearly level to gently sloping Primghar soils are on broad divides and the lower, concave side slopes and in the upper drainageways.

Typically, the surface layer of the Ransom soils is black silty clay loam about 7 inches thick. The subsurface layer is silty clay loam about 13 inches thick. It is black and very dark gray in the upper part and very dark grayish brown in the lower part. The subsoil is about 16 inches thick. It is olive brown, mottled, friable silty clay loam and silt loam in the upper part and light olive brown, mottled, firm loam in the lower part. The substratum to a depth of 60 inches is light olive brown, mottled, calcareous clay loam.

Typically, the surface layer of the Sac soils is black silty clay loam about 7 inches thick. The subsurface layer is very dark gray silty clay loam about 6 inches thick. The subsoil is about 27 inches thick. It is brown and yellowish brown, friable silty clay loam in the upper part; yellowish brown, mottled, friable silt loam in the next

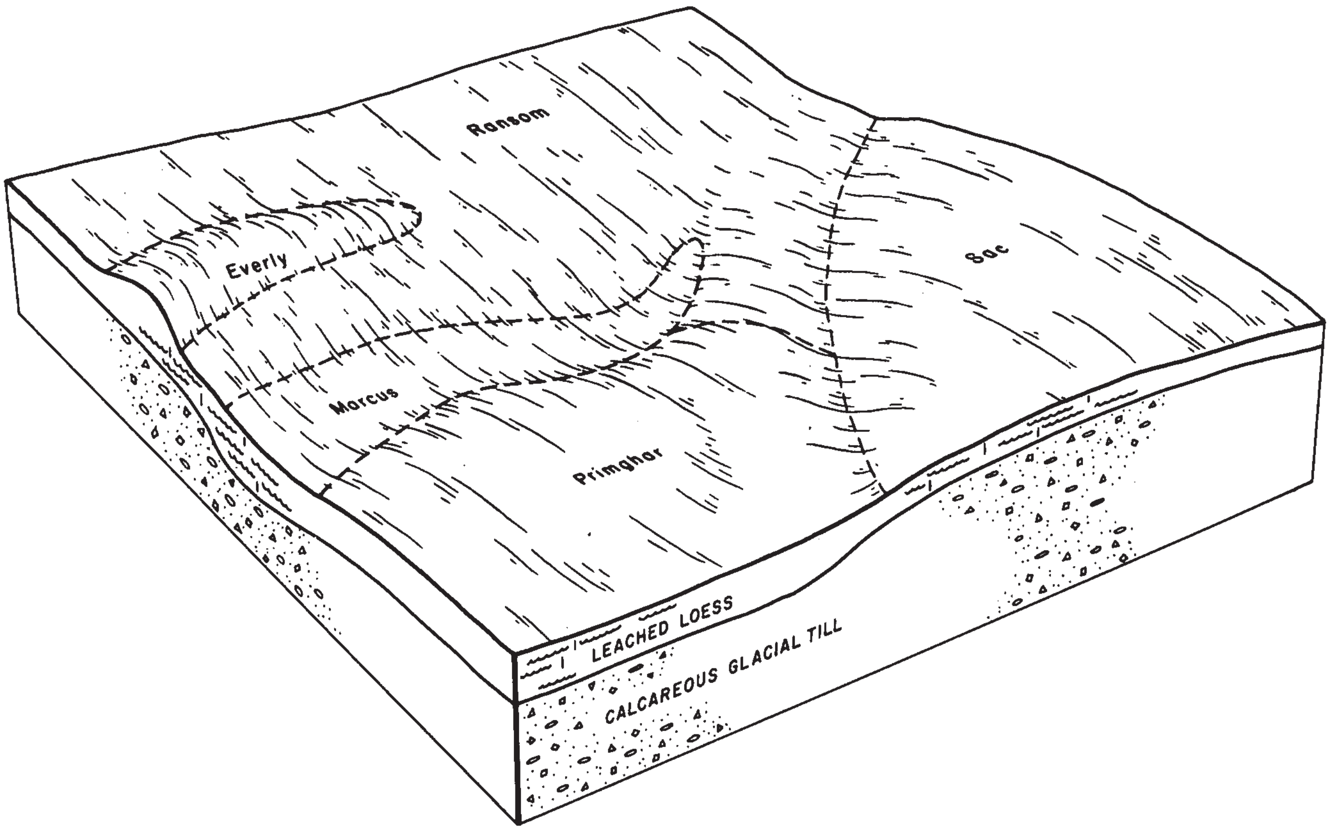


Figure 3.—Pattern of soils and parent material in the Ransom-Sac-Primghar association.

part; and yellowish brown, mottled, firm, calcareous loam in the lower part. The substratum to a depth of 60 inches is light olive brown, mottled, calcareous loam.

Typically, the surface layer of the Primghar soils is black silty clay loam about 7 inches thick. The subsurface layer is silty clay loam about 13 inches thick. It is black in the upper part and black and very dark grayish brown in the lower part. The subsoil is about 19 inches thick. It is friable. The upper part is dark grayish brown and light olive brown silty clay loam; the next part is light olive brown, mottled silty clay loam; and the lower part is mottled gray and yellowish brown, calcareous silt loam. The substratum to a depth of 60 inches is multicolored, calcareous silt loam and clay loam.

Marcus soils are the most extensive minor soils in this association. Less extensive are Everly and Spicer soils. The well drained Everly soils are on upland ridgetops and side slopes. They contain more sand than the Sac soils. The poorly drained Marcus and Spicer soils are on plane and slightly concave, broad uplands and in upland drainageways.

This association is used mainly for row crops. Corn and soybeans are the major crops. They are the only crops on some farms. Alfalfa and oats are grown on some livestock farms. Some farms have a small acreage of permanent pasture. A few areas along the river support native hardwoods.

Erosion and soil blowing are the main concerns of management in cultivated areas. A conservation tillage system that leaves crop residue on the surface, contour farming, and, in areas of the Sac soils, terraces help to prevent excessive soil losses. The hazard of soil blowing is increased if the soils are plowed in the fall. Forgoing fall tillage reduces the hazard of erosion and conserves moisture. Drainage tile is installed in some areas of the Ransom and Primghar soils and in the poorly drained minor soils.

On some farms raising livestock, most commonly hogs, is a major enterprise. Livestock waste can contaminate surface water and ground water, especially in areas of the poorly drained minor soils. On most farms, however, sizable areas of well drained soils are suitable for livestock waste disposal.

3. Wadena-Estherville-Coland association

Nearly level to strongly sloping, well drained, somewhat excessively drained, and poorly drained, loamy and silty soils formed in loamy material overlying sand and gravel and in alluvium; on outwash plains, stream terraces, and bottom land

This association consists of soils on stream bottom land and terraces and in glacial outwash areas. The drainageways are poorly defined in the broad, nearly level areas and well defined in the rest of the association. Most of the permanent streams and larger drainageways in the county are in the areas of this association. Slopes generally range from 0 to 14 percent.

This association makes up about 10 percent of the county. It is about 30 percent Wadena soils, 15 percent Estherville soils, 10 percent Coland soils, and 45 percent minor soils (fig. 4).

The well drained, nearly level to moderately sloping Wadena soils are on broad stream terraces and glacial outwash plains. The somewhat excessively drained, nearly level to strongly sloping Estherville soils are in broad glacial outwash areas and on stream terraces. The poorly drained, nearly level to gently sloping Coland soils are on stream bottom land and in upland drainageways.

Typically, the surface layer of the Wadena soils is very dark brown loam about 7 inches thick. The subsurface layer is loam about 8 inches thick. It is very dark grayish brown and very dark brown in the upper part and very dark grayish brown and brown in the lower part. The subsoil is about 16 inches thick. It is dark yellowish brown, friable clay loam in the upper part; dark yellowish brown, friable loam in the next part; and brown, very friable sandy loam in the lower part. The substratum to a depth of 60 inches is light yellowish brown, calcareous gravelly sand. In about 85 percent of the areas of these soils, sand and gravel are within a depth of 32 inches.

Typically, the surface layer of the Estherville soils is very dark gray loam about 7 inches thick. The subsurface layer is very dark gray loam about 3 inches thick. The subsoil is about 16 inches thick. It is dark yellowish brown, friable and very friable sandy loam and gravelly sandy loam in the upper part and brown, very friable gravelly loamy sand in the lower part. The substratum to a depth of 60 inches is multicolored, stratified, calcareous gravelly loamy sand and gravelly sand.

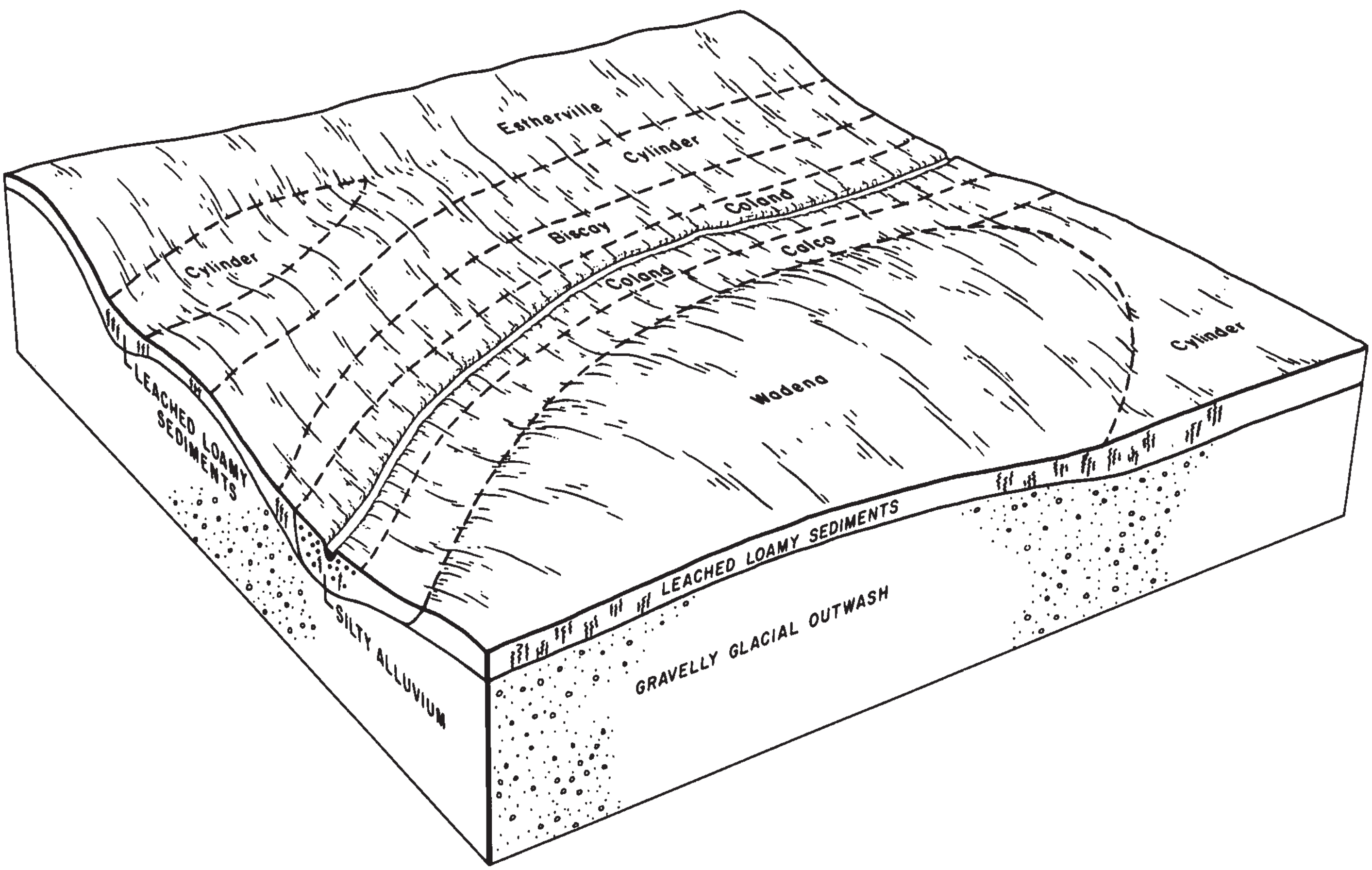


Figure 4.—Pattern of soils and parent material in the Wadena-Estherville-Coland association.

Typically, the surface layer of the Coland soils is black silty clay loam about 7 inches thick. The subsurface layer is about 29 inches thick. It is black silty clay loam in the upper part and very dark gray clay loam in the lower part. The next 7 inches is very dark gray loam. The substratum to a depth of 60 inches is very dark gray loam that has layers of light gray loamy sand and sand.

Cylinder soils are the most extensive minor soils in this association. Less extensive are Biscay, Calco, Cylinder Variant, Salida, Talcot, and Terril soils. The excessively drained Salida soils are on glacial outwash side slopes and on slopes at the edge of stream terraces. The moderately well drained Terril soils are on concave foot slopes and slightly convex alluvial fans. The somewhat poorly drained Cylinder and Cylinder Variant soils are on slightly concave to slightly convex stream terraces and in glacial outwash areas. The poorly drained Biscay and Talcot soils are on plane and slightly concave stream terrraces and in a few places in the higher glacial outwash areas. They have gravelly loamy sand and gravelly sand in the substratum. The poorly drained Calco soils are on plane and slightly concave stream bottom land and in the lower part of upland drainageways. They are calcareous.

This association is used mainly for row crops. Corn and soybeans are the major crops, but in some areas alfalfa and oats are grown extensively. Permanent pasture is maintained on most farms. Some farms have a large acreage of pasture. A few small areas near streams support native hardwoods.

Erosion, wetness, and droughtiness are the main concerns of management in cultivated areas. Also, soil blowing is a hazard. Forgoing fall tillage helps to control soil blowing and conserves moisture. Crop damage from drought is greater on Estherville soils than on Wadena soils when the two soils are managed in the same manner. A conservation tillage system that leaves crop residue on the surface helps to control erosion on the gently sloping and strongly sloping Wadena and Estherville soils but becomes progressively less effective as the slope increases. Terraces can decrease the runoff rate and help to control erosion, but the cut areas generally are too droughty for row crops. In areas of the poorly drained Coland soils, wetness, flooding, and siltation are the main concerns. Tile drains are installed and in some areas flood control measures are provided so that these soils can be efficiently row cropped.

On some farms raising livestock, most commonly hogs and cattle, is a major enterprise. On most of the soils in this association, livestock waste can contaminate surface water and ground water. The sand and gravel underlying the Wadena and Estherville soils have a poor filtering capacity.

4. Clarion-Nicollet association

Very gently sloping to strongly sloping, well drained and somewhat poorly drained, loamy soils formed in glacial till on uplands

This association consists of soils on a young till plain characterized by short, irregular slopes in the higher areas and slight depressions in low areas. Generally, the drainageways are well defined, but some end in depressions or sloughs. The size and abundance of depressions, sloughs, and drained lake bottoms vary considerably throughout the association. There are no permanent streams, but some of the drainage ditches contain water most of the year. Slopes generally range from 1 to 14 percent.

This association makes up about 41 percent of the county. It is about 47 percent Clarion soils, 17 percent Nicollet soils, and 36 percent minor soils (fig. 5).

The well drained, gently sloping to strongly sloping Clarion soils are on upland knolls, ridgetops, and side slopes. The somewhat poorly drained, very gently sloping Nicollet soils are on the lower side slopes, on low knolls and ridges, and in upland drainageways.

Typically, the surface layer of the Clarion soils is very dark brown loam about 6 inches thick. The subsurface layer is about 9 inches thick. It is very dark brown loam in the upper part and very dark grayish brown clay loam in the lower part. The subsoil is about 17 inches thick. It is friable. It is brown and dark yellowish brown clay loam in the upper part and yellowish brown loam in the lower part. The substratum to a depth of 60 inches is calcareous loam. It is light olive brown in the upper part and multicolored in the lower part.

Typically, the surface layer of the Nicollet soils is black loam about 7 inches thick. The subsurface layer is black clay loam about 6 inches thick. The subsoil is about 23 inches thick. It is friable. It is very dark grayish brown and dark grayish brown clay loam in the upper part; light olive brown and dark grayish brown, mottled loam in the next part; and light brownish gray and light yellowish brown, mottled loam in the lower part. The substratum to a depth of 60 inches is light brownish gray, mottled, calcareous loam.

Webster soils are the most extensive minor soils in this association. Less extensive are Canisteo, Crippin, Okoboji, and Storden soils. The calcareous, well drained Storden soils are on upland ridges and side slopes. The calcareous, somewhat poorly drained Crippin soils are on broad, plane uplands and on knolls and ridges. The poorly drained Canisteo and Webster soils are on plane uplands and in upland drainageways. Canisteo soils are also on the convex rims of depressions. The very poorly drained Okoboji soils are in upland depressions.

This association is used mainly for row crops. Corn and soybeans are the major crops. They are the only crops on some farms. Alfalfa and oats are grown on some livestock farms. About one-third of the farms have a small acreage of permanent pasture. A few farms have a relatively large acreage of pasture. Narrow areas adjacent to lakeshores support native hardwoods.

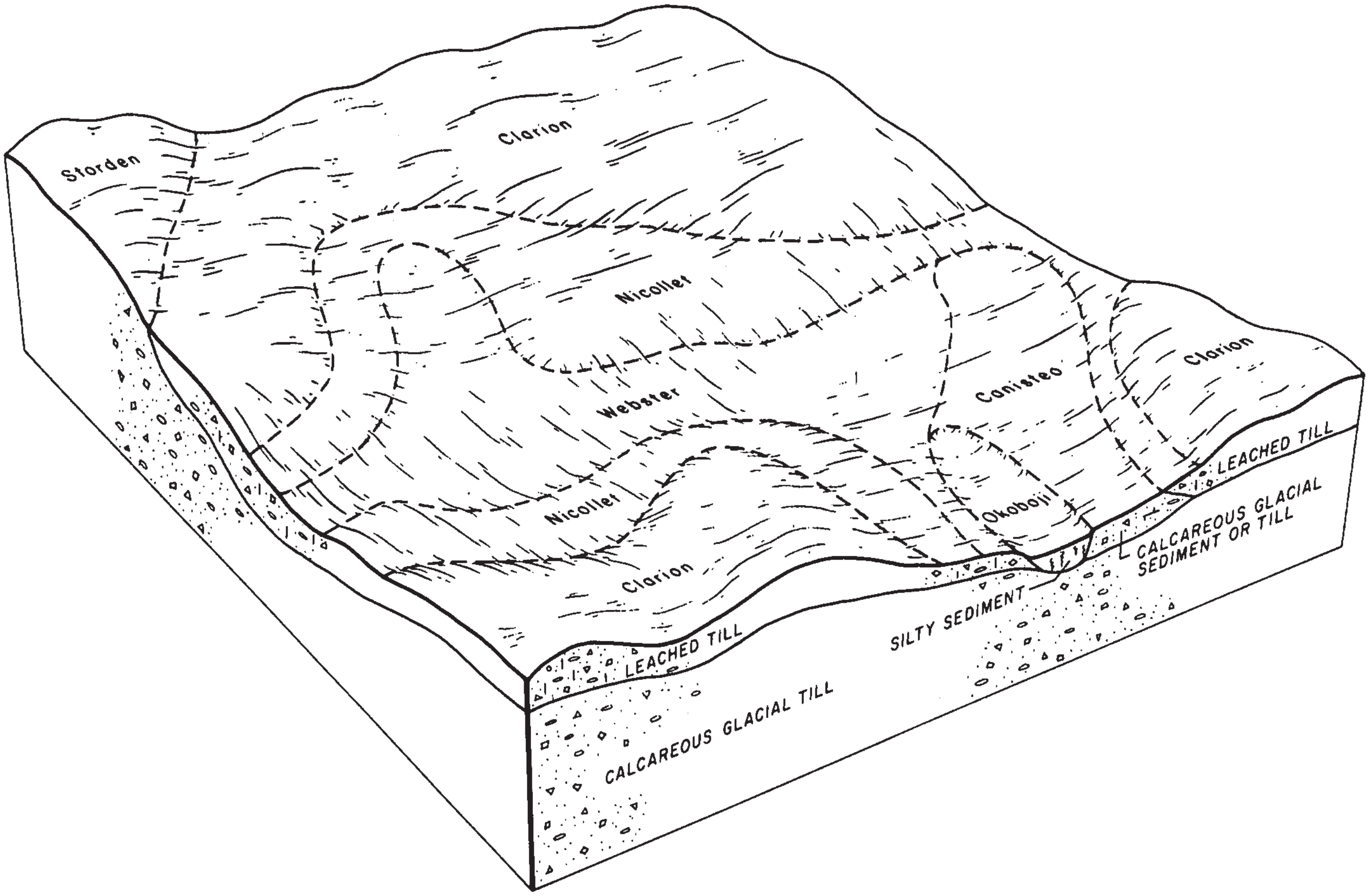


Figure 5.—Pattern of soils and parent material in the Clarion-Nicollet association.

The main concern in managing cultivated areas is the susceptibility of the Clarion soils to erosion. A conservation tillage system that leaves crop residue on the surface helps to control erosion and conserves moisture. If the slopes are sufficently long and uniform, contour farming and terraces also help to control erosion. Tile drains are installed in areas of the poorly drained and very poorly drained minor soils and in some areas of the Nicollet soils. Surface intakes help to prevent the crop damage caused by ponding and improve the timeliness of tillage in some areas of the very poorly drained minor soils in depressions.

On some farms raising livestock is a major enterprise. Raising hogs is the most common enterprise, but raising cattle is a major enterprise on some farms, especially on those that have a high proportion of moderately sloping and strongly sloping Clarion soils. Livestock waste can contaminate surface water and ground water, especially in areas of the poorly drained minor soils. On most farms, however, sizable areas of well drained soils are well suited to livestock waste disposal.

5. Canisteo-Nicollet-Okoboji association

Level to very gently sloping, somewhat poorly drained to very poorly drained, loamy and silty soils formed in glacial till or loamy and silty sediments on uplands

This association consists of soils on a young till plain characterized by short, irregular slopes in the higher areas and slight depressions in low areas. Generally, the drainageways are poorly defined. Many end in small and medium sized depressions. There are no perennial streams, but the larger drainage ditches contain water throughout the year. Slopes generally range from 0 to 3 percent.

This association makes up about 12 percent of the county. It is about 27 percent Canisteo soils, 19 percent Nicollet soils, 11 percent Okoboji soils, and 43 percent minor soils (fig. 6).

The calcareous, poorly drained, nearly level Canisteo soils are on broad uplands, in slightly convex areas adjacent to depressions, and in upland drainageways. The somewhat poorly drained, very gently sloping Nicollet soils are on broad uplands, in drainageways, on the lower side slopes, and on low knolls and ridges. The

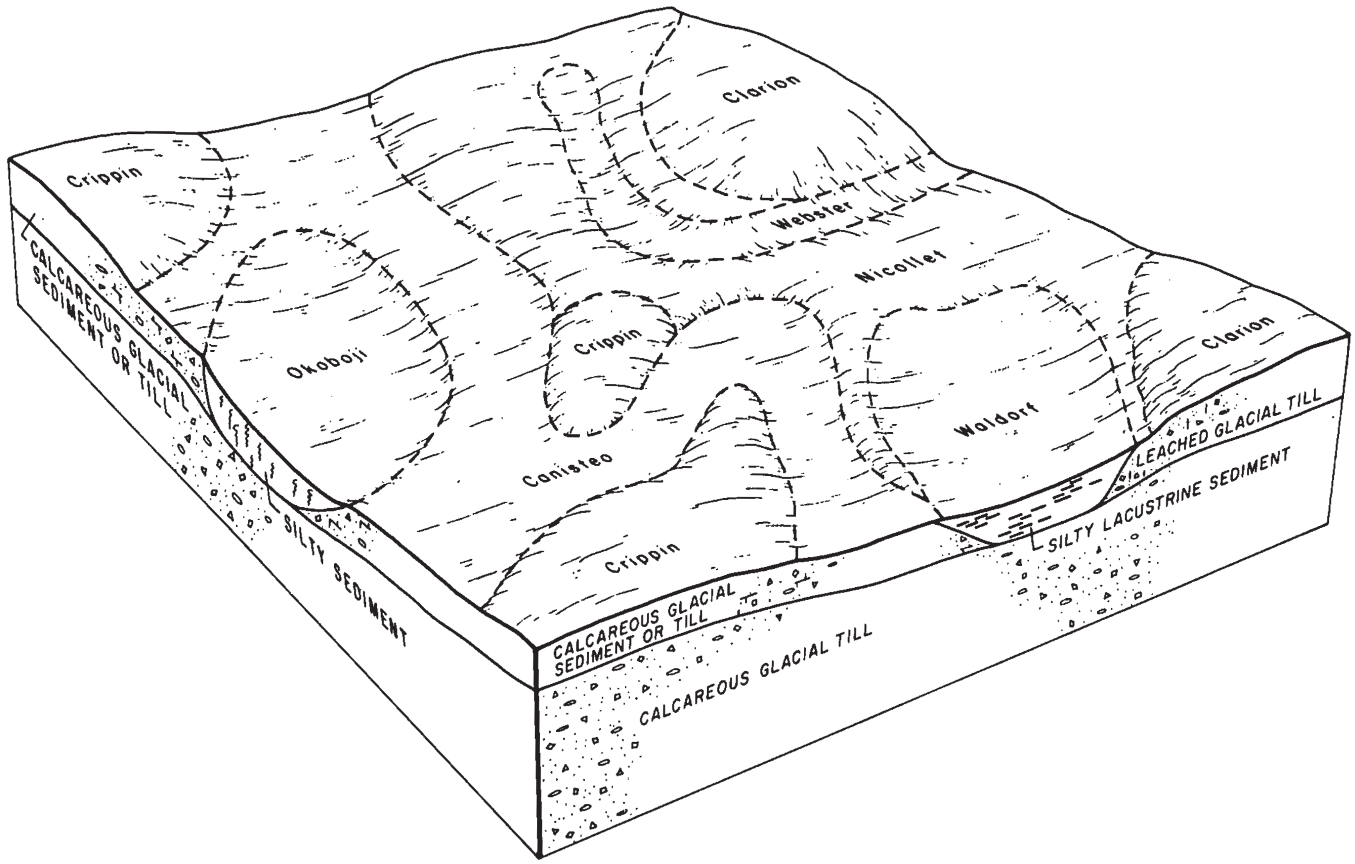


Figure 6.—Pattern of soils and parent material in the Canisteo-Nicollet-Okoboji association.

very poorly drained, level Okoboji soils are in upland depressions.

Typically, the surface layer of the Canisteo soils is black, calcareous silty clay loam about 7 inches thick. The subsurface layer is calcareous silty clay loam about 15 inches thick. It is black in the upper part and very dark gray in the lower part. The subsoil is about 16 inches thick. It is mottled, friable, and calcareous. It is dark gray and very dark gray clay loam in the upper part and olive gray loam in the lower part. The substratum to a depth of 60 inches is olive gray, mottled, calcareous loam and silty clay loam.

Typically, the surface layer of the Nicollet soils is black loam about 7 inches thick. The subsurface layer is black clay loam about 6 inches thick. The subsoil is about 23 inches thick. It is friable. It is very dark grayish brown and dark grayish brown clay loam in the upper part; light olive brown and dark grayish brown, mottled loam in the next part; and light brownish gray and light yellowish brown, mottled loam in the lower part. The substratum to a depth of 60 inches is light brownish gray, mottled, calcareous loam.

Typically, the surface layer of the Okoboji soils is black silty clay loam about 7 inches thick. The subsurface layer is black silty clay loam about 25 inches thick. The subsoil is friable silty clay loam about 24 inches thick. It is very dark gray in the upper part and gray and mottled in the lower part. The substratum to a depth of 60 inches is olive gray, mottled clay loam.

Crippin and Webster soils are the most extensive minor soils in this association. Less extensive are Clarion and Waldorf soils. The well drained Clarion soils are on upland knolls, ridgetops, and side slopes. The calcareous, somewhat poorly drained Crippin soils are on broad, plane uplands and low knolls and ridges. The poorly drained Waldorf and Webster soils are on plane uplands and in upland drainageways. They are not calcareous.

This association is used mainly for row crops. Corn and soybeans are the major crops. They are the only crops on some farms. Alfalfa and oats are grown on some livestock farms. A few farms have a small acreage of permanent pasture.

The main concerns of management in cultivated areas are wetness and soil blowing. Also, the Canisteo soils are calcareous. If the Canisteo and Okoboji soils are plowed in the fall, the hazard of soil blowing is increased, especially in the larger areas of the Canisteo soils. Forgoing fall tillage or using a conservation tillage system that leaves crop residue on the surface helps to control soil blowing and conserves moisture. Conservation tillage also helps to control erosion on the more sloping minor soils. Tile drains are installed in cultivated areas of the Canisteo and Okoboji soils and in some areas of the Nicollet soils. Surface intakes help to prevent the crop damage caused by ponding on the Okoboji soils. Crop varieties and applied chemicals should be compatible with the calcareous soils.

On some farms raising livestock, most commonly hogs, is a major enterprise. Livestock waste can contaminate surface water and ground water, especially in areas of the Canisteo and Okoboji soils. On a few farms, however, sizable areas of well drained soils are well suited to livestock waste disposal.

6. Nicollet-Clarion association

Very gently sloping to moderately sloping, somewhat poorly drained and well drained, loamy soils formed in glacial till on uplands

This association consists of soils on a young till plain characterized by short, irregular slopes in the higher areas and slight depressions in low areas. The drainageways are short or poorly defined and commonly end in small and medium sized depressions. There are no perennial streams, but some of the drainage ditches contain water most of the year. Slopes generally range from 1 to 9 percent.

This association makes up about 25 percent of the county. It is about 36 percent Nicollet soils, 31 percent Clarion soils, and 33 percent minor soils (fig. 7).

The somewhat poorly drained, very gently sloping Nicollet soils are in drainageways, on the lower side slopes, and on low knolls and ridges. The well drained, gently sloping and moderately sloping Clarion soils are on upland knolls, ridgetops, and side slopes.

Typically, the surface layer of the Nicollet soils is black loam about 7 inches thick. The subsurface layer is black clay loam about 6 inches thick. The subsoil is about 23 inches thick. It is friable. It is very dark grayish brown and dark grayish brown clay loam in the upper part; light olive brown and dark grayish brown, mottled loam in the

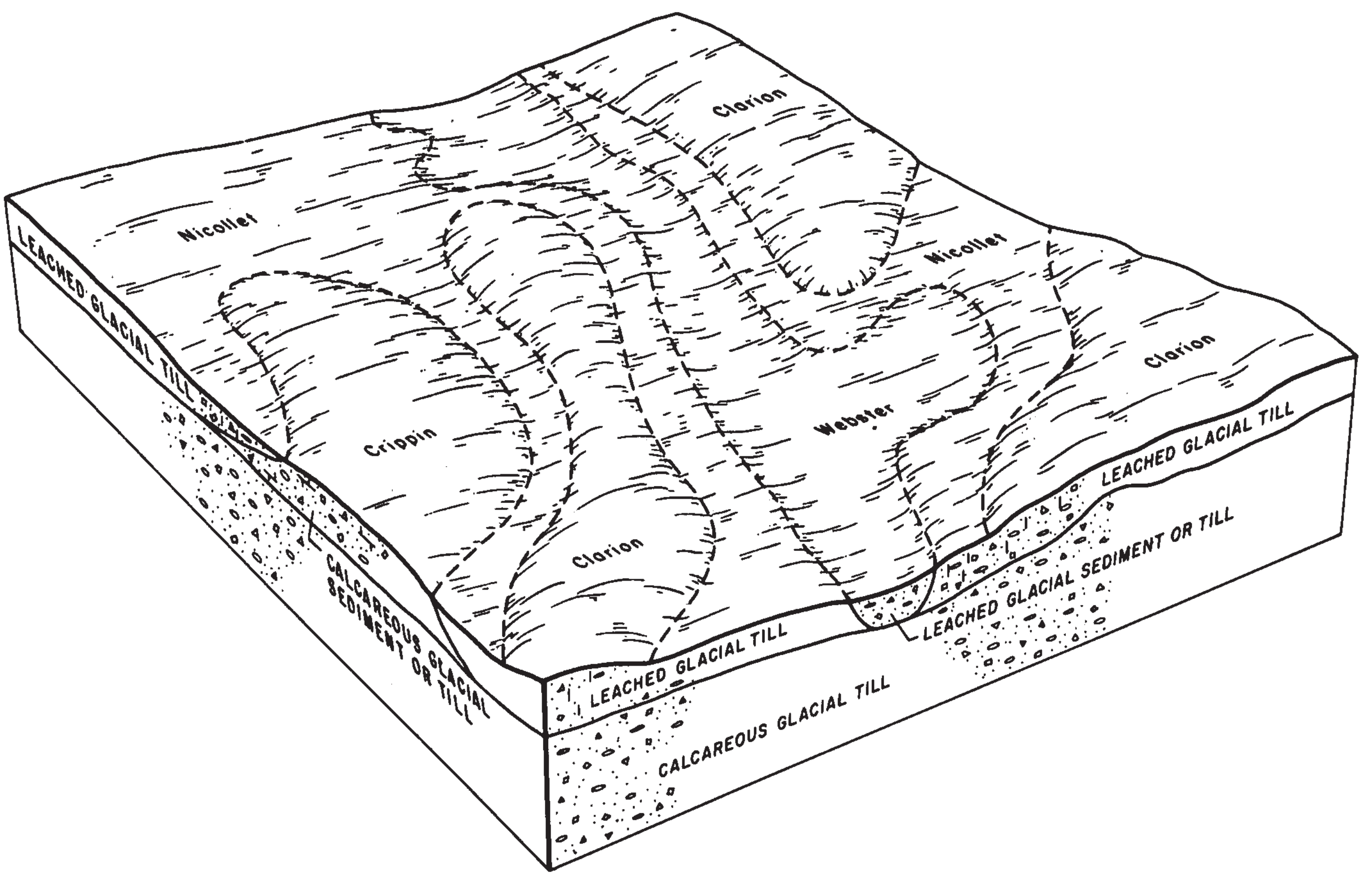


Figure 7.—Pattern of soils and parent material in the Nicollet-Clarion association.

next part; and light brownish gray and light yellowish brown, mottled loam in the lower part. The substratum to a depth of 60 inches is light brownish gray, mottled, calcareous loam.

Typically, the surface layer of the Clarion soils is very dark brown loam about 6 inches thick. The subsurface layer is about 9 inches thick. It is very dark brown loam in the upper part and very dark grayish brown clay loam in the lower part. The subsoil is about 17 inches thick. It is friable. It is brown and dark yellowish brown clay loam in the upper part and yellowish brown loam in the lower part. The substratum to a depth of 60 inches is calcareous loam. It is light olive brown in the upper part and multicolored in the lower part.

Crippin and Webster soils are the most extensive minor soils in this association. Less extensive are Coland and Okoboji soils. The calcareous, somewhat poorly drained Crippin soils are on broad, plane uplands and low knolls and ridges. The poorly drained Webster soils are on plane uplands and in drainageways. The poorly drained Coland soils are in drainageways and in some areas are between side slopes and depressions. The very poorly drained Okoboji soils are in depressions.

This association is used mainly for row crops. Corn and soybeans are the major crops. They are the only crops on some farms. Alfalfa and oats are grown on some livestock farms. A few farms have a small acreage of permanent pasture. Narrow areas adjacent to lakeshores support native hardwoods.

Erosion is the main concern of management in cultivated areas. Also, wetness is a limitation in some areas. A conservation tillage system that leaves crop residue on the surface helps to control erosion in most areas. In the few areas where slopes are sufficiently long and uniform, contour farming and terraces also help to control erosion. Tile drains are installed in areas of the poorly drained and very poorly drained minor soils and in some areas of the Nicollet soils. Surface intakes help to prevent the crop damage caused by ponding and improve the timeliness of tillage in some areas of the very poorly drained minor soils in depressions.

On some farms raising livestock, most commonly hogs, is a major enterprise. Livestock waste can contaminate surface water and ground water, especially in areas of the poorly drained minor soils. On some farms, however, sizable areas of well drained soils are well suited to livestock waste disposal.

Broad Land Use Considerations

The soils in Dickinson County vary widely in their potential for major land uses. The potential of soils reflects the relative cost of common management practices and the hazards of soil-related problems after the practices are installed.

About 76 percent of the county is used for cultivated crops, dominantly corn and soybeans. In parts of the Wadena-Estherville-Coland and Canisteo-Nicollet-Okoboji associations, occasional flooding, principally early in spring, causes slight or moderate crop damage. In the Canisteo-Nicollet-Okoboji association and in a few areas of the Wadena-Estherville-Coland association, crops occasionally are damaged because the drainage system does not remove excess water rapidly enough. Wetness is the main limitation on the Canisteo-Nicollet-Okoboji association, particularly in areas of the Canisteo and Okoboji soils. Droughtiness is the main limitation on the Wadena-Estherville-Coland association, particularly in areas of the Estherville and Wadena soils, which are underlain by sand and gravel. These soils have good potential for irrigation water and for most irrigated crops. Erosion is a hazard in areas of the major or minor soils in all of the associations, especially in areas of the gently sloping and moderately sloping Clarion, Everly, and Ocheyedan soils. On all of the associations, soil blowing is a hazard, mainly late in winter, unless the surface is protected by crop residue.

About 7 percent of the county is used for pasture. All of the associations in the county have good potential for grasses and legumes. Pasture is more extensive in the Wadena-Estherville-Coland association than in the other associations because the potential for cultivated crops is lower.

Animal waste lagoons are used for waste disposal on a few confined livestock facilities in the county. Generally, the Wilmonton-Everly-Ocheyedan, Ransom-Sac-Primghar, Clarion-Nicollet, and Nicollet-Clarion associations have fair potential for this use. The Wadena-Estherville-Coland association has poor potential because the Coland soils are poorly drained and are subject to flooding and because the livestock waste can contaminate ground water in areas of the Estherville and Wadena soils. The Canisteo-Nicollet-Okoboji association has poor potential because the Canisteo soils are poorly drained and the Okoboji soils very poorly drained.

About 13,400 acres in and around the towns in the county is used for streets and buildings and other structures. The towns are mainly on the Wadena-Estherville-Coland, Clarion-Nicollet, and Nicollet-Clarion associations. The well drained Clarion and Wadena and somewhat excessively drained Estherville soils in these associations have fair potential for these uses. A drainage system that lowers the seasonal high water table in Nicollet soils is needed, particularly in areas where buildings have basements.

Dickinson County is an important recreational center. About 6 percent of the county is water, and 7 percent is state-owned land. The areas of water and state-owned land are used extensively for recreation. Much of the state-owned land, however, is managed primarily as wildlife habitat. The Wilmonton-Everly-Ocheyedan, Ransom-Sac-Primghar, Clarion-Nicollet, and Nicollet-Clarion associations have good potential for most recreation uses. The Primghar soils in the Ransom-Sac-Primghar association and the Nicollet soils in the Clarion-Nicollet and Nicollet-Clarion associations have only fair potential for some intensive recreation uses, such as playgrounds and camp areas, because they remain wet longer than the other soils in these associations. The Coland soils in the Wadena-Estherville-Coland association and most of the soils in the Canisteo-Nicollet-Okoboji association have poor potential for most recreation uses because they are poorly drained or very poorly drained and remain wet for long periods. Also, some of the soils in these associations are subject to flooding or ponding.

The soils throughout the county generally have good potential for development of openland wildlife habitat. The soils on bottom land in the Wadena-Estherville-Coland association and the soils in sloughs and depressions in the Canisteo-Nicollet-Okoboji association have good potential for development of wetland wildlife habitat. Most of the state game management areas are on the Clarion-Nicollet and Nicollet-Clarion associations. These and other areas of grassland and trees have good potential for development of habitat for woodland and wetland wildlife.

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 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. Coland-Spillville complex, 1 to 5 percent slopes, is an example.

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

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

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

Soil Descriptions

6—Okoboji silty clay loam, 0 to 1 percent slopes. This level, very poorly drained soil is in depressions on uplands. It is subject to ponding. Most areas are circular or oval and are 2 to 15 acres in size.

Typically, the surface layer is black silty clay loam about 7 inches thick. The subsurface layer is black silty clay loam about 25 inches thick. The subsoil is friable silty clay loam about 24 inches thick. It is very dark gray in the upper part and gray and mottled in the lower part. The substratum to a depth of 60 inches is olive gray, mottled clay loam. In some areas, generally near the center of the depressions, the black subsurface layer extends to a depth of more than 48 inches.

Included with this soil in mapping are areas of calcareous soils. These soils generally are near the edge of the depressions but in some scattered areas are on low rises within the depressions. They make up about 15 percent of the unit.

The Okoboji soil is moderately slowly permeable. It has a seasonal high water table near or above the surface. Surface runoff is ponded. Available water capacity is high. The content of organic matter is about 9 to 11 percent in the surface layer. This layer is neutral or mildly alkaline. If drainage tile is installed and tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and a very low or low supply of available potassium. It has a high shrink-swell potential.

Most areas are cultivated. If drained, this soil is suited to corn, soybeans, and small grain. It is well suited to grasses and legumes for hay and pasture. Cultivated crops are damaged during periods of excessive rainfall, especially in areas where artificial drainage is not adequate. Shallow ditches and a combination of surface intakes and tile drains help to prevent this damage. Even if an adequate drainage system is installed, tillage is often delayed. The larger cultivated areas are subject to soil blowing, especially in winter and early in spring. A conservation tillage system that leaves crop residue on the surface helps to control soil blowing.

A few areas are used for hay and pasture. The grasses and legumes that can tolerate the wetness grow best. Maintaining most legume stands is difficult because of winter killing and root and crown diseases. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIIw.

27B—Terril loam, 2 to 5 percent slopes. This gently sloping, moderately well drained soil is on foot slopes and alluvial fans. Slopes are slightly concave to slightly convex. Most areas on foot slopes occur as long and narrow bands and are 2 to 15 acres in size.

Typically, the surface layer is black loam about 10 inches thick. The subsurface layer is loam about 14 inches thick. It is black in the upper part and black and very dark grayish brown in the lower part. The subsoil is about 22 inches of friable clay loam and loam. It is very dark grayish brown and brown in the upper part and dark yellowish brown in the lower part. The substratum to a depth of 60 inches is yellowish brown and light olive brown, mottled, calcareous loam. In a few places the subsurface layer is more than 30 inches thick.

Included with this soil in mapping are scattered areas of calcareous soils. These soils make up about 5 percent of the unit.

Permeability is moderate in the Terril soil. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 4 to 5 percent in the surface layer. This layer generally is slightly acid or neutral. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and a low supply of available potassium.

Most areas are cultivated or pastured. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Cultivated crops are subject to damage by overflow, erosion, and siltation unless protected from the runoff from soils higher on the landscape. Establishing terraces or diversions on the higher slopes helps to control the runoff. A conservation tillage system that leaves crop residue on the surface helps to control erosion and soil blowing.

A cover of hay or pasture plants decreases the runoff rate and helps to control erosion. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

A few areas remain in native hardwoods. If this soil is used for trees, grazing should be controlled.

The capability subclass is IIe.

27C—Terril loam, 5 to 9 percent slopes. This moderately sloping, moderately well drained soil is on foot slopes and alluvial fans. Slopes are slightly concave to slightly convex. Most areas on foot slopes occur as long and narrow bands and are about 2 to 10 acres in size.

Typically, the surface layer is black loam about 7 inches thick. The subsurface layer is loam about 21 inches thick. It is black in the upper part and very dark brown in the lower part. The subsoil is friable loam about 25 inches thick. It is very dark grayish brown and dark brown in the upper part and brown and dark yellowish brown in the lower part. The substratum to a depth of 60 inches is brown, calcareous loam. In a few places the thickness of the surface layer combined with that of the subsurface layer is less than 24 inches. In a few areas the soil is strongly sloping.

Included with this soil in mapping are small scattered areas of calcareous soils. These soils make up about 3 percent of the unit.

Permeability is moderate in the Terril soil. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 4 to 5 percent in the surface layer. This layer generally is slightly acid or neutral. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and a low supply of available potassium.

Most areas are pastured. A few are cultivated. This soil is suited to corn, soybeans, and small grain. It is well suited to grasses and legumes for hay and pasture. Cultivated crops are subject to damage by overflow, erosion, and siltation unless protected from the runoff from soils higher on the landscape. Establishing terraces or diverions on the higher slopes helps to control the runoff. A conservation tillage system that leaves crop residue on the surface helps to control erosion and soil blowing.

A cover of hay or pasture plants decreases the runoff rate and helps to control erosion. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

A few areas remain in native hardwoods. This soil is well suited to the trees commonly grown in the county. The kinds of trees growing on the soil are a good guide in selecting the trees for planting. Grazing should be controlled in the wooded areas.

The capability subclass is IIIe.

28B—Dickman fine sandy loam, 2 to 5 percent slopes. This gently sloping, somewhat excessively drained soil is on convex ridgetops, side slopes, and knolls. Most areas are longer than they are wide and are 2 to 10 acres in size.

Typically, the surface layer is very dark grayish brown fine sandy loam about 7 inches thick. The subsurface layer is very dark grayish brown and dark brown fine sandy loam about 5 inches thick. The subsoil is very friable loamy fine sand about 38 inches thick. The upper part is dark yellowish brown and yellowish brown, and the lower part is yellowish brown and light yellowish brown. The substratum to a depth of 60 inches is light yellowish brown loamy sand.

Included with this soil in mapping are small areas of the well drained Bolan soils. These soils typically have a surface layer of loam. They are in slightly concave areas below the Dickman soil. Also included are small areas of soils that are somewhat poorly drained. These soils are in drainageways. Included soils make up about 15 percent of the unit.

Permeability is moderately rapid in the upper part of the Dickman soil and rapid in the lower part. Surface runoff is medium. Available water capacity is low. The content of organic matter is about 1 to 2 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil 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. Erosion and soil blowing are serious hazards if cultivated crops are grown. Also, droughtiness is a limitation. It results in more frequent damage to corn and soybeans than to small grain. A conservation tillage system that leaves crop residue on the surface helps to control soil blowing and erosion and conserves moisture.

This soil is well suited to grasses and legumes for hay and pasture, but an even distribution of rainfall is needed. Proper stocking rates and deferred grazing during droughty periods are the main management needs. Because the soil warms rapidly in the spring, the pasture can be grazed early in the grazing season.

The capability subclass is IIIe.

32—Spicer silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is in drainageways and on plains in the uplands. Most areas are longer than they are wide and range from 5 to 40 acres in size.

Typically, the surface layer is black, calcareous silty clay loam about 7 inches thick. The subsurface layer is calcareous silty clay loam about 8 inches thick. It is black in the upper part and very dark gray and black in the lower part. The subsoil is about 21 inches thick. It is calcareous, friable, and mottled. It is multicolored silty clay loam in the upper part and olive gray silt loam in the lower part. The substratum to a depth of 60 inches is mottled light olive gray and brownish yellow, calcareous silt loam. In places the subsurface layer extends below a depth of 24 inches. In a few areas all or part of the surface layer, subsurface layer, or subsoil is noncalcareous.

This soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 6 to 7 percent in the surface layer. This layer is moderately alkaline. If drainage tile is installed and tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil 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. Surface ditches and subsurface tile are effective in removing excess water. Because of runoff from the adjacent soils higher on the landscape, crops are damaged by overflow and siltation in some areas. Establishing grassed waterways in areas where runoff concentrates helps to prevent this damage. If the slopes are sufficiently long and wide, terracing the higher adjacent soils and farming them on the contour also help to prevent this damage. Soil blowing is a hazard in areas where the surface is not protected by plants or crop residue. It can be controlled, however, by a conservation tillage system that leaves crop residue on the surface. Applied pesticides and soybean varieties should be compatible with the calcareous soil conditions.

A few areas are used for hay and pasture. Maintaining some legume stands is difficult because of winter killing and root and crown diseases. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIw.

55—Nicollet loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on broad, smooth uplands, in small drainageways, and on the sides of low knolls and ridges. Most areas are irregular in shape and range from 5 to 35 acres in size.

Typically, the surface layer is black loam about 7 inches thick. The subsurface layer is black clay loam about 6 inches thick. The subsoil is about 23 inches thick. It is friable. It is very dark grayish brown and dark grayish brown clay loam in the upper part; light olive brown and dark grayish brown, mottled loam in the next part; and light brownish gray and light yellowish brown, mottled loam in the lower part. The substratum to a depth of 60 inches is light brownish gray, mottled, calcareous loam. In some concave areas the subsurface layer extends below a depth of 24 inches. In a few other areas the soil is calcareous throughout.

Included with this soil in mapping are small areas of the well drained Clarion soils on knolls. Also included are some areas of the very poorly drained Okoboji soils in small depressions that are subject to ponding. Included soils make up about 5 percent of the unit.

The Nicollet soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 4 to 6 percent in the surface layer. This layer is medium acid to neutral. If tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil 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 (fig. 8). Because of runoff from the adjacent soils higher on the landscape, crops are damaged by overflow and siltation in some concave areas. Establishing grassed waterways in areas where runoff concentrates helps to prevent this damage. If the slopes are sufficiently long and wide, terracing the higher adjacent soils and farming them on the contour also help to prevent this damage. In the wetter years tile drainage improves the timeliness of tillage and soil aeration in some cultivated areas.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability class is I.

62C2—Storden loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on small knolls and the lower, short side slopes in the uplands. Most areas are longer than they are wide and are 2 to 5 acres in size.

Typically, the surface layer is dark grayish brown, calcareous loam about 6 inches thick. It is mixed with streaks and pockets of yellowish brown substratum material. The substratum to a depth of 60 inches is mainly yellowish brown and light olive brown, calcareous loam. It is mottled in the lower part. In places the surface layer is very dark grayish brown or very dark brown and is as much as 10 inches thick.

Included with this soil in mapping are small areas of the noncalcareous Clarion soils. These soils have a subsoil. They generally are in the less convex positions

Figure 8.—Alfalfa and corn on Nicollet loam, 1 to 3 percent slopes.

on the landscape. They make up about 10 percent of the unit.

Permeability is moderate in the Storden soil. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 1 to 2 percent in the surface layer. This layer is moderately alkaline or mildly alkaline. Good tilth can be easily maintained. This soil has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is suited to corn, soybeans, and small grain. It is well suited to grasses and legumes for hay and pasture. Erosion has removed most of the original surface layer. If cultivated crops are grown, further erosion is a hazard. A conservation tillage system that leaves crop residue on the surface helps to control erosion and soil blowing. It cannot adequately control erosion, however, if the soil is row cropped year after year. In areas where slopes are long and uniform, farming on the contour and terracing also help to control erosion. Applied pesticides and soybean varieties should be compatible with the calcareous soil conditions.

A few areas are used for hay and pasture. Hay and pasture are the most practical uses in areas where both this soil and the adjacent soils can be managed for these uses. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates and rotation grazing help to keep the soil and the pasture in good condition.

The capability subclass is IIIe.

62D—Storden loam, 9 to 14 percent slopes. This strongly sloping, well drained soil is on upland ridges and side slopes. Slopes typically are short. Most areas are longer than they are wide and are 2 to 10 acres in size.

Typically, the surface layer is very dark brown, friable, calcareous loam about 5 inches thick. The subsurface layer is very dark grayish brown, friable, calcareous loam about 5 inches thick. The next 7 inches is brown, friable, calcareous loam. The substratum to a depth of 60 inches is light olive brown, mottled, calcareous loam.

Included with this soil in mapping are small areas of the noncalcareous Clarion soils. These soils have a subsoil. They are in the less convex positions on the landscape. They make up about 10 percent of the unit.

Permeability is moderate in the Storden soil. Surface runoff is rapid. Available water capacity is high. The content of organic matter is about 1 to 2 percent in the surface layer. This layer is mildly alkaline or moderately alkaline. Good tilth can be easily maintained. The supply of available phosphorus and potassium below the surface layer is very low.

Most areas are used for hay and pasture. If erosion is controlled, this soil is suited to corn, soybeans, and small grain. It is well suited to grasses and legumes for hay and pasture. It erodes at a relatively rapid rate if conventional farming methods are used. A conservation tillage system that leaves crop residue on the surface helps to control erosion and soil blowing. It cannot adequately control erosion, however, if the soil is row cropped year after year. In areas where slopes are long and uniform, farming on the contour and terracing also help to control erosion. Applied pesticides and soybean varieties should be compatible with the calcareous soil conditions.

Most areas are adjacent to soils that are used for pasture. Hay and pasture are the most practical uses in areas where both this soil and the adjacent soils can be managed for these uses. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates and rotation grazing help to keep the soil and the pasture in good condition. Livestock should be excluded from areas used for trees.

The capability subclass is IIIe.

62D2—Storden loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is on upland ridges and side slopes. Slopes typically are short. Most areas are longer than they are wide and are 2 to 10 acres in size.

Typically, the surface layer is dark grayish brown, calcareous loam about 6 inches thick. It is mixed with streaks and pockets of yellowish brown substratum material. The substratum to a depth of 60 inches is yellowish brown and light olive brown, calcareous loam. It is mottled in the lower part. In places the surface layer is very dark grayish brown or very dark brown. In severely eroded areas it is yellowish brown.

Included with this soil in mapping are small areas of the noncalcareous Clarion soils. These soils have a darker surface layer than the Storden soil and have a subsoil. They are in the less convex positions on the landscape. They make up about 10 percent of the unit.

Permeability is moderate in the Storden soil. Surface runoff is rapid. Available water capacity is high. The content of organic matter is about 1 to 2 percent in the surface layer. This layer is moderately alkaline or mildly alkaline. Good tilth can be easily maintained. This soil has a very low supply of available phosphorus and potassium.

Most areas are cultivated. If erosion is controlled, this soil is suited to corn, soybeans, and small grain. It is well suited to grasses and legumes for hay and pasture. Erosion has removed most of the original surface layer. The soil continues to erode at a relatively rapid rate if conventional farming methods are used. A conservation tillage system that leaves crop residue on the surface helps to control erosion and soil blowing. It cannot adequately control erosion, however, if the soil is row cropped year after year. In areas where slopes are long and uniform, farming on the contour and terracing also help to control erosion. Applied pesticides and soybean varieties should be compatible with the calcareous soil conditions.

A few areas are used for hay and pasture. Hay and pasture are the most practical uses in areas where both this soil and the adjacent soils can be managed for these uses. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates and rotation grazing help to keep the soil and the pasture in good condition.

The capability subclass is IIIe.

62E—Storden loam, 14 to 18 percent slopes. This moderately steep, well drained soil is on short, convex side slopes along streams and on upland ridges. Most areas are longer than they are wide and range from about 2 to 20 acres in size.

Typically, the surface layer is very dark grayish brown, calcareous loam about 7 inches thick. The next 6 inches is very dark grayish brown and yellowish brown, calcareous loam. The substratum to a depth of 60 inches is light olive brown and yellowish brown, friable, calcareous loam. It is mottled in the lower part.

Included with this soil in mapping are the noncalcareous Clarion soils. These soils have a subsoil. They generally are in the less convex positions on the landscape. They make up about 10 percent of the unit.

Permeability is moderate in the Storden soil. Surface runoff is rapid. Available water capacity is high. The content of organic matter is about 1 to 2 percent in the surface layer. This layer is mildly alkaline or moderately alkaline. Good tilth can be easily maintained. This soil has a very low supply of available phosphorus and potassium.

About 30 percent of the acreage is cultivated. If erosion is controlled, this soil is marginally suited to corn, soybeans, and small grain. It is well suited to grasses and legumes for hay and pasture. Erosion has removed much of the original surface layer in areas that have been cultivated. The soil continues to erode at a rapid rate if conventional farming methods are used. A conservation tillage system that leaves crop residue on the surface helps to control erosion. In areas where slopes are long and uniform, farming on the contour and terracing also help to control erosion. In many cultivated areas adequate erosion control is not practical.

In most areas this soil is used for hay and pasture along with the adjacent soils. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates and rotation grazing help to keep the soil and the pasture in good condition.

The capability subclass is IVe.

62G—Storden loam, 18 to 40 percent slopes. This steep and very steep, well drained soil is on side slopes along the major streams. Most areas are irregular in shape and range from 5 to 50 acres in size.

Typically, the surface layer is very dark gray, calcareous loam about 6 inches thick. The next 4 inches is brown and yellowish brown, calcareous loam. The substratum to a depth of 60 inches is yellowish brown and light olive brown, calcareous loam.

Included with this soil in mapping are soils on escarpments that have slopes of more than 60 percent. Also included are soils that have a light colored subsurface layer and a subsoil. These soils are on wooded slopes along the Little Sioux River. Included soils make up less than 10 percent of the unit.

Permeability is moderate in the Storden soil. Surface runoff is very rapid. Available water capacity is high. The content of organic matter is about 1 to 2 percent in the surface layer. This layer is mildly alkaline or moderately alkaline. Good tilth can be easily maintained. This soil has a very low supply of available phosphorus and potassium.

This soil is suited to grasses and legumes for pasture. It is not used for cultivated crops. Most areas are used for pasture. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates and rotation grazing help to keep the soil and the pasture in good condition. Conventional farm equipment cannot be used to control weeds and brush in most of the very steep areas.

The capability subclass is VIIe.

72—Estherville loam, 0 to 2 percent slopes. This nearly level, somewhat excessively drained soil is in broad, smooth glacial outwash areas and on stream terraces. Most areas are irregular in shape and range from 2 to 50 acres in size.

Typically, the surface layer is very dark brown loam about 7 inches thick. The subsurface layer is very dark grayish brown loam about 4 inches thick. The subsoil is about 7 inches of brown, friable loam and loose sandy loam. The substratum to a depth of 60 inches is brown, calcareous gravelly loamy sand and gravelly sand. In places the subsoil is silty clay loam and clay loam throughout.

Included with this soil in mapping are small areas of the well drained Wadena soils that have sand and gravel at a depth of 24 to 32 inches. These soils generally are in concave areas. Also included are small scattered areas of soils that have a gravelly surface layer or have sand and gravel at a depth of 10 to 15 inches. Some of these areas are on the more convex slopes. Included soils make up about 10 percent of the unit.

Permeability is moderately rapid in the upper part of the Estherville soil and rapid in the substratum. Surface runoff is slow. Available water capacity is low. The content of organic matter is about 3 to 4 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium. The root zone is only about 15 to 24 inches thick.

Most areas are cultivated. This soil is suited to corn, soybeans, and small grain. Droughtiness is the main limitation. It results in more frequent damage to corn and soybeans than to small grain. Soil blowing is a hazard in areas where the surface is not protected by plants or crop residue. A conservation tillage system that leaves crop residue on the surface conserves moisture and helps to control soil blowing. For most plants, root development is restricted by the sand and gravel at a depth of 15 to 24 inches.

A few areas are used for hay and pasture. This soil is well suited to grasses and legumes for hay and pasture, but an even distribution of rainfall is needed. Proper stocking rates and deferred grazing during droughty periods are the main management needs. Because the soil warms rapidly in the spring, the pasture can be grazed early in the grazing season. Cool-season grasses tend to be more productive than warm-season grasses.

The capability subclass is IIs.

72B—Estherville loam, 2 to 5 percent slopes. This gently sloping, somewhat excessively drained soil is in broad, smooth glacial outwash areas and on stream terraces. Most areas are long and narrow and range from about 2 to 25 acres in size.

Typically, the surface layer is very dark gray loam about 7 inches thick. The subsurface layer is very dark gray loam about 3 inches thick. The subsoil is about 16 inches thick. It is dark yellowish brown, friable sandy loam and very friable gravelly sandy loam in the upper part and brown, very friable gravelly loamy sand in the lower part. The substratum to a depth of 60 inches is multicolored, calcareous, stratified gravelly loamy sand and gravelly sand.

Included with this soil in mapping are small areas of the well drained Wadena soils that have sand and gravel at a depth of 24 to 32 inches. These soils generally are in concave areas. Also included are scattered areas of soils that have gravel in the surface layer or have sand and gravel at a depth of 10 to 15 inches. Some of these areas are on the more convex slopes. Included soils make up about 10 percent of the unit.

Permeability is moderately rapid in the upper part of the Estherville soil and rapid in the substratum. Surface runoff is slow. Available water capacity is low. The content of organic matter is about 3 to 4 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium. The root zone is only about 15 to 24 inches thick.

Most areas are cultivated. This soil is suited to corn, soybeans, and small grain. If cultivated crops are grown, erosion is a hazard. Soil blowing is a hazard in areas where the surface is not protected by plants or crop residue. Also, droughtiness is a limitation. It results in more frequent damage to corn and soybeans than to small grain. A conservation tillage system that leaves crop residue on the surface helps to control erosion and soil blowing and conserves moisture. In areas where slopes are sufficiently long and wide, contour farming also helps to control erosion. Terraces generally are not constructed on this soil because the cuts would expose the coarse textured, unproductive material in most areas. For most plants, root development is restricted by the sand and gravel at a depth of 15 to 24 inches.

A few areas are used for pasture. This soil is well suited to grasses and legumes for hay and pasture, but an even distribution of rainfall is needed. Proper stocking rates and deferred grazing during droughty periods are the main management needs. Because the soil warms rapidly in the spring, the pasture can be grazed early in the grazing season. Cool-season grasses tend to be more productive than warm-season grasses.

The capability subclass is IIe.

72C2—Estherville loam, 5 to 14 percent slopes, moderately eroded. This moderately sloping and strongly sloping, somewhat excessively drained soil is on glacial outwash side slopes and the edges of stream terraces. Most areas are longer than they are wide and are 2 to 6 acres in size.

Typically, the surface layer is very dark gray loam about 7 inches thick. It is mixed with streaks and pockets of brown subsoil material. The subsoil is about 15 inches thick. It is brown, friable loam in the upper part and yellowish brown and brown, friable sandy loam and yellowish brown, very friable gravelly loamy sand in the lower part. The substratum to a depth of 60 inches is multicolored, calcareous gravelly loamy sand and gravelly sand. In a few places the entire subsoil is gravelly loamy sand.

Permeability is moderately rapid in the upper part of this soil and rapid in the substratum. Surface runoff is medium. Available water capacity is low. The content of organic matter is about 1 to 2 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium. The root zone is only about 15 to 24 inches thick.

Most areas are cultivated. This soil is marginally suited to corn, soybeans, and small grain. Erosion has removed much of the original topsoil. If cultivated crops are grown, further erosion is a hazard. Also, droughtiness is a limitation. It results in more frequent damage to corn and soybeans than to small grain. A cover of plants or crop residue helps to control erosion and soil blowing and conserves moisture. A conservation tillage system that leaves crop residue on the surface and contour farming help to prevent excessive soil loss. A conservation tillage system also conserves moisture. Terraces generally are not constructed on this soil because the cuts would expose the coarse textured, unproductive material in most areas. For most plants, root development is restricted by the sand and gravel at a depth of 15 to 24 inches.

A few areas are used for hay and pasture. This soil is well suited to grasses and legumes for hay and pasture, but an even distribution of rainfall is needed. Proper stocking rates and deferred grazing during droughty periods are the main management needs. Because the soil warms rapidly in the spring, the pasture can be grazed early in the grazing season. Cool-season grasses tend to be more productive than warm-season grasses.

The capability subclass is IIIe.

73D—Salida gravelly sandy loam, 5 to 14 percent slopes. This moderately sloping and strongly sloping, excessively drained soil is on the edges of glacial outwash terraces, on stream terraces, and on short side slopes adjacent to streams and the larger drainageways. Most areas are longer than they are wide and are 2 to 8 acres in size.

Typically, the surface layer is very dark grayish brown, calcareous gravelly sandy loam about 7 inches thick. The subsoil is about 8 inches thick. It is loose. It is brown, calcareous gravelly loamy sand in the upper part and variegated, calcareous gravelly loamy coarse sand in the lower part. The substratum to a depth of 60 inches is multicolored, calcareous, stratified gravelly coarse sand and gravelly sand. In some places the thickness of the surface layer combined with that of a subsurface layer is 12 to 18 inches. In other places the upper part of the subsoil is loam and sandy loam.

Permeability is very rapid. Surface runoff is medium. Available water capacity is very low. The content of organic matter is about 0.5 to 1.0 percent in the surface layer. This layer is neutral to moderately alkaline. Tilth is good. The subsoil has a very low supply of available phosphorus and potassium.

A few areas are cultivated. This soil is poorly suited to corn, soybeans, and small grain. Soil blowing is a serious hazard if cultivated crops are grown. Also, the crops are damaged by drought, and most kinds of tillage are impractical because of the small stones in the surface layer.

Most areas are used for hay and pasture. Harvesting hay is difficult, however, because of the small stones and the uneven topography. This soil is best suited to pasture, but an even distribution of rainfall is needed. Proper stocking rates and deferred grazing during droughty periods are the main management needs. Because the soil warms rapidly in the spring, the pasture can be grazed early in the growing season. In areas where reseeding is needed, cool-season grasses generally are planted.

The capability subclass is IVe.

73E—Salida gravelly sandy loam, 14 to 24 percent slopes. This moderately steep and steep, excessively drained soil is on the edges of glacial outwash terraces, on stream terraces, and on short side slopes adjacent to streams and the larger drainageways. Most areas are longer than they are wide and are 2 to 9 acres in size.

Typically, the surface layer is gravelly sandy loam about 7 inches thick. It is very dark gray in the upper part and very dark grayish brown in the lower part. The subsoil is calcareous gravelly loamy sand about 8 inches thick. It is strong brown and very friable in the upper part and is yellowish brown and loose in the lower part. The substratum to a depth of 60 inches is strong brown and brownish yellow, calcareous, stratified gravelly sand. In places the thickness of the surface layer combined with that of a subsurface layer is 12 to 18 inches.

Permeability is very rapid. Surface runoff is medium in pastured areas. Available water capacity is very low. The content of organic matter is about 0.5 to 1.0 percent in the surface layer. This layer is neutral to moderately alkaline. Tilth is good. The subsoil has a very low supply of available phosphorus and potassium.

This soil is best suited to pasture, but an even distribution of rainfall is needed. The soil is not used for cultivated crops. Most areas are used for pasture. A protective plant cover helps to control erosion and soil blowing. Harvesting hay is difficult because of small stones on the surface and because of the moderately steep and steep, uneven topography. Proper stocking rates and deferred grazing during droughty periods are needed. Because the soil warms rapidly in the spring, the pasture can be grazed early in the grazing season. In areas where reseeding is needed, cool-season grasses generally are planted.

The capability subclass is VIe.

73G—Salida gravelly sandy loam, 24 to 40 percent slopes. This very steep, excessively drained soil is on the edges of glacial outwash terraces, on stream terraces, and on side slopes adjacent to streams and the larger drainageways. Most areas are longer than they are wide and are 2 to 15 acres in size.

Typically, the surface layer is about 7 inches of black, calcareous gravelly sandy loam and gravelly loamy sand. The subsoil is dark yellowish brown, loose, calcareous gravelly sand about 8 inches thick. The substratum to a depth of 60 inches is dark yellowish brown and yellowish brown, calcareous, stratified gravelly coarse sand. In places the thickness of the surface layer combined with that of a subsurface layer is 12 to 18 inches.

Permeability is very rapid. Surface runoff is rapid. Available water capacity is very low. The content of organic matter is about 0.5 to 1.0 percent in the surface layer. This layer is mildly alkaline or moderately alkaline. Tilth is good. The subsoil has a very low supply of available phosphorus and potassium.

This soil is best suited to pasture, but an even distribution of rainfall is needed. The soil is not used for cultivated crops or hay. Most areas are used for pasture. A protective plant cover helps to control erosion and soil blowing. Proper stocking rates and deferred grazing during droughty periods are needed. Because the soil warms rapidly in the spring, the pasture can be grazed early in the grazing season. Conventional farm equipment cannot be easily used to control weeds and brush in most areas because of the very steep slopes.

The capability subclass is VIIe.

77B—Sac silty clay loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on convex upland ridgetops and long side slopes. Most areas are irregular in shape and range from 10 to 50 acres in size.

Typically, the surface layer is black silty clay loam about 7 inches thick. The subsurface layer is very dark gray silty clay loam about 6 inches thick. The subsoil is about 27 inches thick. It is brown and yellowish brown, friable silty clay loam in the upper part; yellowish brown, mottled, friable silt loam in the next part; and yellowish brown, mottled, firm, calcareous loam in the lower part. The substratum to a depth of 60 inches is light olive brown, mottled, calcareous loam. In places the surface layer is less than 7 inches thick or is lighter colored.

Included with this soil in mapping are small scattered areas of soils that tend to be droughty because they are underlain by sandy or gravelly material within a depth of 40 inches. These soils make up about 2 percent of the unit.

Permeability is moderate in the Sac soil. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 3 to 4 percent in the surface layer. This layer is medium acid to neutral, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and a 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. Cultivated areas are subject to erosion, especially on the longer slopes. A conservation tillage system that leaves crop residue on the surface, contour farming, and terraces help to control erosion and soil blowing.

A few areas are used for hay and pasture. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIe.

91—Primghar silty clay loam, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is on broad, plane and convex uplands. Most areas are irregular in shape and range from about 10 to 100 acres in size.

Typically, the surface layer is black silty clay loam about 7 inches thick. The subsurface layer is silty clay loam about 10 inches thick. It is black in the upper part and very dark gray and dark grayish brown in the lower part. The subsoil is about 19 inches thick. It is friable. It is dark grayish brown and grayish brown silty clay loam in the upper part and grayish brown and light brownish gray, mottled silt loam in the lower part. The substratum to a depth of 60 inches is light brownish gray and light olive brown, mottled, calcareous silt loam and loam. In places the soil is calcareous throughout.

Included with this soil in mapping are small scattered areas of soils that have crystalline gypsum. These soils make up about 1 percent of the unit.

The Primghar soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 5 to 6 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. If tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and a very low or low supply of available potassium. It has a high shrink-swell potential.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Soil blowing is a hazard in areas where the surface is not protected by plants or crop residue. It can be controlled, however, by a conservation tillage system that leaves crop residue on the surface. In the wetter years tile drainage improves the timeliness of tillage and soil aeration in some cultivated areas.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability class is I.

91B—Primghar silty clay loam, 2 to 4 percent slopes. This gently sloping, somewhat poorly drained soil is in upland drainageways and on the lower side slopes. Most areas are longer than they are wide and range from about 5 to 30 acres in size.

Typically, the surface layer is black silty clay loam about 7 inches thick. The subsurface layer is silty clay loam about 13 inches thick. It is black in the upper part and black and very dark grayish brown in the lower part. The subsoil is about 19 inches thick. It is friable. The upper part is dark grayish brown and light olive brown silty clay loam; the next part is light olive brown, mottled silty clay loam; and the lower part is mottled gray and yellowish brown, calcareous silt loam. The substratum to a depth of 60 inches is multicolored, calcareous silt loam and clay loam. In places the soil is calcareous throughout.

Included with this soil in mapping are small scattered areas of very poorly drained soils in depressions that are subject to ponding. These soils make up about 2 percent of the unit.

The Primghar soil is moderately permeable. It has a seasonal high water table. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 5 to 6 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. If tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and a very low or low supply of available potassium. It has a high shrink-swell potential.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Erosion is a hazard in cultivated areas, and soil blowing is a hazard in areas where the surface is not protected by crop residue. These hazards can be reduced, however, by a conservation tillage system that leaves crop residue on the surface. Because of runoff from the adjacent soils higher on the landscape, crops are damaged by erosion, overflow, and siltation. Establishing grassed waterways in areas where runoff concentrates helps to prevent this damage. Terracing the higher adjacent soils and farming them on the contour also helps to prevent this damage. In the wetter years tile drainage improves the timeliness of tillage and soil aeration in some cultivated areas. The tile line commonly is installed near the center of drainageways, where the soil tends to be the wettest.

A few areas are used for pasture. Many are used for grassed waterways. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIe.

92—Marcus silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is in upland drainageways and on smooth upland divides. Most areas in the upland drainageways occur as narrow bands. They are 1/4 mile to 2 miles long and are about 3 to 60 acres in size. Most areas on the divides are irregular in shape and range from about 10 to 100 acres in size.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is black and very dark gray silty clay loam about 8 inches thick. The subsoil is about 30 inches thick. It is friable. It is dark gray and olive gray silty clay loam in the upper part and olive gray and light olive gray, mottled silty clay loam and silt loam in the lower part. The upper part of the substratum is light brownish gray, mottled, calcareous, stratified loamy sand, loam, and sandy loam. The lower part to a depth of 60 inches is light brownish gray, mottled, calcareous clay loam. In some places the substratum is loam or clay loam within a depth of 40 inches. In other places the soil is calcareous throughout.

Included with this soil in mapping are scattered areas of soils that have crystalline gypsum. Also included are small areas of the very poorly drained Rolfe soils in depressions that are subject to ponding. Included soils make up about 3 percent of the unit.

The Marcus soil is moderately slowly permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 6 to 7 percent in the surface layer. This layer is slightly acid to mildly alkaline. If drainage tile is installed and tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and a very low or low supply of available potassium. It has a high shrink-swell potential.

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. Cultivated crops are subject to damage in areas where tile drainage is not adequate. Because of runoff from the adjacent soils higher on the landscape, crops also are damaged by overflow and siltation in some concave areas. Establishing tiled grassed waterways in areas where runoff concentrates helps to prevent this damage. Terracing the higher adjacent soils and farming them on the contour also help to prevent this damage. Soil blowing is a hazard in areas where the surface is not protected by plants or crop residue. It can be controlled, however, by a conservation tillage system that leaves crop residue on the surface.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIw.

95—Harps loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on the narrow rims of depressions and on small rises in smooth upland areas. Most areas are longer than they are wide and are 2 to 10 acres in size.

Typically, the surface layer is black, calcareous loam about 7 inches thick. The subsurface layer is black and very dark gray, calcareous clay loam about 13 inches thick. The subsoil is about 18 inches thick. It is mottled, friable, and calcareous. It is dark gray clay loam in the upper part and light olive gray loam in the lower part. The substratum to a depth of 60 inches is multicolored, calcareous loam.

Included with this soil in mapping are small areas of the very poorly drained Okoboji soils. These soils are in slight depressions that are subject to ponding. They make up about 5 percent of the unit.

The Harps soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 4 to 5 percent in the surface layer. This layer is moderately alkaline. If drainage tile is installed and tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil 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. Cultivated crops are subject to damage in areas where tile drainage is not adequate. Soil blowing is a hazard in areas where the surface is not protected by plants or crop residue. It can be controlled, however, by a conservation tillage system that leaves crop residue on the surface. Applied pesticides and soybean varieties should be compatible with the calcareous soil conditions.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIw.

107—Webster silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on broad, smooth uplands and in short, narrow upland drainageways. Most areas are irregular in shape and range from 3 to 40 acres in size.

Typically, the surface layer is black silty clay loam about 7 inches thick. The subsurface layer is silty clay loam about 10 inches thick. It is black in the upper part and very dark gray in the lower part. The subsoil is about 18 inches thick. It is friable. It is mottled dark grayish brown and light olive brown silty clay loam in the upper part and grayish brown and light olive gray, mottled clay loam in the lower part. The substratum to a depth of 60 inches is light olive gray and brownish yellow, mottled, calcareous loam. In places the soil is calcareous throughout.

Included with this soil in mapping are areas of the very poorly drained Okoboji soils. These soils are in small depressions that are subject to ponding. They make up about 1 percent of the unit.

The Webster soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 6 to 7 percent in the surface layer. This layer is slightly acid to mildly alkaline. If drainage tile is installed and tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil 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. Cultivated crops are subject to damage in areas where tile drainage is not adequate. Because of runoff from the adjacent soils higher on the landscape, crops also are damaged by overflow and siltation in some concave areas. Establishing tiled grassed waterways in areas where runoff concentrates helps to prevent this damage. Terracing the higher adjacent soils and farming them on the contour also help to prevent this damage.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIw.

108—Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, well drained soil is on broad, smooth glacial outwash plains and stream terraces. Most areas are irregular in shape and range from 5 to more than 100 acres in size.

Typically, the surface layer is very dark brown loam about 7 inches thick. The subsurface layer is loam about 8 inches thick. It is very dark grayish brown and very dark brown in the upper part and very dark grayish brown and brown in the lower part. The subsoil is about 16 inches thick. It is dark yellowish brown, friable clay loam in the upper part; dark yellowish brown, friable loam in the next part; and brown, very friable sandy loam in the lower part. The substratum to a depth of 60 inches is light yellowish brown, calcareous gravelly sand.

Included with this soil in mapping are small scattered areas of Estherville soils, which have sand and gravel at a depth of 15 to 24 inches. These soils are on small ridges in places. They make up about 5 percent of the unit.

Permeability is moderate in the upper part of the Wadena soil and rapid in the substratum. Surface runoff is slow. Available water capacity is low. The content of organic matter is about 3 to 4 percent in the surface layer. This layer is neutral to strongly acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium. The root zone is only about 24 to 32 inches thick.

Most areas are cultivated. This soil is suited to corn, soybeans, and small grain. Droughtiness is the main limitation. It results in more frequent damage to corn and soybeans than to small grain. A conservation tillage system that leaves crop residue on the surface conserves moisture and helps to control soil blowing. For most plants, root development is restricted by the sand and gravel at a depth of 24 to 32 inches.

A few areas are used for hay and pasture. This soil is well suited to grasses and legumes for hay and pasture, but an even distribution of rainfall is needed. Proper stocking rates, rotation grazing, and restricted use during dry periods help to keep the soil and the pasture in good condition.

The capability subclass is IIs.

108B—Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes. This gently sloping, well drained soil is on broad, smooth glacial outwash plains and stream terraces. Most areas are irregular in shape and range from 2 to more than 40 acres in size.

Typically, the surface layer is very dark brown loam about 7 inches thick. The subsurface layer is loam about 7 inches thick. It is very dark gray in the upper part and very dark gray and very dark grayish brown in the lower part. The subsoil is brown, friable loam about 12 inches thick. The substratum to a depth of 60 inches is strong brown and brownish yellow, calcareous, stratified gravelly loamy sand and gravelly sand.

Included with this soil in mapping are small areas of Estherville soils, which have sand and gravel at a depth of 15 to 24 inches. Also included are a few small areas of soils that have a gravelly surface layer. These soils are in the more convex areas. Included soils make up about 5 percent of the unit.

Permeability is moderate in the upper part of the Wadena soil and rapid in the substratum. Surface runoff is medium. Available water capacity is low. The content of organic matter is about 3 to 4 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium. The root zone generally is only 24 to 32 inches thick.

Most areas are cultivated. This soil is suited to corn, soybeans, and small grain. On the longer slopes and in areas that receive runoff from the adjacent soils, erosion is a hazard. Also, droughtiness is a limitation. It results in more frequent damage to corn and soybeans than to small grain. A conservation tillage system that leaves crop residue on the surface helps to control erosion and soil blowing and conserves moisture. In areas where slopes are long and uniform, contour farming also helps to control erosion. Terraces generally are not constructed on this soil because the cuts would expose material that generally is too droughty for crops. For most plants, root development is restricted by the sand and gravel at a depth of 24 to 32 inches.

A few areas are used for hay and pasture. This soil is well suited to grasses and legumes for hay and pasture, but an even distribution of rainfall is needed. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates, rotation grazing, and restricted use during dry periods help to keep the soil and the pasture in good condition.

The capability subclass is IIe.

108C—Wadena loam, 24 to 32 inches to sand and gravel, 5 to 9 percent slopes. This moderately sloping, well drained soil is on glacial outwash side slopes and on the edges of stream terraces. Most areas are longer than they are wide and are 2 to 5 acres in size.

Typically, the surface layer is very dark brown loam about 7 inches thick. The subsurface layer is loam about 5 inches thick. It is very dark brown and very dark grayish brown in the upper part and very dark grayish brown in the lower part. The subsoil is about 10 inches thick. It is brown, friable loam in the upper part and yellowish brown, very friable sandy loam in the lower part. The substratum to a depth of 60 inches is yellowish brown and light brownish gray, stratified loamy sand and calcareous gravelly sand.

Included with this soil in mapping are small areas of Estherville and Salida soils. These soils are in the more convex areas. They are more droughty than the Wadena soil. They make up about 15 percent of the unit.

Permeability is moderate in the upper part of the Wadena soil and rapid in the substratum. Surface runoff is medium. Available water capacity is low. The content of organic matter is about 3 to 4 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium. The root zone generally is only 24 to 32 inches thick.

About 40 percent of the acreage is cultivated. This soil is marginally suited to corn, soybeans, and small grain. Erosion and soil blowing are the main hazards. Also, droughtiness is a limitation. It results in more frequent damage to corn and soybeans than to small grain. Leaving crop residue on the surface and maintaining a good plant cover help to control erosion and soil blowing and conserve moisture. A conservation tillage system that leaves crop residue on the surface and contour farming help to prevent excessive soil loss. Terraces generally are not constructed on this soil because the cuts would expose material that generally is too droughty for crops. For most plants, root development is restricted by the sand and gravel at a depth of 24 to 32 inches.

About 60 percent of the acreage is used for hay and pasture. This soil is well suited to grasses and legumes for hay and pasture, but an even distribution of rainfall is needed. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates and deferred grazing during droughty periods are the main management needs. Because the soil warms early in the spring, the pasture can be grazed early in the grazing season. Cool-season grasses generally are planted on this soil.

The capability subclass is IIIe.

135—Coland silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on bottom land and on the lower part of upland drainageways. It is subject to flooding. Most areas in the upland drainageways and small areas on the bottom land are relatively long and narrow. The larger areas on the bottom land are irregular in shape. Most areas range from 2 to 25 acres in size.

Typically, the surface layer is black silty clay loam about 7 inches thick. The subsurface layer is about 29 inches thick. It is black silty clay loam in the upper part and very dark gray clay loam in the lower part. The next 7 inches is very dark gray loam. The substratum to a depth of 60 inches is very dark gray, calcareous loam that has strata of light gray loamy sand and sand. In places the soil is calcareous throughout.

Included with this soil in mapping are small areas of Spillville soils on the higher parts of the landscape. These soils are loam throughout. They make up about 10 percent of the unit.

The Coland soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 5 to 7 percent in the surface layer. This layer is neutral or slightly acid. If drainage tile is installed and tillage is deferred when the soil is wet, good tilth can be easily maintained. The soil has a low supply of available phosphorus and a very low supply of available potassium.

Most areas are cultivated, except for narrow areas on bottom land, which generally are pastured. If drained, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Cultivated crops are subject to damage because of the wetness. In some areas they also are subject to the damage caused by flooding and siltation. An adequate tile drainage system helps to overcome the wetness. In some areas straightening the channels reduces the risk of flooding and improves the suitability for farming. A conservation tillage system that leaves crop residue on the surface helps to control soil blowing.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIw.

138B—Clarion loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on convex upland side slopes, knolls, and ridgetops. Most areas have short slopes. They are irregular in shape and range from 5 to 30 acres in size.

Typically, the surface layer is very dark brown loam about 6 inches thick. The subsurface layer is about 9 inches thick. It is very dark brown loam in the upper part and very dark grayish brown clay loam in the lower part. The subsoil is about 17 inches thick. It is friable. It is brown and dark yellowish brown clay loam in the upper part and yellowish brown loam in the lower part. The substratum to a depth of 60 inches is calcareous loam. It is light olive brown in the upper part and multicolored in the lower part.

Included with this soil in mapping are small areas of the calcareous Storden soils and small areas of the very poorly drained Okoboji and Rolfe soils. The Storden soils are on convex ridgetops. The Okoboji and Rolfe soils are in depressions that are subject to ponding. Also included are small areas of soils that have a gravelly surface layer. These soils are on ridges and knolls. Included soils make up about 3 percent of the unit.

Permeability is moderate in the Clarion soil. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 3 to 4 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium.

Most areas are cultivated (fig. 9). This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. In cultivated areas erosion is a hazard, especially on the longer slopes. It can be controlled, however, by a conservation tillage system that leaves crop residue on the surface. If slopes are sufficiently long and wide, terracing the larger areas or farming them on the contour also helps to control erosion.

A few areas are used for hay and pasture. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates and rotation grazing help to keep the soil and the pasture in good condition.

The capability subclass is IIe.

138C—Clarion loam, 5 to 9 percent slopes. This moderately sloping, well drained soil is on small knolls and ridges and on the lower, short, convex side slopes in the uplands. Most areas are longer than they are wide and are 2 to 5 acres in size.

Typically, the surface layer is very dark brown loam about 6 inches thick. The subsurface layer is very dark grayish brown loam about 6 inches thick. It has black and very dark brown coatings on peds. The subsoil is loam about 18 inches thick. It is friable. It is brown and yellowish brown in the upper part and yellowish brown in the lower part. The substratum to a depth of 60 inches is multicolored, calcareous loam and sandy loam.

Included with this soil in mapping are small areas of the calcareous Storden soils. These soils are on convex ridgetops. Also included are areas of the very poorly drained Okoboji and Rolfe soils. These soils are in small depressions that are subject to ponding. Included soils make up about 5 percent of the unit.

Permeability is moderate in the Clarion soil. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 3 to 4 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium.

A few areas are cultivated. This soil is suited to corn, soybeans, and small grain. It is well suited to grasses and legumes for hay and pasture. In cultivated areas erosion is a hazard. It can be controlled, however, by a conservation tillage system that leaves crop residue on the surface. If slopes are sufficiently long and uniform, terracing the larger areas or farming them on the contour also helps to control erosion (fig. 10).

Figure 9.—Soybeans on Clarion loam, 2 to 5 percent slopes.

Most areas are used for hay and pasture. They are adjacent to other soils that are used for hay and pasture. Hay and pasture are the most practical uses in areas where both this soil and the adjacent soils can be managed for these uses. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates and rotation grazing help to keep the soil and the pasture in good condition.

The capability subclass is IIIe.

138C2—Clarion loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on small knolls and on the lower, short, convex side slopes in the uplands. Most areas are longer than they are wide and are 2 to 5 acres in size.

Typically, the surface layer is very dark grayish brown loam about 7 inches thick. It is mixed with streaks and pockets of yellowish brown subsoil material. The subsoil is yellowish brown, friable loam about 20 inches thick. The substratum to a depth of 60 inches is multicolored, calcareous loam.

Included with this soil in mapping are small areas of the calcareous Storden soils on ridges and knolls. These included soils make up approximately 10 percent of the unit.

Permeability is moderate in the Clarion soil. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 2 to 3 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is suited to corn, soybeans, and small grain. It is well suited to grasses and legumes for hay and pasture. Erosion has removed much of the original topsoil. If cultivated crops are grown, further erosion is a hazard. A conservation tillage system that leaves crop residue on the surface helps to control erosion and soil blowing. It cannot adequately control erosion, however, if the soil is row cropped year after year. In areas where slopes are long and uniform, farming on the contour and terracing also help to control erosion.

A few areas are used for hay and pasture, which are the most practical uses in areas where both this soil and the adjacent soils can be managed for these uses. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates and rotation grazing help to keep the soil and the pasture in good condition.

Figure 10.—Tile outlet terraces with vegetated back slopes on Clarion loam, 5 to 9 percent slopes. The crops are soybeans and alfalfa.

The capability subclass is IIIe.

138D—Clarion loam, 9 to 14 percent slopes. This strongly sloping, well drained soil is on upland ridges and side slopes. Slopes typically are short. Most areas are longer than they are wide and are 2 to 5 acres in size.

Typically, the surface layer is very dark brown loam about 8 inches thick. The subsurface layer is very dark grayish brown and brown loam about 4 inches thick. The subsoil is friable loam about 13 inches thick. It is brown in the upper part and yellowish brown in the lower part. The substratum to a depth of 60 inches is multicolored, calcareous loam.

Included with this soil in mapping are small areas of the calcareous Storden soils on convex ridgetops. These soils make up about 10 percent of the unit.

Permeability is moderate in the Clarion soil. Surface runoff is rapid. Available water capacity is high. The content of organic matter is about 3 to 4 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium.

Most areas are used for hay and pasture (fig. 11). Some areas have been cultivated for a few years. If erosion is controlled, this soil is suited to corn, soybeans, and small grain. It is well suited to grasses and legumes for hay and pasture. The soil erodes at a relatively rapid rate if conventional farming methods are used. A conservation tillage system that leaves crop residue on the surface helps to control erosion and soil blowing. It cannot adequately control erosion, however, if the soil is row cropped year after year. Contour farming and terraces also help to control erosion, but they are not practical in many areas because of the short, irregular slopes.

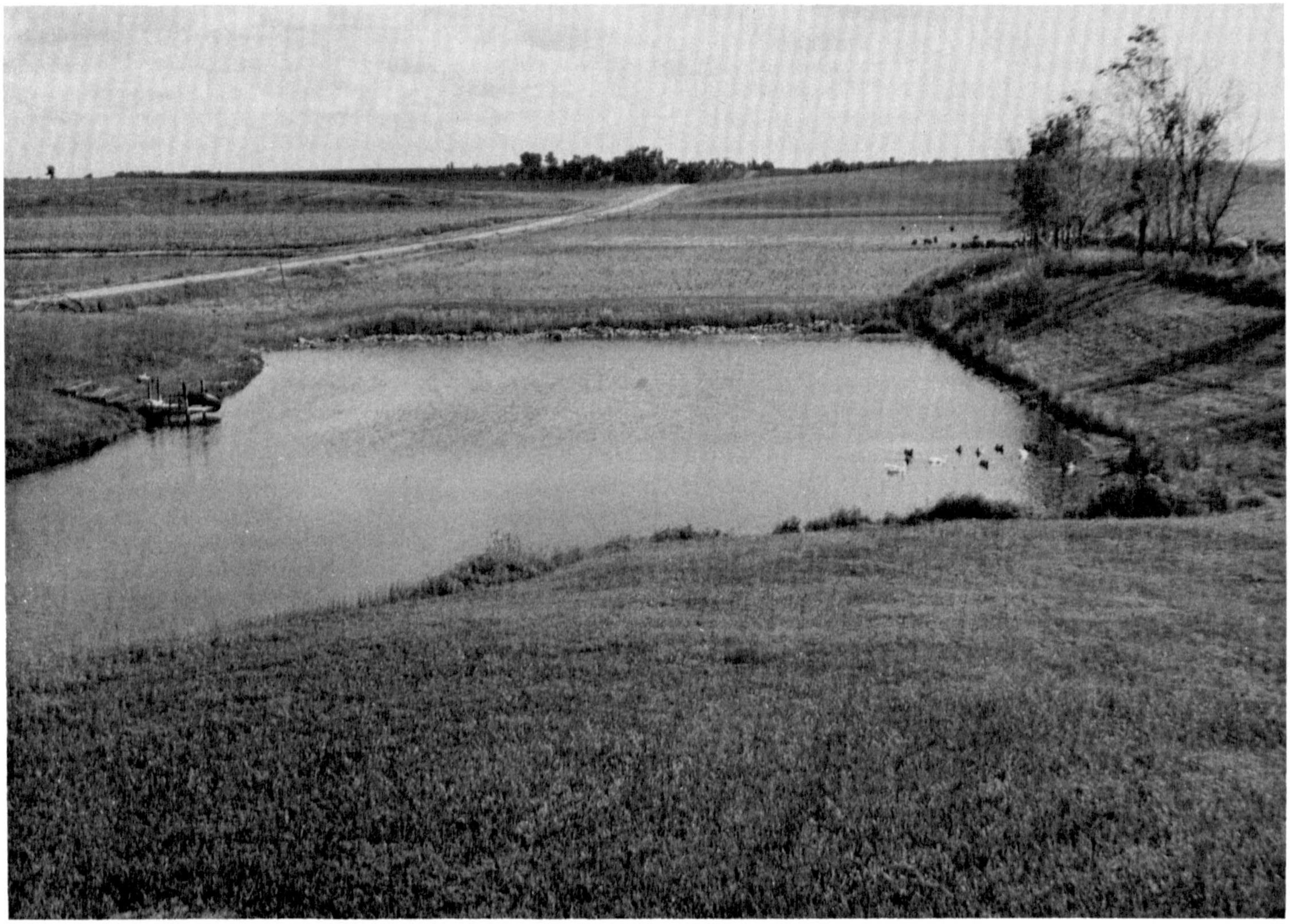


Figure 11.—A farm pond in a pastured area of Clarion loam, 9 to 14 percent slopes. Blue Earth and Okoboji soils are in the background.

In most areas this soil is adjacent to soils that are used for pasture. Hay and pasture are the most practical uses in areas where both this soil and the adjacent soils can be managed for these uses. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates and rotation grazing help to keep the soil and the pasture in good condition.

The capability subclass is IIIe.

138D2—Clarion loam, 9 to 14 percent slopes, moderately eroded. This strongly sloping, well drained soil is on upland ridges and side slopes. Slopes typically are short. Most areas are longer than they are wide and are 2 to 5 acres in size.

Typically, the surface layer is very dark grayish brown loam about 7 inches thick. It is mixed with streaks and pockets of brown subsoil material. The subsoil is loam about 17 inches thick. It is friable. It is brown in the upper part, dark yellowish brown in the next part, and yellowish brown in the lower part. The substratum to a depth of 60 inches is multicolored, calcareous loam.

Included with this soil in mapping are small areas of the calcareous Storden soils on convex ridgetops. These soils make up about 10 percent of the unit.

Permeability is moderate in the Clarion soil. Surface runoff is rapid. Available water capacity is high. The content of organic matter is about 2 to 3 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium.

Most areas are cultivated. If erosion is controlled, this soil is suited to corn, soybeans, and small grain. It is well suited to grasses and legumes for hay and pasture. Erosion has removed much of the original topsoil. The soil erodes at a relatively rapid rate if conventional farming methods are used. A conservation tillage system that leaves crop residue on the surface helps to control erosion and soil blowing. It cannot adequately control erosion, however, if the soil is row cropped year after year. Contour farming and terraces also help to control erosion, but they are not practical in many areas because of short, irregular slopes.

Some areas are pastured. Most of these areas are adjacent to other pastured areas. Hay and pasture are the most practical uses in areas where both this soil and the adjacent soils can be managed for these uses. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates and rotation grazing help to keep the soil and the pasture in good condition.

The capability subclass is IIIe.

201B—Coland-Spillville complex, 1 to 5 percent slopes. These very gently sloping and gently sloping soils are on narrow bottom land, in upland drainageways, and on foot slopes. They are subject to flooding. The poorly drained Coland soil is in the lower, more concave areas, and the somewhat poorly drained Spillville soil is upslope from the Coland soil. The Spillville soil and most areas of the Coland soil are gently sloping. Areas commonly are long and narrow and are about 5 to 20 acres in size. They are about 50 to 70 percent Coland soil and 20 to 40 percent Spillville soil. The two soils occur as areas so small and so intricately mixed that mapping them separately is not practical.

Typically, the Coland soil has a surface layer of black silty clay loam about 7 inches thick. The subsurface layer is about 29 inches thick. It is black silty clay loam in the upper part and very dark gray clay loam in the lower part. The next 7 inches is very dark gray loam. The substratum to a depth of 60 inches is very dark gray loam that has layers of light gray loamy sand and sand.

Typically, the Spillville soil has a surface layer of black loam about 8 inches thick. The subsurface layer is loam about 22 inches thick. It is very dark gray in the upper part and very dark grayish brown in the lower part. The next 6 inches is dark grayish brown and very dark grayish brown loam. The substratum to a depth of 60 inches is grayish brown and light olive brown, calcareous loam.

Included with these soils in mapping are small scattered areas of the calcareous Calco soils. These included soils make up about 2 percent of the unit.

The Coland and Spillville soils are moderately permeable. They have a seasonal high water table. Surface runoff is slow on the Coland soil and medium on the Spillville soil. Available water capacity is high in both soils. The content of organic matter is 5 to 7 percent in the surface layer of the Coland soil and 4 to 6 percent in the surface layer of the Spillville soil. This layer is neutral or slightly acid in both soils. If tillage is deferred when the Coland soil is wet, good tilth can be easily maintained. The subsoil of both soils has a low supply of available phosphorus and a very low supply of available potassium.

Most areas in upland drainageways and adjacent to drained depressions are cultivated. These soils are well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Cultivated crops are subject to damage in areas of the Coland soil where tile drainage is not adequate. Both tile and surface drains are installed in areas where flooding occurs during the cropping season. A conservation tillage system that leaves crop residue on the surface increases the infiltration rate and helps to control soil blowing. Terraces on the soils that are upslope intercept runoff and thus help to control floodwater and siltation. Also, tiled grassed waterways and drainage ditches remove excess water.

Some areas are used for hay and pasture (fig. 12). Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIw.

202—Cylinder loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is in smooth glacial outwash areas and on stream terraces. Most areas are irregular in shape and range from 2 to 20 acres in size.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is loam about 7 inches thick. It is very dark gray in the upper part and very dark grayish brown and very dark gray in the lower part. The subsoil is friable loam about 11 inches thick. It is dark grayish brown and light olive brown in the upper part and light olive brown in the lower part. The substratum to a depth of 60 inches is light olive brown, light yellowish brown, very pale brown, and light gray, mottled, calcareous gravelly loamy sand and gravelly coarse sand. In a few places the depth to the underlying sand and gravel is 20 to 24 inches. In a few other places the surface layer is silty clay loam. In some areas the soil is calcareous throughout.

Included with this soil in mapping are small areas of very poorly drained soils. These soils are in depressions that are subject to ponding. They make up about 1 percent of the unit.

The Cylinder soil is moderately permeable in the upper part and very rapidly permeable in the substratum. It has a seasonal high water table. Surface runoff is slow. Available water capacity is moderate. The content of organic matter is about 4 to 5 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. If tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium. The root zone generally is only 24 to 32 inches thick.

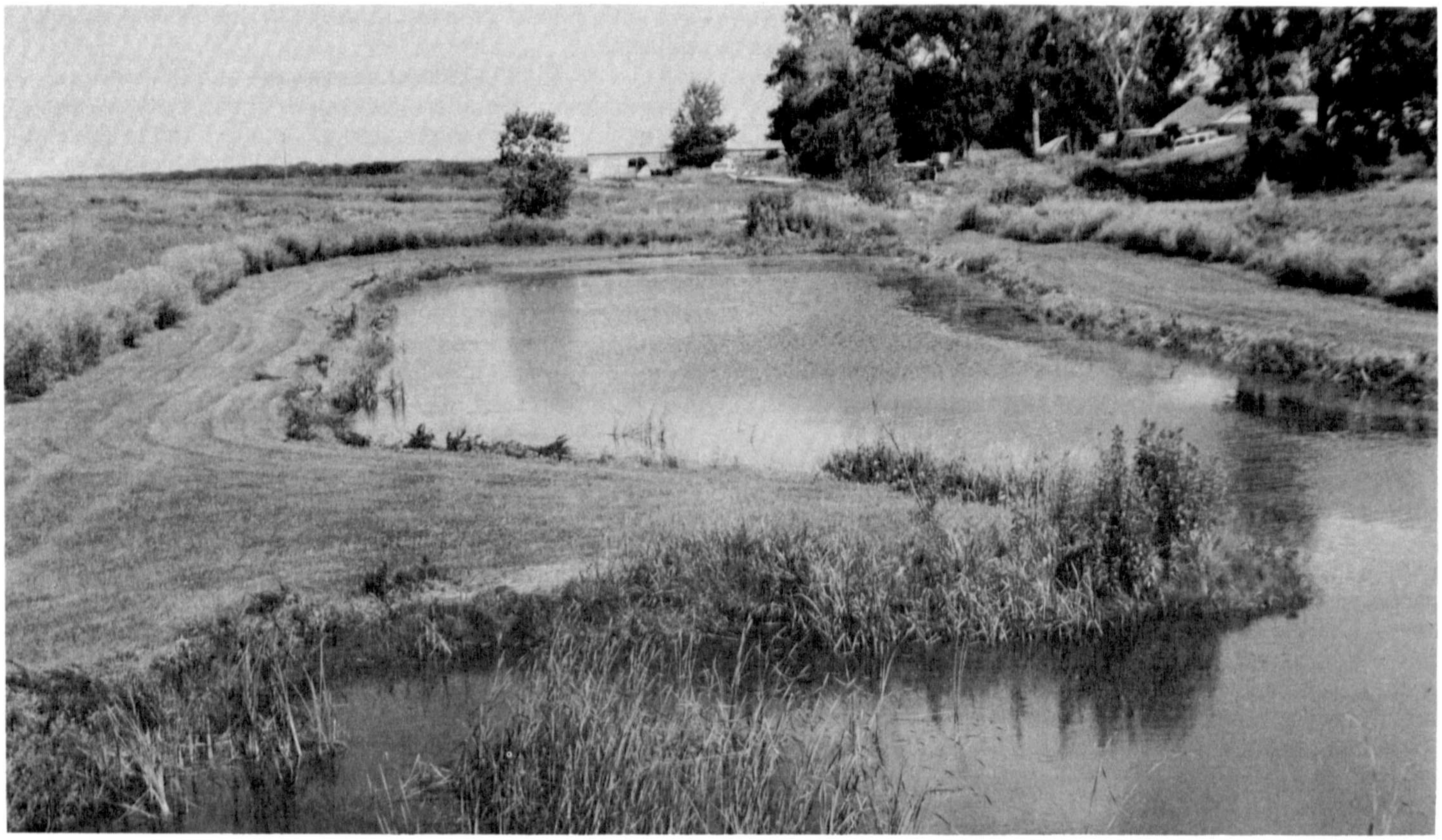


Figure 12.—A pit pond in a pastured area of Coland-Spillville complex, 1 to 5 percent slopes. Clarion loam is on the adjacent side slopes.

Most areas are cultivated. This soil is suited to corn, soybeans, and small grain. Cultivated crops can be damaged by drought, however, during periods of low rainfall. A conservation tillage system that leaves crop residue on the surface conserves moisture and helps to control soil blowing. For most plants, root development is restricted by the sand and gravel at a depth of 24 to 32 inches. In the wetter years tile drainage improves the timeliness of tillage and soil aeration in some cultivated areas. It tends to make the soil more droughty, however, especially in areas where the sand and gravel are near a depth of 24 inches.

A few areas are used for hay and pasture. This soil is well suited to grasses and legumes for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIs.

203—Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is in smooth glacial outwash areas and on stream terraces. Areas generally range from 2 to 20 acres in size. Most are irregular in shape, but those in drainageways are long and narrow.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is loam about 13 inches thick. It is black in the upper part and very dark grayish brown and black in the lower part. The subsoil is about 14 inches thick. It is friable. It is dark grayish brown and light olive brown clay loam in the upper part and light yellowish brown, mottled loam in the lower part. The upper part of the substratum is light yellowish brown, mottled, calcareous loamy sand. The lower part to a depth of 60 inches is pale yellow and very pale brown, mottled, calcareous gravelly loamy sand and gravelly coarse sand. In places the depth to the underlying sand and gravel is as much as 48 inches. In a few areas the surface layer is silty clay loam. In some areas the soil is calcareous throughout.

Included with this soil in mapping are small areas of very poorly drained soils. These soils are in depressions that are subject to ponding. They make up about 1 percent of the unit.

The Cylinder soil is moderately permeable in the upper part and very rapidly permeable in the substratum. It has a seasonal high water table. Surface runoff is slow. Available water capacity is moderate. The content of organic matter is about 4 to 5 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. If tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and a low supply of available potassium. The root zone generally is only 32 to 40 inches thick.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Droughtiness is the main limitation. A conservation tillage system that leaves crop residue on the surface conserves moisture and helps to control soil blowing. For most plants, root development is restricted by the sand and gravel at a depth of 32 to 40 inches. In the wetter years tile drainage improves the timeliness of tillage and soil aeration in some cultivated areas.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIs.

259—Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, poorly drained soil is on stream terraces. Areas generally range from 5 to 40 acres in size. Most of those in narrow stream valleys are long and narrow, and most of those in the wider valleys along the major streams are irregular in shape.

Typically, the surface layer is black clay loam about 7 inches thick. The subsurface layer is clay loam about 17 inches thick. It is black in the upper part, black and very dark gray in the next part, and very dark gray in the lower part. The subsoil is about 10 inches thick. It is olive gray, mottled, friable clay loam in the upper part and olive gray, mottled, very friable sandy loam in the lower part. The substratum to a depth of 60 inches is light olive gray and light brownish gray, mottled, calcareous gravelly loamy sand. In some places the depth to the underlying sand and gravel is more than 40 inches. In other places the soil is calcareous throughout.

Included with this soil in mapping are small areas of very poorly drained soils. These soils are in depressions that are subject to ponding. They make up about 1 percent of the unit.

The Biscay soil is moderately permeable in the upper part and rapidly permeable in the substratum. It has a seasonal high water table. Surface runoff is slow. Available water capacity is moderate. The content of organic matter is about 5 to 7 percent in the surface layer. This layer is mildly alkaline to slightly acid. If drainage tile is installed and tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium. The root zone is only 32 to 40 inches thick.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Cultivated crops are subject to damage because of the wetness. In some areas they are also subject to the damage caused by overflow and siltation from the adjacent soils or by minor flooding. A tile drainage system helps to overcome the wetness. Installing the tile is difficult in some areas, however, because the sand and gravel cave in. Terracing the adjacent soils on uplands and farming them on the contour help to prevent the damage caused by overflow and siltation. In some areas channel straightening and drainage ditches reduce the risk of flooding and improve the suitability for farming. A conservation tillage system that leaves crop residue on the surface helps to control soil blowing. For most plants, root development is restricted by the sand and gravel at a depth of 32 to 40 inches.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIw.

274—Rolfe silty clay loam, 0 to 1 percent slopes. This level, very poorly drained soil is in upland depressions. It is subject to ponding. Most areas are circular or oval and are 2 to 4 acres in size.

Typically, the surface layer is black silty clay loam about 10 inches thick. The subsurface layer is gray, mottled silty clay loam about 7 inches thick. The subsoil is about 35 inches thick. It is firm. It is very dark gray and grayish brown, mottled silty clay in the upper part; grayish brown, mottled silty clay in the next part; and gray and olive gray, mottled silty clay and clay loam in the lower part. The substratum to a depth of 60 inches is light olive gray and grayish brown, mottled, stratified clay loam, loam, and sandy loam. In places it is silty clay loam.

The Rolfe soil is slowly permeable. It has a seasonal high water table near or above the surface. Surface runoff is ponded. Available water capacity is high. The content of organic matter is about 4 to 5 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. If drainage tile is installed and tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium. It has a high shrink-swell potential.

Most areas are cultivated. This soil is suited to corn, soybeans, and small grain. Cultivated crops are subject to the damage caused by ponding and poor soil aeration in areas where artificial drainage is not adequate. Shallow ditches and a combination of surface intakes and tile drains help to prevent this damage. Even if an adequate drainage system is installed, tillage is often delayed. A conservation tillage system that leaves crop residue on the surface helps to control soil blowing.

A few areas are used for hay and pasture. This soil is well suited to grasses and legumes for hay and pasture. The grasses and legumes that can withstand periods of ponding and poor soil aeration should be selected for planting. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIIw.

282—Ransom silty clay loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on broad, smooth uplands and the lower side slopes. Most areas are irregular in shape and are 2 to 15 acres in size.

Typically, the surface layer is black silty clay loam about 7 inches thick. The subsurface layer is silty clay loam about 13 inches thick. It is black and very dark gray in the upper part and very dark grayish brown in the lower part. The subsoil is about 16 inches thick. It is olive brown, mottled, friable silty clay loam and silt loam in the upper part and light olive brown, mottled, firm loam in the lower part. The substratum to a depth of 60 inches is light olive brown, mottled, calcareous clay loam. In a few places the soil is calcareous throughout. In a few areas sandy or gravelly layers more than 5 inches thick are within a depth of 40 inches.

Included with this soil in mapping are small scattered areas of soils that have crystalline gypsum. Also included are small areas of the very poorly drained Rolfe soils in depressions that are subject to ponding. Included soils make up about 2 percent of the unit.

The Ransom soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 4 to 5 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. If tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and a very low or low supply of available potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Because of runoff from the adjacent soils higher on the landscape, crops are damaged by overflow and siltation in some concave upland areas. Establishing grassed waterways in areas where runoff concentrates helps to prevent this damage. Terracing the higher adjacent soils and farming them on the contour also help to prevent this damage. In the wetter years tile drainage improves the timeliness of tillage and soil aeration in some cultivated areas.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability class is I.

308—Wadena loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, well drained soil is on plane and concave glacial outwash plains and stream terraces. Most areas are long and narrow or are broad and oval. They range from 2 to 30 acres in size.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is loam about 15 inches thick. It is black and very dark brown in the upper part and very dark brown and very dark grayish brown in the lower part. The subsoil is about 17 inches thick. It is friable. It is dark yellowish brown clay loam and loam in the upper part and brown sandy loam in the lower part. The substratum to a depth of 60 inches is light yellowish brown, stratified gravelly loamy sand. In many areas all or part of the surface layer and subsurface layer is silty clay loam. In places the depth to sandy and gravelly material is more than 40 inches.

Permeability is moderate in the upper part of this soil and rapid in the substratum. Surface runoff is slow. Available water capacity is moderate. The content of organic matter is about 3 to 4 percent in the surface layer. This layer is neutral to strongly acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium. The root zone is only 32 to 40 inches thick.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Corn and soybeans are damaged by drought in years when the distribution of rainfall is poor. A conservation tillage system that leaves crop residue on the surface conserves moisture and helps to control soil blowing. For most plants, root development is restricted by the sand and gravel at a depth of 32 to 40 inches.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during dry periods help to keep the soil and the pasture in good condition.

The capability subclass is IIs.

308B—Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes. This gently sloping, well drained soil is on broad, smooth glacial outwash plains and stream terraces. Most areas are irregular in shape and range from 2 to 20 acres in size.

Typically, the surface layer is very dark brown loam about 7 inches thick. The subsurface layer is very dark grayish brown loam about 5 inches thick. The subsoil is about 27 inches thick. It is friable. It is brown and yellowish brown clay loam in the upper part and pale brown and light yellowish brown, mottled loam in the lower part. The substratum to a depth of 60 inches is multicolored, calcareous, stratified gravelly loamy sand, sand, and gravelly sand. In a few places all or part of the surface layer, subsurface layer, and subsoil is silty clay loam. In a few areas the depth to sandy and gravelly material is more than 40 inches.

Permeability is moderate in the upper part of this soil and rapid in the substratum. Surface runoff is medium. Available water capacity is moderate. The content of organic matter is about 3 to 4 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium. The root zone is only 32 to 40 inches thick.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Erosion is a hazard, especially on the longer slopes and in areas that receive runoff from the adjacent soils. Corn and soybeans are damaged by drought in years when the distribution of rainfall is poor. A conservation tillage system that leaves crop residue on the surface helps to control erosion and soil blowing and conserves moisture. If slopes are sufficiently long and wide, contour farming and terraces help to control erosion. If deep cuts are made when the terraces are constructed, however, the exposed soil is too droughty for crops. For most plants, root development is restricted by the sand and gravel at a depth of 32 to 40 inches.

A few areas are used for hay and pasture. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates, rotation grazing, and restricted use during dry periods help to keep the soil and the pasture in good condition.

The capability subclass is IIe.

330—Kingston silty clay loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on broad, smooth uplands. Most areas are irregular in shape and range from 2 to 50 acres in size.

Typically, the surface layer is black silty clay loam about 6 inches thick. The subsurface layer is silty clay loam about 12 inches thick. It is black in the upper part and very dark gray and black in the lower part. The subsoil is about 21 inches thick. It is friable. It is dark grayish brown silty clay loam in the upper part; light olive brown, mottled silt loam in the next part; and light yellowish brown, mottled silt loam in the lower part. The substratum to a depth of 60 inches is light brownish gray, mottled, calcareous silt loam. In a few places the soil is calcareous throughout.

Included with this soil in mapping are small areas of very poorly drained soils in depressions that are subject to ponding. These soils make up about 1 percent of the unit.

The Kingston soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 5 to 6 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. If tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil 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 runoff from the adjacent soils, crops are damaged by overflow and siltation in some concave areas. Establishing grassed waterways in areas where runoff concentrates helps to prevent this damage. Terracing the higher adjacent soils and farming them on the contour also help to prevent this damage. In the wetter years tile drainage improves the timeliness of tillage and soil aeration in some cultivated areas.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability class is I.

331—Madelia silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is in plane areas and swales on uplands. Most areas are longer than they are wide and are 3 to 10 acres in size.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is silty clay loam about 9 inches thick. It is black in the upper part and very dark gray in the lower part. The subsoil is friable, mottled silty clay loam about 15 inches thick. It is dark gray and grayish brown in the upper part and grayish brown in the lower part. The substratum to a depth of 60 inches is mottled olive, gray, and light yellowish brown, calcareous, stratified silt loam and silty clay loam. In places the lower part of the subsoil is stratified with lenses of sandy loam and loamy sand. In a few places the soil is calcareous throughout.

Included with this soil in mapping are scattered areas of soils that have crystalline gypsum. Also included are small areas of the very poorly drained Okoboji soils in depressions that are subject to ponding. Included soils make up about 2 percent of the unit.

The Madelia soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 6 to 7 percent in the surface layer. This layer is slightly acid or neutral. If drainage tile is installed and tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil 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. Cultivated crops are subject to the damage caused by poor soil aeration in areas where tile drainage is not adequate. Because of runoff from the adjacent soils, crops also are damaged by overflow and siltation in some concave areas. Establishing grassed waterways in areas where runoff concentrates helps to prevent this damage. Terracing the higher adjacent soils and farming them on the contour also help to prevent this damage.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIw.

384—Collinwood silty clay loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on slightly convex to slightly concave uplands. Most areas are irregular in shape and are 2 to 10 acres in size.

Typically, the surface layer is black silty clay loam about 10 inches thick. The subsurface layer is very dark gray silty clay loam about 5 inches thick. The subsoil is about 25 inches thick. It is firm. It is mottled dark grayish brown and olive brown silty clay loam in the upper part; mottled light olive brown and grayish brown silty clay loam and silty clay in the next part; and mottled grayish brown and brownish yellow silty clay loam in the lower part. The substratum to a depth of 60 inches is light brownish gray, mottled, calcareous silty clay loam and silt loam. In places stratified loamy sand and sandy loam are within a depth of 60 inches.

Included with this soil in mapping are small areas of the very poorly drained Rolfe and Okoboji soils in depressions that are subject to ponding. These soils make up about 2 percent of the unit.

The Collinwood soil is slowly permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 5 to 6 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. If tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium. It has a high shrink-swell potential.

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 runoff from the adjacent soils, crops are damaged by overflow and siltation in some concave areas. Establishing grassed waterways in areas where runoff concentrates helps to prevent this damage. Terracing the higher adjacent soils and farming them on the contour also help to prevent this damage. Tile drainage improves the timeliness of tillage and soil aeration in some cultivated areas. Soil blowing is a hazard in areas where the surface is not protected by plants or crop residue. It can be controlled, however, by a conservation tillage system that leaves crop residue on the surface.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability class is I.

390—Waldorf silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on plane and concave uplands. Most areas are irregular in shape and are 2 to 10 acres in size.

Typically, the surface layer is black silty clay loam about 10 inches thick. The subsurface layer is very dark gray, mottled silty clay about 6 inches thick. It has black coatings on peds. The subsoil is about 22 inches thick. It is dark grayish brown, mottled, firm silty clay in the upper part and olive gray, mottled, firm silty clay and friable silty clay loam in the lower part. The substratum to a depth of 60 inches is olive gray, mottled, calcareous silty clay loam. In a few places the soil is calcareous throughout.

Included with this soil in mapping are small areas of very poorly drained soils in depressions that are subject to ponding. These soils make up about 5 percent of the unit.

The Waldorf soil is moderately slowly permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 6 to 7 percent in the surface layer. This layer is neutral or slightly acid. If drainage tile is installed and tillage is deferred when the soil is wet, good tilth can be maintained. The subsoil has a very low supply of available phosphorus and potassium. It has a high shrink-swell potential.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Cultivated crops are subject to damage in areas where tile drainage is not adequate. Tile removes excess water more slowly from this soil than from less clayey soils. Because of runoff from the adjacent soils, crops are damaged by overflow and siltation in some concave areas. Terracing the higher adjacent soils and farming them on the contour help to prevent this damage. Soil blowing is a hazard in areas where the surface is not protected by plants or crop residue. It can be controlled, however, by a conservation tillage system that leaves crop residue on the surface.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIw.

397—Letri silty clay loam, 0 to 1 percent slopes. This level, poorly drained soil is in broad, smooth areas and swales on uplands. Most areas are longer than they are wide and range from 3 to 35 acres in size.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is silty clay loam about 12 inches thick. It is black in the upper part and very dark gray and black in the lower part. The subsoil is firm clay loam about 12 inches thick. It is olive gray and mottled in the upper part and mottled light brownish gray and brownish yellow in the lower part. The substratum to a depth of 60 inches is mottled brownish yellow and light brownish gray, calcareous clay loam. In a few places the soil is calcareous throughout.

Included with this soil in mapping are small scattered areas of soils that have crystalline gypsum. Also included are a few small areas of very poorly drained soils in depressions that are subject to ponding. Included soils make up about 6 percent of the unit.

The Letri soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 6 to 8 percent in the surface layer. This layer is neutral or slightly acid. If drainage tile is installed and tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil 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. Cultivated crops are subject to damage in areas where tile drainage is not adequate. Because of runoff from the adjacent soils, crops also are damaged by overflow and siltation in some concave areas. Establishing tiled grassed waterways in areas where runoff concentrates helps to prevent this damage. Terracing the more sloping adjacent soils and farming them on the contour also help to prevent this damage.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIw.

456—Wilmonton silty clay loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is in broad, smooth areas and the upper part of drainageways on uplands. Most areas are irregular in shape or long and narrow and range from 2 to 50 acres in size.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is silty clay loam about 10 inches thick. It is black and very dark gray in the upper part and very dark grayish brown and very dark gray in the lower part. The subsoil is about 18 inches thick. It is dark grayish brown and light olive brown, friable clay loam in the upper part; light olive brown, mottled, firm clay loam in the next part; and light olive brown and brownish yellow, firm loam in the lower part The substratum to a depth of 60 inches is mottled light brownish gray and brownish yellow, calcareous loam. In a few places the soil is calcareous throughout.

Included with this soil in mapping are small areas of soils that tend to be droughty because they are underlain by sandy or gravelly material. Also included are small areas of very poorly drained soils in depressions that are subject to ponding. Included soils make up about 7 percent of the unit.

The Wilmonton soil is moderately slowly permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 5 to 6 percent in the surface layer. This layer generally is neutral to medium acid, depending on past liming practices. If tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil 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 runoff from the adjacent soils, crops are damaged by overflow and siltation in some concave areas. Establishing grassed waterways in areas where runoff concentrates helps to prevent this damage. Terracing the higher adjacent soils and farming them on the contour also help to prevent this damage. In the wetter years tile drainage improves the timeliness of tillage and soil aeration in some cultivated areas.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability class is I.

474B—Bolan loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on convex upland side slopes and ridgetops. Most areas are irregular in shape and are about 2 to 15 acres in size.

Typically, the surface layer is very dark brown loam about 7 inches thick. The subsurface layer is loam about 11 inches thick. It is very dark brown in the upper part and very dark grayish brown and very dark brown in the lower part. The subsoil is about 20 inches thick. It is brown and yellowish brown, friable loam in the upper part; yellowish brown, very friable fine sandy loam in the next part; and yellowish brown, very friable loamy fine sand in the lower part. The substratum to a depth of 60 inches is yellowish brown, mottled loamy fine sand and fine sand. In places it is silt loam below a depth of 40 inches.

Included with this soil in mapping are small areas of soils that have a sand or loamy sand surface layer. These soils are in the more convex positions on the landscape. They tend to be more droughty than the Bolan soil. They make up about 8 percent of the unit.

Permeability is moderate in the upper part of the Bolan soil and rapid in the substratum. Surface runoff is medium. Available water capacity is moderate. The content of organic matter is about 3 to 4 percent in the surface layer This layer is neutral to medium acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is suited to corn, soybeans, and small grain. Erosion is a hazard, however, especially on the longer slopes. Also, corn and soybeans can be damaged by drought, especially in years when the distribution of rainfall is poor. A conservation tillage system that leaves crop residue on the surface helps to control erosion and soil blowing and conserves moisture. Contour farming also helps to control erosion. If terraces are constructed on this soil, the cuts could expose the more droughty fine sandy loam or loamy fine sand underlying the loam. Plant growth would be poor in the cut areas because of a greatly reduced available water capacity.

A few areas are used for hay and pasture. This soil is well suited to grasses and legumes for hay and pasture. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates, rotation grazing, and restricted use during dry periods help to keep the soil and the pasture in good condition.

The capability subclass is IIe.

474C2—Bolan loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on convex upland side slopes. Most areas are long and narrow and are 2 to 5 acres in size.

Typically, the surface layer is very dark brown loam about 8 inches thick. It is mixed with streaks and pockets of brown subsoil material. The subsoil is about 20 inches thick. It is brown and very dark grayish brown, friable loam in the upper part; yellowish brown, friable loam in the next part; and yellowish brown, very friable fine sandy loam in the lower part. The substratum to a depth of 60 inches is yellowish brown and brownish yellow loamy fine sand. In places it is silt loam below a depth of 40 inches.

Permeability is moderate in the upper part of this soil and rapid in the substratum. Surface runoff is medium. Available water capacity is moderate. The content of organic matter is about 1 to 2 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is suited to corn, soybeans, and small grain. It is well suited to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion and drought are hazards. A conservation tillage system that leaves crop residue on the surface helps to control erosion and soil blowing and conserves moisture. Contour farming also helps to control erosion. If terraces are constructed on this soil, the cuts could expose the more droughty fine sandy loam or loamy fine sand underlying the loam. Plant growth would be poor in the cut areas because of a greatly reduced available water capacity.

About 35 percent of the acreage is used for hay and pasture. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates, rotation grazing, and restricted use during dry periods help to keep the soil and the pasture in good condition.

The capability subclass is IIIe.

485—Spillville loam, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is on stream bottom land and in some areas along the lower part of large upland drainageways. It is subject to flooding. Most areas are longer than they are wide and range from 2 to 20 acres in size.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is loam about 26 inches thick. It is black in the upper part and very dark gray in the lower part. The next 8 inches is very dark gray and very dark grayish brown loam. The substratum to a depth of 60 inches is dark grayish brown and olive brown, mottled loam. In places stratified sandy or gravelly material is within a depth of 40 inches.

Included with this soil in mapping are small areas of Coland and Millington soils. Coland soils are in old stream channels and in low, wet areas on bottom land. As a result of the wetness, tillage is delayed. Millington soils are near the present channels. They are calcareous and more stratified than the Spillville soil. Also, they are frequently flooded. Also included are a few small areas of soils that have gravelly material in the surface layer. Included soils make up about 7 percent of the unit.

The Spillville soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 4 to 5 percent in the surface layer. This layer is neutral or slightly acid. If tillage is deferred when the soil is wet, good tilth can be easily maintained. This soil 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. Cultivated crops are subject to flooding. Also, soil blowing is a hazard in areas where the surface is not protected by plants or crop residue. In some areas straightening the channel reduces the risk of flooding and improves the suitability for farming. A conservation tillage system that leaves crop residue on the surface helps to control soil blowing.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIw.

485B—Spillville loam, 2 to 5 percent slopes. This gently sloping, somewhat poorly drained soil is on foot slopes, in small drainageways, and on the lower side slopes adjacent to the larger drainageways. Most areas are longer than they are wide and are 2 to 15 acres in size.

Typically, the surface layer is black loam about 8 inches thick. The subsurface layer is loam about 22 inches thick. It is very dark gray in the upper part and very dark grayish brown in the lower part. The next 6 inches is dark grayish brown and very dark grayish brown loam. The substratum to a depth of 60 inches is grayish brown and light olive brown, mottled, calcareous loam. In places the subsurface layer is silty clay loam.

Included with this soil in mapping are small areas of the poorly drained Coland soils. These soils are on the more concave slopes below the Spillville soil. They remain wet for longer periods than the Spillville soil. Also included are a few small areas of the very poorly drained Okoboji soils in small depressions that are subject to ponding. Included soils make up about 12 percent of the unit.

The Spillville soil is moderately permeable. It has a seasonal high water table. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 4 to 5 percent in the surface layer. This layer is neutral or slightly acid. If tillage is deferred when the soil is wet, good tilth can be easily maintained. This soil 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. Cultivated crops can be damaged by overflow, erosion, and siltation unless protected from the runoff from cultivated soils higher on the landscape. If the slopes are sufficiently long and wide, terracing the higher adjacent soils and farming them on the contour help to prevent this damage. A conservation tillage system that leaves crop residue on the surface helps to control erosion. A tile line commonly is installed near the center of drainageways, where the soil tends to be wetter than in other areas.

Some areas are used for hay and pasture. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIe.

507—Canisteo silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is in broad, smooth areas and short, narrow drainageways on uplands. Most areas are irregular in shape and range from 5 to 20 acres in size.

Typically, the surface layer is black, calcareous silty clay loam about 7 inches thick. The subsurface layer is calcareous silty clay loam about 15 inches thick. It is black in the upper part and very dark gray and mottled in the lower part. The subsoil is about 16 inches thick. It is mottled, friable, and calcareous. It is dark gray and very dark gray clay loam in the upper part and olive gray loam in the lower part. The substratum to a depth of 60 inches is olive gray, mottled, calcareous loam and silty clay loam.

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

The Canisteo soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow (fig. 13). Available water capacity is high. The content of organic matter is about 6 to 7 percent in the surface layer. This layer is moderately alkaline. If drainage tile is installed and tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil 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. Cultivated crops are subject to damage in areas where tile drainage is not adequate. Because of runoff from the adjacent soils, crops are damaged by overflow and siltation in some concave areas. Establishing grassed waterways in areas where runoff concentrates helps to prevent this damage. If slopes are sufficiently long and wide, terracing the higher adjacent soils and farming them on the contour also help to prevent this damage. Soil blowing is a hazard in areas where the surface is not protected by plants or crop residue. It can be controlled, however, by a conservation tillage system that leaves crop residue on the surface. Applied pesticides and soybean varieties should be compatible with the calcareous soil conditions.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIw.

511—Blue Earth mucky silt loam, 0 to 1 percent slopes. This level, very poorly drained soil is in upland depressions and on drained glacial lake bottoms. It is subject to ponding. Areas generally are irregular in shape. Most are 2 to 10 acres in size, but a few are as large as 60 acres.

Typically, the surface layer is black, calcareous mucky silt loam about 7 inches thick. The upper part of the substratum is black, calcareous mucky silt loam. The lower part to a depth of 60 inches is black, calcareous silty clay loam and silt loam. In a few areas the upper part of the substratum is not calcareous. In a few other areas the surface layer is silt loam in which the content of organic matter is less than 11 percent.

Included with this soil in mapping are small scattered areas of soils that have a surface layer of noncalcareous mucky silt loam or calcareous silty clay loam. These soils generally are on the lowest part of the depressions and drained lake bottoms. They make up about 5 percent of the unit.

Figure 13.—New condominium construction on Canisteo silty clay loam, 0 to 2 percent slopes. The slow removal of surface runoff and a seasonal high water table are severe limitations if this soil is used as a site for buildings.

The Blue Earth soil is moderately slowly permeable. It has a seasonal high water table near or above the surface. Surface runoff is ponded. Available water capacity is high. The content of organic matter is more than 15 percent in the surface layer. This layer is moderately alkaline. If drainage tile is installed and tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium.

Most areas are cultivated. If drained, this soil is suited to corn, soybeans, and small grain. It is well suited to grasses and legumes for hay and pasture. Cultivated crops are subject to damage during periods of excessive rainfall. The larger cultivated areas are subject to soil blowing, especially in winter and early in spring. A conservation tillage system that leaves crop residue on the surface helps to control soil blowing. Applied pesticides and soybean varieties should be compatible with the calcareous soil conditions.

A few areas are used for hay and pasture. The grasses that can tolerate the wetness grow best. Maintaining most legume stands is difficult because of winter killing and root and crown diseases. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIIw.

559—Talcot silty clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes. This nearly level, poorly drained soil is on stream terraces. Most areas are irregular in shape and range from 3 to 25 acres in size.

Typically, the surface layer is black, calcareous silty clay loam about 8 inches thick. The subsurface layer is about 16 inches thick. It is calcareous. It is black and very dark gray silty clay loam in the upper part and very dark gray and dark grayish brown, mottled clay loam in the lower part. The subsoil is about 11 inches thick. It is friable and calcareous. It is olive gray and dark grayish brown, mottled clay loam in the upper part and olive gray, mottled loam in the lower part. The substratum to a depth of 60 inches is stratified, yellowish brown, mottled, calcareous gravelly loamy sand; strong brown, calcareous loamy sand; and light brownish gray and pale brown, calcareous gravelly sand and gravelly coarse sand. In places the depth to sand and gravel is more than 40 inches.

Included with this soil in mapping are small areas of soils in depressions that are subject to ponding. These soils make up about 5 percent of the unit.

The Talcot soil is moderately permeable in the upper part and rapidly permeable in the substratum. It has a seasonal high water table. Surface runoff is slow. Available water capacity is moderate. The content of organic matter is about 5 to 7 percent in the surface layer. This layer is moderately alkaline. If drainage tile is installed and tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil 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. Cultivated crops are subject to damage because of the wetness. In some areas they are also subject to the damage caused by overflow, siltation, and minor flooding. Soil blowing is a hazard in areas where the surface is not protected by plants or crop residue. A tile drainage system helps to overcome the wetness. Installing the tile is difficult in some areas, however, because the sand and gravel cave in. Terracing the adjacent soils on uplands and farming them on the contour help to prevent the damage caused by overflow and siltation. In some areas channel straightening and drainage ditches reduce the risk of flooding and improve the suitability for farming. A conservation tillage system that leaves crop residue on the surface helps to control soil blowing. For most plants, root development is restricted by the sand and gravel at a depth of 32 to 40 inches. Applied pesticides and soybean varieties should be compatible with the calcareous soil conditions.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIw.

577—Everly clay loam, 0 to 2 percent slopes. This nearly level, well drained soil is on broad upland ridgetops. Most areas are irregular in shape and range from 2 to 20 acres in size.

Typically, the surface layer is black clay loam about 7 inches thick. The subsurface layer is black loam about 5 inches thick. The subsoil is loam about 29 inches thick. It is very dark grayish brown and brown and friable in the upper part; yellowish brown and brown and friable in the next part; and light olive brown, mottled, and firm in the lower part. The substratum to a depth of 60 inches is mottled brownish yellow and light gray, calcareous loam.

Permeability is moderate. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 3 to 4 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil 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. Soil blowing is a hazard in areas where the surface is not protected by plants or crop residue. It can be controlled, however, by a conservation tillage system that leaves crop residue on the surface.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability class is I.

577B—Everly clay loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on convex upland ridgetops and long side slopes. Most areas are irregular in shape and are 2 to 15 acres in size.

Typically, the surface layer is black clay loam about 7 inches thick. The subsurface layer is black and very dark brown clay loam about 4 inches thick. The subsoil is about 25 inches thick. It is very dark grayish brown and brown, friable clay loam in the upper part; dark yellowish brown, friable clay loam in the next part; and yellowish brown, mottled, firm loam in the lower part. The substratum to a depth of 60 inches is brownish yellow, light gray, and yellowish brown, mottled, calcareous loam.

Included with this soil in mapping are small convex areas of soils that have glacial till in the surface layer and small areas of soils that tend to be droughty because they are underlain by sandy or gravelly material. These soils make up about 7 percent of the unit. Also included, on the east side of the Little Sioux River, is about 50 acres of soils that have a light colored subsurface layer and contain more clay in the subsoil than the Everly soil.

Permeability is moderate in the Everly soil. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 3 to 4 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil 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. In cultivated areas erosion is a hazard, especially on the longer slopes. A conservation tillage system that leaves crop residue on the surface, contour farming, and terraces help to control erosion.

A few areas are used for hay and pasture. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates and rotation grazing help to keep the soil and the pasture in good condition.

The capability subclass is IIe.

577C2—Everly clay loam, 5 to 9 percent slopes, moderately eroded. This moderately sloping, well drained soil is on upland side slopes. Most areas are irregular in shape and are about 2 to 5 acres in size.

Typically, the surface layer is very dark gray clay loam about 8 inches thick. It is mixed with streaks and pockets of brown subsoil material. The subsoil is about 22 inches thick. It is brown and very dark grayish brown, friable loam in the upper part; yellowish brown and brown, friable loam in the next part; and yellowish brown and light yellowish brown, firm loam in the lower part. The substratum to a depth of 60 inches is light yellowish brown and brownish yellow, mottled, calcareous loam.

Included with this soil in mapping are small areas of soils that have glacial till in the surface layer. These soils are in the more convex positions on the landscape. They make up about 10 percent of the unit.

Permeability is moderate in the Everly soil. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 2 to 3 percent in the surface layer. This layer is neutral to medium acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is suited to corn, soybeans, and small grain. It is well suited to grasses and legumes for hay and pasture. In cultivated areas further erosion is a hazard. A conservation tillage system that leaves crop residue on the surface helps to control erosion. If slopes are sufficiently long and wide, contour farming and terraces also help to control erosion.

A few areas are used for hay and pasture, which are the most practical uses in areas where the adjacent soils are managed for these uses. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates and rotation grazing help to keep the soil and the pasture in good condition.

The capability subclass is IIIe.

655—Crippin loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is on broad, smooth uplands and low knolls and ridges. Most areas are irregular in shape or are long and narrow. They range from 5 to 25 acres in size.

Typically, the surface layer is black, calcareous loam about 7 inches thick. The subsurface layer is calcareous loam about 9 inches thick. It is very dark gray in the upper part and very dark grayish brown in the lower part. The subsoil is friable, calcareous loam about 19 inches thick. It is dark grayish brown in the upper part and light olive brown and mottled in the lower part. The substratum to a depth of 60 inches is light olive brown, mottled, calcareous loam. In a few areas it is stratified silt loam.

Included with this soil in mapping are areas of the well drained Clarion soils on small, prominent knolls and a few scattered areas of soils that have crystalline gypsum. Also included are the very poorly drained Okoboji soils in small depressions that are subject to ponding. Included soils make up about 10 percent of the unit.

The Crippin soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 5 to 6 percent in the surface layer. This layer is mildly alkaline or moderately alkaline. If tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil 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 runoff from the adjacent soils higher on the landscape, crops are damaged by overflow and siltation in some concave upland areas. Establishing grassed waterways in areas where runoff concentrates helps to prevent this damage. Terracing the higher adjacent soils and farming them on the contour also help to prevent this damage. Soil blowing is a hazard in areas where the surface is not protected by plants or crop residue. It can be controlled, however, by a conservation tillage system that leaves crop residue on the surface. Applied pesticides and soybean varieties should be compatible with the calcareous soil conditions. In the wetter years tile drainage improves the timeliness of tillage and soil aeration in some cultivated areas.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability class is I.

733—Calco silty clay loam, 0 to 2 percent slopes. This nearly level, poorly drained soil is on flood plains along large streams, on bottom land along small streams, and on the lower part of upland drainageways. It is subject to flooding. Areas generally range from about 10 to 45 acres in size. Most of those in the upland drainageways and on the bottom land along small streams are long and narrow, and most of those on the flood plains are irregular in shape.

Typically, the surface layer is black, calcareous silty clay loam about 13 inches thick. The subsurface layer is mottled, calcareous silty clay loam about 19 inches thick. It is black and very dark gray in the upper part and very dark gray in the lower part. The next 8 inches is very dark grayish brown and very dark gray, mottled, calcareous silty clay loam. The substratum to a depth of 60 inches is very dark grayish brown and grayish brown, mottled, calcareous clay loam and sandy loam. In places the soil is loam within a depth of 40 inches and is noncalcareous.

This soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 5 to 7 percent in the surface layer. This layer is moderately alkaline. If drainage tile is installed and tillage is deferred when the soil is wet, good tilth can be easily maintained. The soil has a very low supply of available phosphorus and potassium.

Most areas are cultivated. The narrow areas on bottom land typically are pastured. If drained, this soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. Cultivated crops can be damaged by wetness and in places by flooding and siltation. Also, soil blowing is a hazard in areas where the surface is not protected by plants or crop residue. Tile drains help to prevent the damage caused by wetness. In places straightening the channel reduces the risk of flooding and improves the suitability for farming. A conservation tillage system that leaves crop residue on the surface helps to control soil blowing. Applied pesticides and soybean varieties should be compatible with the calcareous soil conditions.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIw.

878—Ocheyedan loam, 0 to 2 percent slopes. This nearly level, well drained soil is on broad, smooth upland ridgetops. Most areas are irregular in shape and range from about 3 to 20 acres in size.

Typically, the surface layer is very dark brown loam about 7 inches thick. The subsurface layer is very dark brown loam about 5 inches thick. The subsoil is about 34 inches thick. It is friable. It is very dark grayish brown and brown loam in the upper part; dark yellowish brown sandy loam and loam in the next part; and light olive brown, mottled silt loam in the lower part. The substratum to a depth of 60 inches is dark yellowish brown, mottled loam.

Included with this soil in mapping are small scattered areas of soils that have sandy or gravelly material at a depth of 30 to 40 inches. These soils tend to be droughty. They make up about 5 percent of the unit.

Permeability is moderate in the Ocheyedan soil. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 3 to 4 percent in the surface layer. This layer is neutral to strongly acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil 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. Soil blowing can be controlled by a conservation tillage system that leaves crop residue on the surface.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability class is I.

878B—Ocheyedan loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on convex upland ridgetops and side slopes. Most areas are irregular in shape and range from about 3 to 25 acres in size.

Typically, the surface layer is black loam about 10 inches thick. The subsurface layer is very dark grayish brown loam about 5 inches thick. The subsoil is about 30 inches thick. It is brown and yellowish brown, friable loam in the upper part; yellowish brown, very friable sandy loam and friable loam in the next part; and light olive brown, mottled, friable silt loam in the lower part. The substratum to a depth of 60 inches is light brownish gray and yellowish brown, mottled, calcareous silt loam and loam.

Included with this soil in mapping are small convex areas of soils that have a loamy sand or sand surface layer. Also included are small scattered areas of soils that tend to be droughty because they are underlain by sandy or gravelly material within a depth of 40 inches. Included soils make up about 8 percent of the unit.

Permeability is moderate in the Ocheyedan soil. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 3 to 4 percent in the surface layer. This layer is neutral to strongly acid, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. If cultivated crops are grown, erosion is a hazard, especially on the longer slopes. A conservation tillage system that leaves crop residue on the surface, contour farming, and terraces help to control erosion and soil blowing.

A few areas are used for hay and pasture. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates and rotation grazing help to keep the soil and the pasture in good condition.

The capability subclass is IIe.

879—Fostoria loam, 1 to 3 percent slopes. This very gently sloping, somewhat poorly drained soil is in broad, smooth areas and at the slightly concave head of drainageways on uplands. Most areas are irregular in shape or are long and narrow. They range from 2 to 30 acres in size.

Typically, the surface layer is black loam about 7 inches thick. The subsurface layer is loam about 13 inches thick. It is black in the upper part and very dark grayish brown in the lower part. The subsoil is friable loam about 11 inches thick. It is dark grayish brown and light olive brown in the upper part and light olive brown and mottled in the lower part. The upper part of the substratum is light brownish gray and olive gray, mottled, calcareous silt loam. The lower part to a depth of 60 inches is mottled yellowish brown and light brownish gray, calcareous clay loam. In places the soil is calcareous throughout.

Included with this soil in mapping are small scattered areas of soils that are underlain by sandy or gravelly material. Also included are small areas of soils that have a sandy loam surface layer and subsurface layer. These soils are somewhat droughty. Included soils make up about 7 percent of the unit.

The Fostoria soil is moderately permeable. It has a seasonal high water table. Surface runoff is slow. Available water capacity is high. The content of organic matter is about 5 to 6 percent in the surface layer. This layer is neutral or slightly acid. If tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil 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 runoff from the adjacent soils higher on the landscape, crops are damaged by overflow and siltation in some concave areas. Establishing grassed waterways in areas where runoff concentrates helps to prevent this damage. Terracing the higher adjacent soils and farming them on the contour also help to prevent this damage. In the wetter years tile drainage improves the timeliness of tillage and soil aeration in some cultivated areas.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability class is I.

1202—Cylinder Variant loam, 0 to 2 percent slopes. This nearly level, somewhat poorly drained soil is in outwash areas and on stream terraces. Areas range from 2 to 20 acres in size. Most are irregular in shape, but some are long and narrow.

Typically, the surface layer is black, calcareous loam about 7 inches thick. The subsurface layer is calcareous loam about 11 inches thick. It is black and very dark gray in the upper part and very dark grayish brown in the lower part. The subsoil is about 9 inches thick. It is dark grayish brown and light olive brown, friable, calcareous sandy clay loam in the upper part and light olive brown, mottled, very friable, calcareous gravelly sandy clay loam in the lower part. The upper part of the substratum is light yellowish brown and light brownish gray, calcareous gravelly loamy sand. The lower part to a depth of 60 inches is mottled light brownish gray and brownish yellow, calcareous gravelly loamy sand and gravelly sand. In places sandy and gravelly material is within a depth of 24 inches.

Included with this soil in mapping are small areas of soils in depressions that are subject to ponding. These soils make up about 5 percent of the unit.

The Cylinder Variant soil is moderately permeable in the upper part and very rapidly permeable in the substratum. It has a seasonal high water table. Surface runoff is slow. Available water capacity is moderate. The content of organic matter is about 4 to 5 percent in the surface layer. This layer is mildly alkaline or moderately alkaline. If tillage is deferred when the soil is wet, good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium. The root zone generally is only 24 to 32 inches thick.

Most areas are cultivated. This soil is suited to corn, soybeans, and small grain. It is well suited to grasses and legumes for hay and pasture. Cultivated crops can be damaged by drought during periods of low rainfall. Also, soil blowing is a hazard in areas where the surface is not protected by plants or crop residue. A conservation tillage system that leaves crop residue on the surface conserves moisture and helps to control soil blowing. For most plants, root development is restricted by the sand and gravel at a depth of 24 to 32 inches. In the wetter years tile drainage improves the timeliness of tillage and soil aeration in some cultivated areas. Installing the tile is difficult in some areas, however, because the sand and gravel cave in. Also, tile drainage tends to make the soil more droughty, especially in areas where the sand and gravel are near a depth of 24 inches. Applied pesticides and soybean varieties should be compatible with the calcareous soil conditions.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIs.

1384B—Collinwood Variant silty clay loam, 2 to 5 percent slopes. This gently sloping, well drained soil is on slightly convex upland ridgetops and side slopes. Most areas are irregular in shape and are 2 to 10 acres in size.

Typically, the surface layer is black silty clay loam about 8 inches thick. The subsurface layer is very dark brown and very dark grayish brown silty clay loam about 6 inches thick. The subsoil is friable silty clay loam about 31 inches thick. It is brown and yellowish brown in the upper part and yellowish brown in the lower part. The substratum to a depth of 60 inches is light olive brown, mottled, calcareous silt loam and loam. In places the surface layer or subsurface layer is clay loam.

Permeability is moderately slow. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 3 to 4 percent in the surface layer. This layer is medium acid to neutral, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium. It has a high shrink-swell potential.

Most areas are cultivated. This soil is well suited to corn, soybeans, and small grain and to grasses and legumes for hay and pasture. In cultivated areas erosion is a hazard, especially on the longer slopes. A conservation tillage system that leaves crop residue on the surface, contour farming, and terraces help to control erosion and soil blowing.

A few areas are used for hay and pasture. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIe.

1384C—Collinwood Variant silty clay loam, 5 to 9 percent slopes. This moderately sloping, well drained soil is on upland side slopes. Most areas are irregular in shape and are 2 to 15 acres in size.

Typically, the surface layer is black and very dark gray silty clay loam about 8 inches thick. The subsurface layer is very dark gray and very dark grayish brown silty clay loam about 4 inches thick. The subsoil is friable silty clay loam about 26 inches thick. It is brown and yellowish brown in the upper part and yellowish brown in the lower part. The upper part of the substratum is light olive brown silt loam. The lower part to a depth of 60 inches is light olive brown loam.

Permeability is moderately slow. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 3 to 4 percent in the surface layer. This layer is medium acid to neutral, depending on past liming practices. Good tilth can be easily maintained. The subsoil has a very low supply of available phosphorus and potassium. It has a high shrink-swell potential.

Most areas are cultivated. This soil is suited to corn, soybeans, and small grain. It is well suited to grasses and legumes for hay and pasture. In cultivated areas erosion is a hazard. A conservation tillage system that leaves crop residue on the surface, contour farming, and terraces help to control erosion and soil blowing.

A few areas are used for hay and pasture. A cover of grasses and legumes decreases the runoff rate and helps to control erosion. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition.

The capability subclass is IIIe.

1458—Millington loam, channeled, 0 to 2 percent slopes. This nearly level, poorly drained soil is in the larger areas of stream bottom land. It is subject to flooding. Most areas are adjacent to the present stream channel and are about 2 to 5 feet below the adjacent soils on bottom land. They are dissected by old channels. They are irregular in shape and range from 3 to 30 acres in size.

Typically, the surface layer is very dark gray, calcareous loam about 14 inches thick. The subsurface layer is very dark gray, calcareous loam about 7 inches thick. The subsoil is very dark gray, mottled, friable, calcareous loam about 13 inches thick. The subsurface layer and the subsoil are stratified with thin, dark gray lenses of loamy sand and sand. The upper part of the substratum is very dark gray, mottled loam that has dark gray lenses of loamy sand, sand, and sandy loam. The lower part to a depth of 60 inches is dark gray, calcareous loamy sand. In a few areas recent sandy deposits are on the surface.

Included with this soil in mapping are small areas of Spillville soils on the higher parts of the bottom land and small areas of Coland and Calco soils in old stream channels. Also included are low areas of recently deposited stratified material. These areas are subject to ponding. Included areas make up about 10 percent of the unit.

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

A few areas are used for row crops. This soil is poorly suited to corn, soybeans, small grain, and hay. Farming is impractical unless the old or meandering stream channels are filled or straightened. Also, the soil is subject to more frequent flooding and deposition than the other soils on bottom land. In some areas straightening the channels reduces the risk of flooding.

Most areas are pastured. This soil is well suited to grasses and legumes for pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soil and the pasture in good condition. The grasses and legumes selected for planting should be tolerant of the flooding and deposition.

The capability subclass is Vw.

1511—Blue Earth muck, ponded, 0 to 1 percent slopes. This level, very poorly drained soil is in undrained sloughs and upland depressions. It is ponded most of the year. Most areas are irregular in shape and range from 2 to 40 acres in size.

Typically, about 3 inches of very dark gray, undecomposed organic duff is on the surface. The surface layer is black, calcareous muck about 10 inches thick. The subsurface layer is mucky silt loam about 14 inches thick. It is very dark gray in the upper part and very dark gray and dark gray in the lower part. The substratum to a depth of 60 inches is dark gray and gray, calcareous silt loam. In places the surface layer and subsurface layer are neutral or mildly alkaline and are noncalcareous.

This soil is moderately slowly permeable. It has a seasonal high water table near or above the surface. It is covered by less than 1 foot to about 4 feet of surface water from 6 to 12 months each year. Available water capacity is very high. The content of organic matter is more than 20 percent in the surface layer. This layer is moderately alkaline. The supply of available phosphorus and potassium below a depth of 10 inches is very low.

This soil is not suited to cultivated crops or hay. It is marginally suited to water-tolerant grasses for pasture if the duration of ponding is short enough to allow grazing.

This soil is well suited to wetland wildlife habitat. It is suited to temporary upland wildlife habitat when it is not ponded. The natural vegetation includes cattail, arrowhead, and bulrush (fig. 14). Sloughgrass typically is in the slightly higher areas near the edges of the sloughs.

The capability subclass is Vw.

5010—Pits, gravel. This map unit is on outwash terraces that have been mined for sand and gravel. Most of the pits are near Milford, on an upland outwash terrace. Most are roughly square or rectangular and range from 2 to more than 40 acres in size. The pits on outwash terraces along streams typically are less than 15 feet deep. When mined out, they are subject to ponding. The pits on upland outwash terraces typically are more than 15 feet deep. When mined out, they are not subject to ponding. The sand and gravel are used as roadbuilding material and in manufacturing concrete and asphalt.

Pits that were abandoned a number of years ago support some trees, shrubs, and herbaceous vegetation

Figure 14.—Native vegetation on Blue Earth muck, ponded, 0 to 1 percent slopes. The adjacent soils in the background and foreground are Clarion loam and Storden loam.

in areas that are not ponded. The density of the vegetation varies from place to place, depending on the content of gravel in the remaining material. Some of the pits are suitable as wildlife habitat because a sufficient amount of appropriate vegetation is available for food and cover.

No capability class or subclass is assigned.

5040—Orthents, loamy. These very gently sloping, well drained soils are in areas on uplands, stream terraces, and outwash terraces where part or all of the original soil either has been excavated or is buried by fill. Most areas are roughly square or rectangular and are 2 to 15 acres in size.

Typically, the surface layer is loam about 12 inches thick. It generally is mixed backfill material from the topsoil and the subsoil of the original soil. The underlying material varies greatly from place to place. In the uplands it typically is loam glacial till, but in a very few areas as much as 18 inches of friable silt loam and silty clay loam is between the surface layer and the glacial till. On the stream terraces and outwash terraces, the underlying material commonly is 6 to 24 inches of mixed loamy material. Below this is sandy or gravelly material.

Included with these soils in mapping are some areas that are covered by roads or structures. Also included are several small areas that are used for solid waste disposal. The surface layer in these areas varies greatly, depending on the kind and amount of fill covering the solid waste. Included areas make up about 10 percent of the unit.

The properties of these soils vary greatly from place to place. The most common Orthents, in the uplands, are moderately permeable. Surface runoff is medium. Available water capacity is high. The content of organic matter is about 0.5 to 2.0 percent in the surface layer. This layer is neutral or slightly acid. The supply of available phosphorus and potassium below the surface is very low.

Most areas are cultivated. These soils are suited to corn, soybeans, and small grain. They are well suited to grasses and legumes for hay and pasture. Cultivated crops are generally more productive in areas where grasses and legumes are grown for several years after the borrow areas have been reclaimed. Growing grasses and legumes is especially beneficial in areas where the new surface layer is low in content of organic matter and in areas where glacial till is within a depth of 2 feet. Erosion and soil blowing are hazards in cultivated areas. Also, drought is a hazard in areas where less than 3 feet of backfilled soil material overlies coarse textured layers. A conservation tillage system that leaves crop residue on the surface and contour farming help to control erosion and soil blowing and conserve moisture.

A few areas are used for hay and pasture. Proper stocking rates, rotation grazing, and restricted use during wet periods help to keep the soils and the pasture in good condition.

No capability class or subclass is assigned.

Prime Farmland

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

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

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

About 176,000 acres throughout Dickinson County, or about 71 percent of the total acreage, meets the requirements for prime farmland. This land is less extensive in the Clarion-Nicollet association, which is described under the heading "General Soil Map Units," than in the other associations.

All of the soils that are considered prime farmland in Dickinson County are not equally suited to all of the commonly grown crops. The crops grown on these soils and the management requirements vary. For example, some crops require a sustained moisture supply throughout the growing season. As a result, these crops grow better on soils that have a high available water capacity, such as Kingston silty clay loam, 1 to 3 percent slopes, than on soils that have a low available water capacity, such as Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes. In most years the crops that require moisture only during the early part of the growing season grow about as well on the Wadena soil as on the Kingston soil.

The map units that are considered prime farmland in Dickinson County are listed in this section. 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 mangement are described in the section "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 a drainage system. The need for drainage is indicated in parentheses after the name of these soils on the following list. Onsite evaluation is needed to determine whether or not this limitation has been overcome by corrective measures.

The map units that meet the requirements for prime farmland are:

27B Terril loam, 2 to 5 percent slopes
32 Spicer silty clay loam, 0 to 2 percent slopes (where drained)
55 Nicollet loam, 1 to 3 percent slopes
77B Sac silty clay loam, 2 to 5 percent slopes
91 Primghar silty clay loam, 0 to 2 percent slopes
91B Primghar silty clay loam, 2 to 4 percent slopes
92 Marcus silty clay loam, 0 to 2 percent slopes (where drained)
95 Harps loam, 0 to 2 percent slopes (where drained)
107 Webster silty clay loam, 0 to 2 percent slopes (where drained)
108 Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes
108B Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes
135 Coland silty clay loam, 0 to 2 percent slopes (where drained)
138B Clarion loam, 2 to 5 percent slopes
201B Coland-Spillville complex, 1 to 5 percent slopes (where the Coland soil is drained)
202 Cylinder loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes
203 Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes
259 Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes (where drained)
282 Ransom silty clay loam, 1 to 3 percent slopes
308 Wadena loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes
308B Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes
330 Kingston silty clay loam, 1 to 3 percent slopes
331 Madelia silty clay loam, 0 to 2 percent slopes (where drained)
384 Collinwood silty clay loam, 1 to 3 percent slopes
390 Waldorf silty clay loam, 0 to 2 percent slopes (where drained)
397 Letri silty clay loam, 0 to 1 percent slopes (where drained)
456 Wilmonton silty clay loam, 1 to 3 percent slopes
474B Bolan loam, 2 to 5 percent slopes
485 Spillville loam, 0 to 2 percent slopes
485B Spillville loam, 2 to 5 percent slopes
507 Canisteo silty clay loam, 0 to 2 percent slopes (where drained)
559 Talcot silty clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes (where drained)
577 Everly clay loam, 0 to 2 percent slopes
577B Everly clay loam, 2 to 5 percent slopes
655 Crippin loam, 1 to 3 percent slopes
733 Calco silty clay loam, 0 to 2 percent slopes (where drained)
878 Ocheyedan loam, 0 to 2 percent slopes
878B Ocheyedan loam, 2 to 5 percent slopes
879 Fostoria loam, 1 to 3 percent slopes
1202 Cylinder Variant loam, 0 to 2 percent slopes
1384B Collinwood Variant silty clay loam, 2 to 5 percent slopes

Use and Management of the Soils

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

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

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

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

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

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

Crops and Pasture

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

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

In 1980, about 225,000 acres in Dickinson County was used for crops and pasture (*20*). In 1979, about 105,000 acres was used for corn, 80,000 acres for soybeans, 6,400 acres for oats, and 9,300 acres for alfalfa and other hay. The acreage used for corn and soybeans has increased in recent years, whereas that used for oats, alfalfa, and pasture has decreased.

The potential of the soils in Dickinson County for increased efficiency of crop production is good. Productivity can be increased both through the application of new crop production technology and through better application of the older technology.

The new technology includes a conservation tillage system and irrigation. A conservation tillage system helps to control soil blowing and water erosion by leaving a protective cover of crop residue on the surface from one growing season to the next. It conserves more moisture at planting depth than conventional tillage. Also, the cost of crop production is lower. A conservation tillage system is applicable to all the soils in the county but is especially important in gently sloping to strongly sloping areas of well drained soils, such as Clarion, Everly, Sac, and Storden.

Following are examples of the major kinds of conservation tillage. 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 at least 90 percent of the surface. Till-plant also is a system in which the seedbed is prepared and the seed planted in one operation. Tillage is limited to a strip not wider than one-third of the row. A protective cover of crop residue is left on two-thirds of the surface. Chisel-disk or rotary tillage is a system in which the soil is loosened throughout the field and crop residue is partly incorporated into the soil. Preparing the seedbed and planting can be one or separate operations. Conservation tillage is not practical unless enough crop residue is left on the surface after planting to control erosion.

Irrigation is most beneficial on soils that tend to be droughty, such as Estherville and Wadena. Areas that can supply the quantity of water needed for irrigation are very limited in Dickinson County. Some areas with irrigation potential are on the bottom land and terraces along the Little Sioux River and Stony Creek.

The older technology includes selection of crops and crop varieties and use of agricultural chemicals and fertilizers. Crops that use the entire growing season to mature, such as corn and soybeans, often grow poorly on droughty soils, such as Estherville and Wadena. In most years, however, crops that mature early in the growing season, such as small grain, are productive on these soils. Deep-rooted, perennial crops, such as alfalfa, also grow well in areas where the content of gravel in the substratum is relatively low. The content of sand and gravel in the substratum of Estherville, Wadena, and similar soils varies widely from place to place.

Some soybean varieties do not grow well on soils that have a high pH level. Other soybean varieties can tolerate a high pH level and generally are more productive in fields that include calcareous soils, such as Blue Earth, Calco, Canisteo, Crippin, and Harps. These and other calcareous soils also affect the performance of some of the commonly used herbicides.

If an excessive amount of nitrogen fertilizer is applied in areas used for corn, the nitrogen accumulates in the subsoil and substratum of a well drained soil (*13*). Deep leaching of nitrogen in well drained soils, such as Clarion, and loss of nitrogen into ground water under somewhat poorly drained soils, such as Nicollet, and poorly drained soils, such as Webster, can be controlled by application rates that are compatible with the productive capacity of the major soils in a field.

Fertilizers and other applied chemicals are lost along with the topsoil when erosion occurs. Soils that would be too erosive for conventional row cropping can be farmed if management that controls erosion is applied. For example, when Clarion loam, 9 to 14 percent slopes, is protected by terraces and a conservation tillage system that leaves 3,000 pounds of crop residue on the surface at planting time, the amount of soil lost through erosion is 50 percent less than the amount lost when this soil is conventionally row cropped.

Many of the more recently installed terraces are parallel and have tile outlets. Although crop rows do not exactly follow the contour, erosion is controlled because the slopes between the terraces are short. Terraces are not practical on Estherville and Dickman soils and in most areas of Bolan and Wadena soils because the cuts would expose coarse textured, unproductive material.

Erosion control provides a protective plant cover, decreases the runoff rate, and increases the infiltration rate. A cropping system that keeps a plant cover on the surface for extended periods helps to prevent excessive soil losses. On livestock farms, where part of the acreage is pasture and hayland, including legumes and grasses in the cropping system not only provides nitrogen and improves tilth for the following crop but also reduces the risk of erosion on the more sloping soils. Information and assistance in designing erosion-control practices is available in the local office of the Soil Conservation Service.

Poorly drained and very poorly drained soils make up about 28 percent of the acreage in Dickinson County. Tile drainage is needed if cultivated crops are grown on the poorly drained soils, such as Canisteo and Webster. Also, in some years tile drainage is beneficial on the somewhat poorly drained soils, such as Nicollet and Crippin, because it improves the timeliness of tillage. In some years, however, the tile removes water that would benefit the crops later in the growing season. In some areas of the poorly drained and somewhat poorly drained soils that are used for pasture, little or no tile drainage is needed. Information and assistance in designing artificial drainage systems is available in the local office of the Soil Conservation Service.

Sampling for fertility tests is an important part of cropland management. Samples from two soils that have similar properties, such as Clarion and Nicollet, may be combined for testing, especially if the soils are likely to be managed in the same manner. Samples from soils that have different properties, such as Crippin and Nicollet, generally should not be combined, even if the same general management is planned. A separate analysis of the samples from each soil or group of similar soils results in the best estimate of the fertility status of a field. Samples from soils of minor extent in a field are needed only if the soil properties are so different from those of the other soils that different management is planned. More specific information on soil sampling for fertility tests is available in the local office of the Cooperative Extension Serivce.

In the areas used for pasture, the most common species are bromegrass, bluegrass, reed canarygrass, orchardgrass, switchgrass, big bluestem, indiangrass, alfalfa, crownvetch, and ladino clover.

Forage production can be enhanced by management practices. 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. Erosion is a severe hazard if the protective plant cover is destroyed when the more sloping areas of pasture and hayland are renovated. If cultivated crops are grown prior to seeding, soil losses can be reduced by a conservation tillage system that leaves crop residue on the surface, contour farming, and grassed waterways. Interseeding grasses and legumes into the existing sod eliminates the need for destroying the plant cover during seedbed preparation.

Yields Per Acre

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

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

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

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

Crops other than those shown in table 5 are grown in the survey area, but estimated yields are not listed because the acreage of such crops is small. The local office of the Soil Conservation Service or of the Cooperative Extension Service can provide information about the management and productivity of the soils 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 acreage of soils in each capability class and subclass is shown in table 6. The capability classification of each map unit is given in the section "Detailed Soil Map Units."

Windbreaks and Environmental Plantings

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

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

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

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

Recreation

Dickinson County is a major recreational center for northwest Iowa and nearby areas in the surrounding states. The main attraction is about 15,000 acres of lakes. The largest of these are Spirit Lake, West and East Okoboji Lakes, and Silver Lake. The lakes are used mostly for boating, sailing, fishing, and swimming in the summer and for ice fishing and snowmobiling in the winter. Many private vacation homes and cottages are on or near the shores of the lakes. Public fishing areas and boat ramps are on most of the lakes. Public access to the largest stream in the county, the Little Sioux River, is limited. The river is used for limited fishing.

The Iowa Conservation Commission maintains about a dozen areas that are open to the public for hunting. Many of these areas are in the Canisteo-Nicollet-Okoboji association, which is described under the heading "General Soil Map Units." These level to gently undulating areas support vegetation favorable to upland and wetland wildlife.

Dickinson County has seven state parks and one large county park. Most communities maintain municipal parks. The activities available include picnicking, camping, and swimming. Other recreational activities are provided by the nature trails in Caylor Prairie, the Hogsback Area, and the Hafner Preserve; the state-operated fish hatchery in Orleans, which is open to the public; Sharp Cabin in Arnolds Park and the Spirit Lake Museum, which are of interest to the historical sightseer; and six golf courses.

In summer some of the public recreation areas and facilities are sometimes used to their capacity. The potential for additional development of public facilities is somewhat limited, however, by the demand for private facilities.

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

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

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

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

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

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

Paths and trails for hiking 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

Dickinson County provides habitat for a large and varied population of fish and other wildlife. The lakes and streams are the habitat of bluegill, bullhead, catfish, crappie, largemouth bass, muskellunge, northern pike, perch, sunfish, and walleye. The lakes, sloughs, and streams are the habitat of fur bearing animals and also provide resting and feeding areas for migratory waterfowl and shore birds. The land areas of the county provide habitat for cottontail, jackrabbit, coyote, Hungarian partridge, pheasant, quail, red fox, numerous predatory birds and songbirds, and white-tailed deer.

Areas that have the best potential for wildlife habitat generally are adjacent to lakes, streams, drainage ditches, and undrained sloughs or small depressions. Many of these areas are in the Wadena-Estherville-Coland and Clarion-Nicollet soil associations. These associations are described in the section "General Soil Map Units."

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, switchgrass, wheatgrass, and grama.

Hardwood trees and woody understory produce nuts or other fruit, buds, catkins, twigs, bark, and foliage. Soil properties and features that affect the growth of hardwood trees and shrubs are depth of the root zone, available water capacity, and wetness. Examples of these plants are oak, poplar, cherry, apple, hawthorn, dogwood, black walnut, 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, cattail, 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 Hungarian partridge, 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, 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 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 or to a cemented pan, large stones, and flooding affect the ease of excavation and construction. Landscaping and grading that require cuts and fills of more than 5 to 6 feet are not considered.

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

Lawns and landscaping require soils on which turf and ornamental trees and shrubs can be established and maintained. The ratings are based on soil properties, site features, and observed performance of the soils. Soil reaction, a high water table, the available water capacity in the upper 40 inches, and a high 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, and flooding affect absorption of the effluent. Large stones 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, 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 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, 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 the water table to permit revegetation. The soil material used as final cover for a landfill should be suitable for plants. The surface layer generally has the best workability, more organic matter, and the best potential for plants. Material from the surface layer should be stockpiled for use as the final cover.

Construction Materials

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

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

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

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

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

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

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

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

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

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

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

Soils rated *fair* are sandy soils, loamy soils that have a relatively high content of clay, soils that have only 20 to 40 inches of suitable material, soils that have an appreciable amount of gravel 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 and for embankments, dikes, and levees. The limitations are considered *slight* if soil properties and site features are generally favorable for the indicated use and limitations are minor and are easily overcome; *moderate* if soil properties or site features are not favorable for the indicated use and special planning, design, or maintenance is needed to overcome or minimize the limitations; and *severe* if soil properties or site features are so unfavorable or so difficult to overcome that special design, significant increase in construction costs, and possibly increased maintenance are required.

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

Pond reservoir areas hold water behind a dam or embankment. Soils best suited to this use have low seepage potential in the upper 60 inches. The seepage potential is determined by the permeability of the soil. 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 organic matter. A high water table affects the amount of usable material. It also affects trafficability.

Drainage is the removal of excess surface and subsurface water from the soil. How easily and effectively the soil is drained depends on 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 large stones, slope, and the hazard of cutbanks caving. The productivity of the soil after drainage is adversely affected by extreme acidity or by toxic substances in the root zone, such as a high content of calcium carbonate. Availability of drainage outlets is not considered in the ratings.

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

Terraces and diversions are embankments or a combination of channels and ridges constructed across a slope to reduce erosion and conserve moisture by intercepting runoff. Slope, wetness, and large stones 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, and slope 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.

Engineering Index Properties

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

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

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

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

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

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

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

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

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

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

Physical and Chemical Properties

Table 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 and the amount of soil lost. Soils are grouped according to the following distinctions:

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

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

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

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

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

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

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

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

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

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

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

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

Soil and Water Features

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

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

The four hydrologic soil groups are:

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

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

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

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

In table 16, some soils are assigned to two hydrologic groups. The first letter is for drained areas, and the second is for undrained areas.

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

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

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

High water table (seasonal) is the highest level of a saturated zone in the soil in most years. The depth to a seasonal high water table applies to undrained soils. The estimates are based mainly on the evidence of a saturated zone, namely grayish colors or mottles in the soil. Indicated in table 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 (*26*). 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-silty, mixed, mesic Typic Haplaquolls.

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

Soil Series and Their Morphology

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

Characteristics of the soil and the material in which it formed are identified for each series. The soil is compared with similar soils and with nearby soils of other series. A pedon, a small three-dimensional area of soil, that is typical of the series in the survey area is described. The detailed description of each soil horizon follows standards in the *Soil Survey Manual* (*25*). Many of the technical terms used in the descriptions are defined in *Soil Taxonomy* (*26*). Unless otherwise stated, colors in the descriptions are for moist soil. Following the pedon description is the range of important characteristics of the soils in the series.

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

Biscay Series

The Biscay series consists of poorly drained soils on low stream terraces. These soils formed in loamy material overlying sand and gravel. Permeability is moderate in the solum and rapid in the substratum. Slope ranges from 0 to 2 percent.

Biscay soils are similar to Talcot soils and commonly are adjacent to Cylinder, Cylinder Variant, and Talcot soils. Talcot soils are calcareous throughout the solum. They are in positions on the landscape similar to those of the Biscay soils. Cylinder and Cylinder Variant soils are on stream terraces and are higher on the landscape than the Biscay soils. Also, their B horizon is browner.

Typical pedon of Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, in an area of cropland; 1,815 feet north and 75 feet west of the southeast corner of sec. 6, T. 98 N., R. 38 W.

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

A1—7 to 13 inches; black (N 2/0) clay loam, black (10YR 2/1) dry; weak fine subangular blocky structure parting to moderate fine granular; friable; neutral; gradual smooth boundary.

A2—13 to 18 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; weak fine subangular blocky structure; friable; mildly alkaline; gradual smooth boundary.

A3—18 to 24 inches; very dark gray (10YR 3/1) clay loam, gray (10YR 5/1) dry; few fine distinct brownish yellow (10YR 6/6 and 6/8) mottles; weak fine subangular blocky structure; friable; mildly alkaline; gradual smooth boundary.

Bg—24 to 31 inches; olive gray (5Y 5/2) clay loam; common fine prominent brownish yellow (10YR 6/6 and 6/8) mottles; weak fine prismatic structure parting to weak fine subangular blocky; friable; few very dark gray (10YR 3/1) and very dark grayish brown (2.5Y 3/2) root channels; common black accumulations (iron and manganese oxides); few fine soft masses of lime in the lower part; mildly alkaline; gradual smooth boundary.

BCg—31 to 34 inches; olive gray (5Y 5/2) sandy loam; common fine prominent brownish yellow (10YR 6/6 and 6/8) mottles; weak fine prismatic structure; very friable; common fine black accumulations (iron and manganese oxides); about 15 percent gravel; slight effervescence; moderately alkaline; abrupt wavy boundary.

2Cg1—34 to 42 inches; light olive gray (5Y 6/2) gravelly loamy sand stratified with gravelly sandy loam; common fine prominent olive yellow (2.5Y 6/6) and brownish yellow (10YR 6/6 and 6/8) mottles; single grained; loose; about 20 percent gravel; common fine concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual smooth boundary.

2Cg2—42 to 60 inches; light brownish gray (2.5Y 6/2) gravelly loamy sand; single grained; loose; about 30 percent gravel, the content increasing with increasing depth; few fine to coarse concretions and soft masses of lime; strong effervescence; moderately alkaline.

The thickness of the solum, or the depth to sand and gravel, ranges from 32 to 40 inches. The depth to free carbonates commonly ranges from 28 to 40 inches. The thickness of the mollic epipedon ranges from 16 to 24 inches.

The A horizon either has hue of 10YR, value of 2 or 3, and chroma of 1 or is neutral in hue and has value of 2 and chroma of 0. It is dominantly clay loam, but the range includes silty clay loam. The Bg horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 to 3. It is clay loam, silty clay loam, or loam. It is neutral or mildly alkaline. The 2C horizon has hue of 5Y or 2.5Y, value of 5 or 6, and chroma of 2 to 4. It commonly is gravelly loamy sand or gravelly sand in which the content of gravel is 15 to 35 percent. In some strata, however, the content of gravel is less than 10 percent.

Blue Earth Series

The Blue Earth series consists of very poorly drained, moderately slowly permeable, calcareous soils in upland depressions and old glacial lakebeds. These soils formed in silty coprogenous earth. Slope is 0 to 1 percent.

Blue Earth soils commonly are adjacent to Canisteo and Coland soils. The adjacent soils are higher on the landscape than the Blue Earth soils. Also, their solum contains less organic matter. Canisteo soils formed mainly in glacial till. Coland soils formed in alluvium. They are not calcareous.

Typical pedon of Blue Earth mucky silt loam, 0 to 1 percent slopes, in an area of cropland; 2,560 feet east and 445 feet south of the northwest corner of sec. 25, T. 100 N., R. 37 W.

Ap—0 to 7 inches; black (10YR 2/1) mucky silt loam, dark gray (10YR 4/1) dry; weak fine and very fine granular structure; friable; very few snail shell fragments; strong effervescence; moderately alkaline; clear smooth boundary.

C1—7 to 20 inches; black (10YR 2/1) mucky silt loam, dark gray (10YR 4/1) dry; weak thick and very thick platy structure parting to weak fine and very fine granular; friable; few snail shells and shell fragments; strong effervescence; moderately alkaline; gradual smooth boundary.

C2—20 to 40 inches; black (10YR 2/1) silty clay loam, gray (5Y 5/1) dry; weak fine prismatic and medium subangular blocky structure; friable; few very fine dark reddish brown (5YR 3/3) and reddish brown (5YR 4/4) organic stains; few snail shells and shell fragments; strong effervescence; moderately alkaline; gradual wavy boundary.

C3—40 to 60 inches; black (10YR 2/1) silty clay loam, grading to very dark gray (5Y 3/1) in the lower part; weak medium prismatic structure; friable; few very fine dark reddish brown (5YR 3/3) and reddish brown (5YR 4/4) organic stains; few snail shells and shell fragments; strong effervescence; moderately alkaline.

The thickness of the coprogenous earth and the depth to loamy glacial till or lacustrine sediments range from 30 to more than 60 inches. The solum typically contains snail shell fragments in most layers, and some layers contain snail shells.

The A and C horizons have hue of 10YR or 5Y, value of 2 to 4, and chroma of 1 or 2. They commonly have mottles, organic stains, or iron stains. They are silty clay loam, mucky silt loam, or silt loam. If it occurs, the 2C horizon has hue of 2.5Y or 5Y, value of 3 to 5, and chroma of 1 or 2. It commonly has mottles. It is silty clay loam, silt loam, or loam.

Bolan Series

The Bolan series consists of well drained soils on upland ridgetops and side slopes. These soils formed in loamy and sandy eolian sediments. Permeability is moderate in the solum and rapid in the substratum. Slope ranges from 2 to 9 percent.

Bolan soils are similar to Wadena soils and commonly are adjacent to Dickman, Fostoria, Ocheyedan, and Wilmonton soils. Wadena soils are underlain by sand and gravel within a depth of 40 inches. Dickinson soils contain more sand in the upper part of the solum than the Bolan soils. Fostoria and Ocheyedan soils contain less sand in the B horizon than the Bolan soils. They commonly have silty sediments within 40 inches of the surface. Wilmonton soils contain more clay and less sand throughout the solum than the Bolan soils. They commonly have firm glacial till within 30 inches of the surface. Wilmonton and Fostoria soils are on the lower side slopes and in drainageways below the Bolan soils. Dickman and Ocheyedan soils are in positions on the landscape similar to those of the Bolan soils.

Typical pedon of Bolan loam, 2 to 5 percent slopes, in an area of cropland; 2,595 feet west and 215 feet north of the southeast corner of sec. 29, T. 98 N., R. 38 W.

Ap—0 to 7 inches; very dark brown (10YR 2/2) loam, dark grayish brown (10YR 4/2) dry; weak fine and very fine granular structure; friable; medium acid; clear smooth boundary.

A1—7 to 13 inches; very dark brown (10YR 2/2) loam, dark grayish brown (10YR 4/2) dry; weak fine and very fine granular structure; friable; medium acid; gradual smooth boundary.

A2—13 to 18 inches; very dark grayish brown (10YR 3/2) and very dark brown (10YR 2/2) loam, grayish brown (10YR 5/2) dry; weak fine subangular blocky and granular structure; friable; few brown (10YR 4/3) worm casts; medium acid; clear wavy boundary.

BA—18 to 22 inches; brown (10YR 4/3) loam; weak fine and very fine subangular blocky structure; friable; few very dark grayish brown (10YR 3/2) worm casts; medium acid; clear wavy boundary.

Bw1—22 to 28 inches; yellowish brown (10YR 5/4) loam; brown (10YR 4/3) coatings on faces of peds; weak fine prismatic structure parting to weak fine and very fine subangular blocky; friable; medium acid; clear wavy boundary.

Bw2—28 to 31 inches; yellowish brown (10YR 5/4) fine sandy loam; few brown (10YR 4/3) coatings on faces of peds; weak fine prismatic and subangular blocky structure; very friable; medium acid; gradual wavy boundary.

BC—31 to 38 inches; yellowish brown (10YR 5/4) loamy fine sand; weak fine prismatic structure; very friable; medium acid; gradual wavy boundary.

C1—38 to 44 inches; yellowish brown (10YR 5/6) loamy fine sand; few fine distinct light gray (2.5Y 7.2) mottles; single grained; loose; medium acid; diffuse wavy boundary.

C2—44 to 60 inches; yellowish brown (10YR 5/4) fine sand; common fine faint brownish yellow (10YR 6/6 and 6/8) and few fine distinct light gray (10YR 7/2) mottles; single grained; loose; few fine black accumulations (iron and manganese oxides); medium acid.

The thickness of the solum ranges from 30 to 48 inches. The depth to free carbonates ranges from 48 to more than 60 inches. The thickness of the mollic epipedon ranges from about 10 to 20 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is loam or silt loam high in content of sand. The B horizon generally has hue of 10YR, value of 3 to 6, and chroma of 4 to 6, but in some pedons the upper part has value and chroma of 3. The upper part of this horizon commonly is loam, but the range includes fine sandy loam. The content of sand in this horizon commonly increases with increasing depth. The C horizon has hue of 10YR, value of 4 to 6, and chroma of 3 to 6. It is loamy fine sand, fine sand, or sand.

Calco Series

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

Calco soils are similar to Coland soils and commonly are adjacent to Coland, Millington, and Spillville soils. Coland and Spillville soils are noncalcareous. Millington soils contain more sand throughout than the Calco soils. Millington and Spillville soils commonly are nearer to the stream than the Calco soils. Coland soils are in positions on the landscape similar to those of the Calco soils.

Typical pedon of Calco silty clay loam, 0 to 2 percent slopes, in an area of pasture; 2,325 feet south and 180 feet east of the northwest corner of sec. 22, T. 98 N., R. 38 W.

A1—0 to 4 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; friable; common fine white (10YR 8/1) accumulations; strong effervescence; moderately alkaline; clear smooth boundary.

A2—4 to 13 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; friable; strong effervescence; moderately alkaline; gradual smooth boundary.

A3—13 to 21 inches; black (10YR 2/1) and very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; few fine prominent brown (7.5YR 4/4) mottles; weak fine subangular blocky and granular structure; friable; strong effervescence; moderately alkaline; gradual smooth boundary.

A4—21 to 32 inches; very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; common fine faint dark grayish brown (2.5Y 4/2), dark brown (7.5YR 3/2), and grayish brown (2.5Y 5/2) mottles; weak fine subangular blocky structure parting to weak very fine subangular blocky; friable; strong effervescence; moderately alkaline; gradual smooth boundary.

AC—32 to 40 inches; very dark grayish brown (2.5Y 3/2) and very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) dry; common fine faint dark grayish brown (2.5Y 4/2) mottles; weak fine subangular blocky structure; friable; few fine concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual smooth boundary.

C—40 to 54 inches; very dark grayish brown (2.5Y 3/2) clay loam, grayish brown (2.5Y 5/2) dry; common fine faint dark grayish brown (2.5Y 4/2) and few fine distinct reddish yellow (7.5YR 6/6 and 6/8) mottles; weak medium and fine angular blocky structure; friable; few black accumulations (manganese oxide); strong effervescence; moderately alkaline; clear wavy boundary.

2Cg—54 to 60 inches; grayish brown (2.5Y 5/2) sandy loam; common fine distinct light brown (7.5YR 6/4) and reddish yellow (7.5YR 6/6 and 6/8) mottles; single grained; loose; strong effervescence; moderately alkaline.

The thickness of the solum and the thickness of the mollic epipedon range from 40 to 50 inches. Some pedons do not have free carbonates below a depth of 24 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 0 to 2. In some pedons it contains snail shells and snail shell fragments. The content of clay in this horizon generally ranges from 30 to 35 percent, but some pedons have subhorizons in which the content of clay is less than 30 percent.

Canisteo Series

The Canisteo series consists of poorly drained, moderately permeable, calcareous soils in broad till areas and swales on uplands. These soils formed in glacial till or in local alluvium derived from till. Slope ranges from 0 to 2 percent.

Canisteo soils are similar to Harps and Webster soils and commonly are adjacent to Blue Earth, Crippin, Harps, Okoboji, and Webster soils. Harps soils have a calcic horizon. Webster soils have a noncalcareous solum. They are in positions on the landscape similar to those of the Canisteo soils. Blue Earth soils formed in coprogenous earth. They are in depressions below the Canisteo soils. Crippin soils are on the steeper, more convex slopes and are higher on the landscape than the Canisteo soils. Also, their B horizon is browner. Okoboji soils have a noncalcareous solum and have a black A horizon more than 24 inches thick. They are in depressions below the Canisteo soils.

Typical pedon of Canisteo silty clay loam, 0 to 2 percent slopes, in an area of cropland; 1,780 feet east and 85 feet south of the northwest corner of sec. 1, T. 98 N., R. 35 W.

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; moderate fine and very fine granular structure; friable; slight effervescence; moderately alkaline; clear smooth boundary.

A—7 to 16 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; moderate fine subangular blocky and granular structure; friable; strong effervescence; moderately alkaline; clear smooth boundary.

AB—16 to 22 inches; very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) and gray (10YR 5/1) dry; common fine prominent yellowish brown (10YR 5/6 and 5/8) mottles; weak medium and fine subangular blocky structure; friable; few dark gray (5Y 4/1) worm casts; strong effervescence; moderately alkaline; gradual wavy boundary.

Bg1—22 to 27 inches; dark gray (5Y 4/1) and very dark gray (10YR 3/1) clay loam; common fine prominent yellowish brown (10YR 5/6 and 5/8) mottles; weak fine and very fine subangular blocky structure; friable; very few fine concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

Bg2—27 to 34 inches; olive gray (5Y 5/2) loam; common fine prominent yellowish brown (10YR 5/6 and 5/8) and strong brown (7.5YR 5/6 and 5/8) mottles; weak medium and fine subangular blocky structure; friable; few fine black accumulations (manganese oxide); very few very fine concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual smooth boundary.

BCg—34 to 38 inches; olive gray (5Y 5/2) loam; few fine and medium prominent strong brown (7.5YR 5/6 and 5/8) mottles; weak medium subangular blocky structure; friable; few fine black accumulations (manganese oxide); few very fine concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

Cg1—38 to 48 inches; olive gray (5Y 5/2) loam; common fine prominent strong brown (7.5YR 5/6 and 5/8) mottles; massive; friable; common fine black accumulations (manganese oxide); very few very fine concretions and soft masses of lime; strong effervescence; moderately alkaline; diffuse wavy boundary.

Cg2—48 to 60 inches; olive gray (5Y 5/2) silty clay loam; common fine and medium prominent strong brown (7.5YR 5/6 and 5/8) mottles; massive; friable; few fine black accumulations (manganese oxide); few fine and medium concretions and soft masses of lime; slight effervescence; moderately alkaline.

The thickness of the solum ranges from 20 to 40 inches. Free carbonates commonly are throughout the solum, but in some pedons the lower part of the subsoil does not have carbonates. The thickness of the mollic epipedon ranges from about 14 to 24 inches.

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

Clarion Series

The Clarion series consists of well drained, moderately permeable soils on upland ridgetops, side slopes, and knolls. These soils formed in loamy glacial till. Slope ranges from 2 to 14 percent.

Clarion soils are similar to Everly and Ocheyedan soils and are adjacent to Nicollet, Storden, and Webster soils. Everly soils contain more silt and clay in the solum than the Clarion soils. Ocheyedan soils are stratified in the lower part of the solum and in the substratum. Nicollet and Webster soils are on concave slopes and are lower on the landscape than the Clarion soils. Also, their B horizon is grayer. Storden soils do not have a B horizon. They are calcareous. They are on convex slopes below the Clarion soils.

Typical pedon of Clarion loam, 2 to 5 percent slopes (fig. 15), in an area of cropland; 2,458 feet west and 140 feet north of the southeast corner of sec. 9, T. 99 N., R. 35 W.

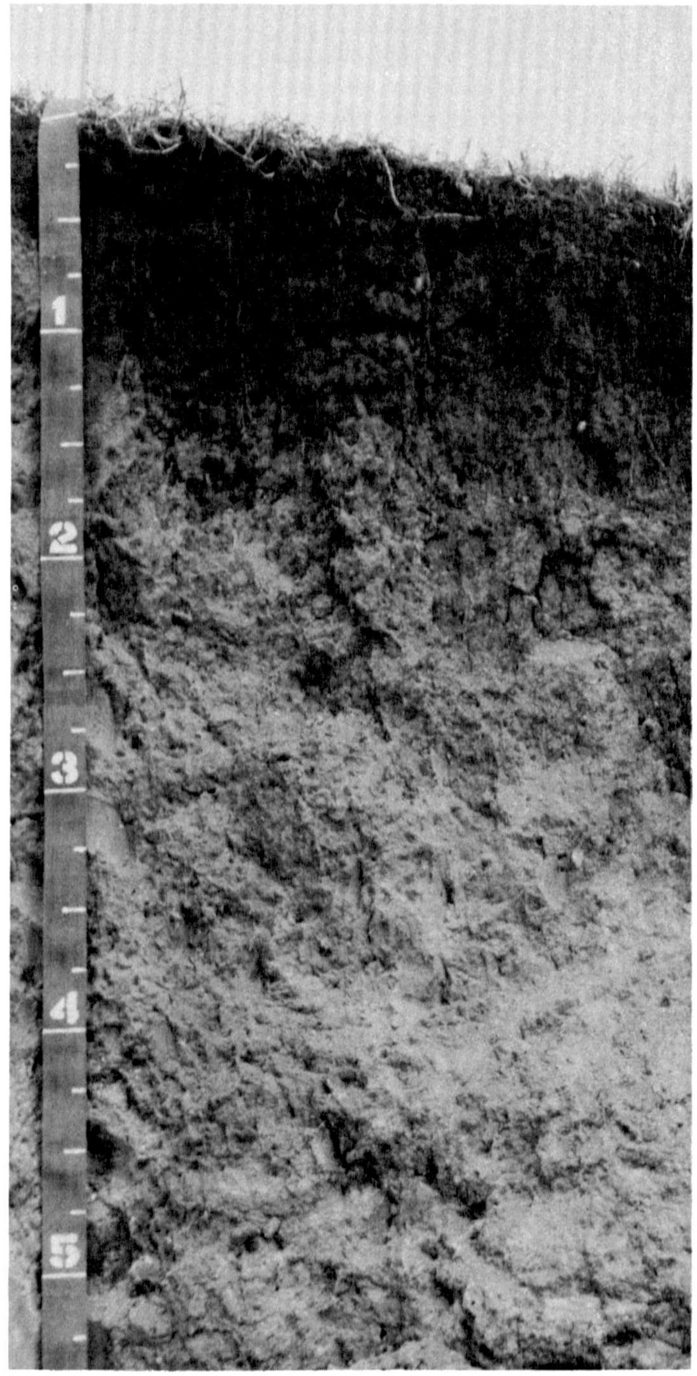


Figure 15.—Profile of Clarion loam. Depth is marked in feet.

Ap—0 to 6 inches; very dark brown (10YR 2/2) loam, very dark grayish brown (10YR 3/2) dry; weak fine granular structure; friable; slightly acid; clear smooth boundary.

A—6 to 11 inches; very dark brown (10YR 2/2) loam, very dark grayish brown (10YR 3/2) dry; weak fine subangular blocky and granular structure; friable; slightly acid; gradual smooth boundary.

AB—11 to 15 inches; very dark grayish brown (10YR 3/2) clay loam, brown (10YR 4/3) dry; weak fine subangular blocky structure; friable; common brown (10YR 4/3) worm casts; slightly acid; gradual smooth boundary.

Bw1—15 to 20 inches; brown (10YR 4/3) clay loam; weak medium and fine subangular blocky structure; friable; few very dark grayish brown (10YR 3/2) worm casts; neutral; gradual wavy boundary.

Bw2—20 to 27 inches; dark yellowish brown (10YR 4/4) clay loam; weak medium prismatic and subangular blocky structure; friable; neutral; gradual wavy boundary.

BC—27 to 32 inches; yellowish brown (10YR 5/4) loam; weak medium and fine prismatic structure; friable; few fine strong brown (7.5YR 5/6) accumulations (iron oxide); neutral; clear wavy boundary.

C1—32 to 50 inches; light olive brown (2.5Y 5/4) loam; common fine distinct light brownish gray (2.5Y 6/2) and strong brown (7.5YR 5/6 and 5/8) mottles; massive; friable; common fine concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

C2—50 to 60 inches; yellowish brown (10YR 5/6), light olive brown (2.5Y 5/4), and light brownish gray (2.5Y 6/2) loam; common fine distinct strong brown (7.5YR 5/6 and 5/8) mottles; massive; friable; common fine and medium filaments, concretions, and soft masses of lime; strong effervescence; moderately alkaline.

The thickness of the solum ranges from about 20 to 48 inches. The depth to free carbonates commonly is the same as the thickness of the solum, but in some pedons the lower 4 to 8 inches of the solum contains free carbonates. The thickness of the mollic epipedon ranges from about 10 to 16 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It typically is loam, but in some pedons the lower part is sandy loam or clay loam. The B horizon generally has hue of 10YR, value of 4 or 5, and chroma of 3 or 4, but in some pedons the upper part has value and chroma of 3. This horizon is dominantly loam or clay loam, but in some pedons the lower part is sandy loam in which the content of sand is less than 60 percent. The C horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 2 to 6.

Coland Series

The Coland series consists of poorly drained, moderately permeable soils on bottom land, in upland drainageways, and on foot slopes. These soils formed in silty and loamy alluvium. Slope ranges from 0 to 5 percent.

Coland soils are similar to Calco soils and are adjacent to Blue Earth, Calco, Millington, and Spillville soils. Calco and Millington soils are calcareous. Blue Earth soils formed in coprogenous earth. They are in depressions. Millington and Spillville soils contain more sand and less clay in the solum than the Coland soils. Millington soils are adjacent to stream channels, and Spillville soils are on the slightly higher bottom land above the Coland soils.

Typical pedon of Coland silty clay loam, 0 to 2 percent slopes, in an area of cropland; 2,070 feet north and 120 feet east of the southwest corner of sec. 34, T. 98 N., R. 37 W.

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

A1—7 to 15 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 parting to weak very fine subangular blocky and granular; friable; neutral; gradual smooth boundary.

A2—15 to 24 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 and very fine subangular blocky structure; friable; neutral; gradual wavy boundary.

A3—24 to 36 inches; very dark gray (10YR 3/1) clay loam, grayish brown (10YR 5/2) dry; black (10YR 2/1) coatings on faces of peds; few fine faint dark brown (7.5YR 3/2) mottles; weak fine prismatic and subangular blocky structure; friable; mildly alkaline; clear wavy boundary.

AC—36 to 43 inches; very dark gray (10YR 3/1) loam, grayish brown (2.5Y 5/2) dry; black (10YR 2/1) coatings on faces of prisms; few fine distinct brown (10YR 4/3) mottles; weak fine prismatic structure; slight effervescence; mildly alkaline; clear wavy boundary.

C—43 to 60 inches; very dark gray (5Y 3/1) loam stratified with light gray (10YR 7/1) loamy sand and sand; massive; friable; few snail and clam shell fragments; slight effervescence; moderately alkaline.

The thickness of the solum ranges from about 36 to 48 inches. The thickness of the mollic epipedon and the depth to free carbonates are 36 inches or more.

The A horizon is neutral in hue or has hue of 10YR. It has value of 2 or 3 and chroma of 0 to 1. It generally is silty clay loam high in content of sand or is clay loam. In some pedons, however, it is loam in the upper 10 inches. The C horizon is neutral in hue or has hue of 2.5Y or 5Y. It has value of 2 to 5 and chroma of 0 to 2. It is dominantly clay loam, loam, sandy clay loam, or sandy loam. In some pedons, however, thin strata of loamy sand or sand are below the solum, most commonly below a depth of 48 inches.

Collinwood Series

The Collinwood series consists of somewhat poorly drained, slowly permeable soils on uplands. These soils formed in silty and clayey lacustrine sediments. Slope ranges from 1 to 3 percent.

Collinwood soils are adjacent to Collinwood Variant and Waldorf soils. Collinwood Variant soils are on the more convex slopes and are higher on the landscape than the Collinwood soils. Also, their B horizon is browner. Waldorf soils are on the more concave slopes and are lower on the landscape than the Collinwood soils. Also, their B horizon is more olive or grayish.

Typical pedon of Collinwood silty clay loam, 1 to 3 percent slopes, in an area of cropland; 1,975 feet south and 80 feet east of the northwest corner of sec. 19, T. 99 N., R. 37 W.

Ap—0 to 10 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; moderate fine and very fine granular structure; friable; medium acid; clear smooth boundary.

AB—10 to 15 inches; very dark gray (10YR 3/1) silty clay loam, gray (10YR 5/1) dry; moderate fine and very fine subangular blocky and granular structure; friable; few dark grayish brown (2.5Y 4/2) worm casts; slightly acid; gradual wavy boundary.

Bw1—15 to 20 inches; mottled dark grayish brown (2.5Y 4/2) and olive brown (2.5Y 4/4) silty clay loam; moderate fine and very fine subangular blocky structure; firm; common very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) worm casts; few very fine black accumulations (manganese oxide); slightly acid; gradual wavy boundary.

Bw2—20 to 26 inches; mottled light olive brown (2.5Y 5/4) and grayish brown (2.5Y 5/2) silty clay loam; moderate fine and very fine subangular blocky structure; firm; few very dark grayish brown (10YR 3/2) and very dark gray (10YR 3/1) worm casts; common very fine black accumulations (manganese oxide); slightly acid; gradual wavy boundary.

Bw3—26 to 34 inches; grayish brown (2.5Y 5/2) and light olive brown (2.5Y 5/4) silty clay; dark grayish brown (2.5Y 4/2) coatings on faces of peds; common fine distinct brownish yellow (10YR 6/6 and 6/8) mottles; moderate fine prismatic and subangular blocky structure; firm; common fine black accumulations (manganese oxide); neutral; gradual wavy boundary.

BC—34 to 40 inches; mottled grayish brown (2.5Y 5/2) and brownish yellow (10YR 6/6 and 6/8) silty clay loam; grayish brown (2.5Y 5/2) coatings on faces of peds; weak fine prismatic and subangular blocky structure; firm; common fine black accumulations (manganese oxide); neutral; clear wavy boundary.

Cg1—40 to 52 inches; light brownish gray (2.5Y 6/2) silty clay loam; common fine prominent reddish yellow (7.5YR 6/6 and 6/8) mottles; weak fine prismatic structure; friable; common fine black accumulations (iron and manganese oxides); common fine concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

2Cg2—52 to 60 inches; light brownish gray (2.5Y 6/2) silt loam that has a few thin sand lenses; common fine prominent brownish yellow (10YR 6/6 and 6/8) and reddish yellow (7.5YR 6/6 and 6/8) mottles; massive; friable; common fine black accumulations (iron and manganese oxides); common fine concretions and soft masses of lime; strong effervesence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 24 to 40 inches. The thickness of the mollic epipedon ranges from 14 to 24 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1. The B horizon is silty clay or silty clay loam. It has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 2 to 4. The mottles or mottled colors in the lower part of this horizon have chroma of 2 to 8. The Cg horizon has value of 5 or 6 and chroma of 2 to 4. It is silty clay loam or silt loam. The 2Cg horizon is loam or silt loam and commonly has thin strata of coarser textures.

Collinwood Variant

The Collinwood Variant consists of well drained, moderately slowly permeable soils on upland ridgetops and side slopes. These soils formed in silty lacustrine sediments or in lacustrine sediments overlying loamy and sandy glacial drift. Slope ranges from 2 to 9 percent.

Collinwood Variant soils are adjacent to Collinwood and Waldorf soils. The adjacent soils are on concave slopes and are lower on the landscape than the Collinwood Variant soils. Also, their B horizon has lower chroma or is more olive.

Typical pedon of Collinwood Variant silty clay loam, 2 to 5 percent slopes, in an area of cropland; 985 feet east and 180 feet north of the southwest corner of sec. 2, T. 98 N., R. 36 W.

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

A—8 to 14 inches; very dark brown (10YR 2/2) and very dark grayish brown (10YR 3/2) silty clay loam, very dark brown (10YR 2/2) rubbed, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure parting to moderate fine and very fine granular; friable; slightly acid; gradual smooth boundary.

Bw1—14 to 20 inches; brown (10YR 4/3) and yellowish brown (10YR 5/4) silty clay loam; very dark grayish brown (10YR 3/2) coatings on faces of peds; weak fine subangular blocky structure parting to moderate very fine subangular blocky; friable; common very dark grayish brown (10YR 3/2) worm casts; slightly acid; gradual smooth boundary.

Bw2—20 to 26 inches; yellowish brown (10YR 5/4) silty clay loam; brown (10YR 4/3) coatings on faces of peds; weak fine prismatic structure parting to moderate fine and very fine subangular blocky; friable; few very dark grayish brown (10YR 3/2) worm casts and root channel fillings; slightly acid; gradual smooth boundary.

Bw3—26 to 34 inches; yellowish brown (10YR 5/4) silty clay loam; brown (10YR 4/3) coatings on faces of peds; weak fine prismatic structure parting to weak fine and very fine subangular blocky; friable; few very dark grayish brown (10YR 3/2) and brown (10YR 4/3) worm casts; slightly acid; gradual smooth boundary.

Bw4—34 to 40 inches; yellowish brown (10YR 5/4) silty clay loam; brown (10YR 4/3) coatings on faces of prisms; weak fine prismatic structure parting to weak fine subangular blocky; friable; neutral; gradual smooth boundary.

BC—40 to 45 inches; yellowish brown (10YR 5/4) silty clay loam; few brown (10YR 4/3) coatings on faces of prisms; few fine distinct light brownish gray (2.5Y 6/2), brownish yellow (10YR 6/8), and reddish yellow (7.5YR 6/8) mottles; weak fine prismatic structure; friable; neutral; clear smooth boundary.

C1—45 to 53 inches; light olive brown (2.5Y 5/4) silt loam; many fine distinct light brownish gray (2.5Y 6/2), brownish yellow (10YR 6/8), and reddish yellow (7.5YR 6/8) mottles; weak medium prismatic structure; friable; few fine black accumulations (iron and manganese oxides); strong effervescence; common fine soft lime masses; moderately alkaline; clear wavy boundary.

2C2—53 to 60 inches; light olive brown (2.5Y 5/4) loam; many fine distinct light brownish gray (2.5Y 6/2), brownish yellow (10YR 6/8), and reddish yellow (7.5YR 6/8) mottles; massive; friable; few fine black accumulations (iron and manganese oxides); slight effervescence; moderately alkaline.

The thickness of the solum ranges from 30 to 60 inches. The depth to free carbonates ranges from 30 to 54 inches. The thickness of the silty lacustrine sediments ranges from 36 to 60 inches. The thickness of the mollic epipedon ranges from 10 to 20 inches.

The A horizon has hue of 10YR, value of 2 or 3 (3 to 5 dry), and chroma of 1 to 3. The Bw horizon has hue of 10YR, value of 4 to 6, and chroma of 3 to 5. It dominantly is silty clay loam, but in some pedons part of this horizon is silty clay. The C horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 2 to 4. It is silty clay loam or silt loam. The 2C2 horizon is loam, sandy loam, or loamy sand and commonly has strata of these textures.

Crippin Series

The Crippin series consists of somewhat poorly drained, moderately permeable, calcareous soils in broad, smooth areas and on low knolls and ridges in the uplands. These soils formed in loamy glacial till. Slope ranges from 1 to 3 percent.

Crippin soils are similar to Fostoria and Nicollet soils and are adjacent to Canisteo, Harps, and Okoboji soils. Fostoria and Nicollet soils are not calcareous. Canisteo soils are on the more concave slopes and are lower on the landscape than the Crippin soils. Also, their B horizon is grayer or more olive. Harps soils contain more lime than the Crippin soils. They are on the rims of depressions below the Crippin soils. Okoboji soils are in depressions and are lower on the landscape than the Crippin soils. Also, their A horizon is thicker, and their solum is noncalcareous.

Typical pedon of Crippin loam, 1 to 3 percent slopes, in an area of cropland; 520 feet north and 75 feet east of the southwest corner of sec. 13, T. 98 N., R. 36 W.

Ap—0 to 7 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine granular structure; friable; strong effervescence; moderately alkaline; clear smooth boundary.

A1—7 to 13 inches; very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; black (10YR 2/1) coatings on faces of peds; weak fine subangular blocky and granular structure; friable; violent effervescence; moderately alkaline; gradual smooth boundary.

A2—13 to 16 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky structure; friable; common very dark gray (10YR 3/1) and dark grayish brown (2.5Y 4/2) worm casts; violent effervescence; moderately alkaline; clear smooth boundary.

BA—16 to 19 inches; dark grayish brown (2.5Y 4/2) loam; weak medium and fine subangular blocky structure; friable; many very dark grayish brown (10YR 3/2) worm casts; strong effervescence; moderately alkaline; gradual wavy boundary.

Bw1—19 to 24 inches; light olive brown (2.5Y 5/4) loam; few fine prominent light gray (10YR 6/1) and few fine distinct yellowish brown (10YR 5/6 and 5/8) mottles; weak medium and fine subangular blocky structure; friable; common very dark grayish brown (10YR 3/2) worm casts; strong effervescence; moderately alkaline; gradual wavy boundary.

Bw2—24 to 30 inches; light olive brown (2.5Y 5/4) loam; common fine prominent yellowish brown (10YR 5/6 and 5/8) mottles; weak medium and fine subangular blocky structure; friable; strong effervescence; moderately alkaline; gradual wavy boundary.

BC—30 to 35 inches; light olive brown (2.5Y 5/4) loam; common fine and medium prominent yellowish brown (10YR 5/6 and 5/8) mottles; weak fine subangular blocky structure; friable; few fine black accumulations (manganese oxide); few fine strong brown (7.5YR 5/6) accumulations (iron oxide); common fine concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

C1—35 to 46 inches; light olive brown (2.5Y 5/4) and yellowish brown (10YR 5/4) loam; common medium and fine distinct light brownish gray (2.5Y 6/2) and few medium distinct yellowish brown (10YR 5/6 and 5/8) mottles; massive; friable; common medium and fine black accumulations (iron and manganese oxides); common medium and fine concretions and soft masses of lime; strong effervescence; moderately alkaline; diffuse wavy boundary.

C2—46 to 60 inches; light olive brown (2.5Y 5/4) loam; many medium and coarse distinct light brownish gray (2.5Y 6/2) and common medium distinct yellowish brown (10YR 5/6 and 5/8) mottles; massive; friable; common medium and fine strong brown (7.5YR 5/6) accumulations (iron oxide); few fine black accumulations (iron and manganese oxides); common medium and coarse concretions and soft masses of lime; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 20 to 40 inches. The thickness of the mollic epipedon ranges from 14 to 24 inches.

The A horizon is neutral in hue or has hue of 10YR. It has value of 2 or 3 and chroma of 0 to 2. It is mildly alkaline or moderately alkaline. It is dominantly loam, but the range includes clay loam.

The upper part of the B horizon has hue of 10YR or 2.5Y, value of 3 or 4, and chroma of 1 or 2. The lower part has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 to 4. It has mottles with value of 4 or more and chroma of 2 to 8. It typically is loam, but the range includes clay loam.

The C horizon has hue of 10YR or 2.5Y, value of 4 or 5, and chroma of 2 to 4. It has mottles similar to those in the lower part of the B horizon and has accumulations with hue of 10YR or 7.5YR, value of 5 or 6, and chroma of 6 to 8. It typically is loam, but the range includes clay loam.

Cylinder Series

The Cylinder series consists of somewhat poorly drained soils on stream terraces and in glacial outwash areas. These soils formed in loamy alluvium over sand and gravel. Permeability is moderate in the solum and very rapid in the substratum. Slope ranges from 0 to 2 percent.

Cylinder soils are similar to Cylinder Variant soils and commonly are adjacent to Biscay, Cylinder Variant, Talcot, and Wadena soils. Cylinder Variant soils are calcareous. They are in positions on the landscape similar to those of the Cylinder soils. Biscay and Talcot soils are on the more concave slopes and are lower on the landscape than the Cylinder soils. Also, their B horizon is grayer. Wadena soils are on convex slopes and are higher on the landscape than the Cylinder soils. Also, their B horizon is browner.

Typical pedon of Cylinder loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes, in an area of cropland; 1,910 feet east and 260 feet north of the southwest corner of sec. 9, T. 98 N., R. 38 W.

Ap—0 to 8 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak fine and very fine granular structure; friable; neutral; clear smooth boundary.

A—8 to 12 inches; very dark gray (10YR 3/1) loam, dark grayish brown (10YR 4/2) dry; black (10YR 2/1) coatings on faces of peds; weak fine and very fine granular structure; friable; few black (10YR 2/1) worm casts; neutral; clear smooth boundary.

AB—12 to 15 inches; very dark grayish brown (2.5Y 3/2) and very dark gray (10YR 3/1) loam, grayish brown (2.5Y 5/2) dry; weak very fine subangular blocky and granular structure; friable; neutral; clear wavy boundary.

Bw—15 to 20 inches; dark grayish brown (2.5Y 4/2) and light olive brown (2.5Y 5/3) loam, dark grayish brown (2.5Y 4/2) rubbed; very dark grayish brown (2.5Y 3/2) coatings on faces of peds; weak fine and very fine subangular blocky structure; friable; few very dark gray (2.5Y 3/1) and very dark grayish brown (2.5Y 3/2) worm casts; neutral; gradual wavy boundary.

BC—20 to 26 inches; light olive brown (2.5Y 5/4) loam; very dark grayish brown (2.5Y 3/2) coatings on faces of peds; weak fine prismatic and subangular blocky structure; friable; common fine black accumulations (iron and manganese oxides); few fine soft masses of lime; slight effervescence; mildly alkaline; gradual wavy boundary.

2C1—26 to 31 inches; light olive brown (2.5Y 5/4) gravelly loamy sand; few fine distinct brownish yellow (10YR 6/6 and 6/8) mottles; single grained; loose; common fine black accumulations (iron and manganese oxides); slight effervescence; mildly alkaline; gradual wavy boundary.

2C2—31 to 60 inches; light yellowish brown (10YR 6/4), very pale brown (10YR 7/3), and light gray (2.5Y 7/2) gravelly coarse sand; few fine faint brownish yellow (10YR 6/6 and 6/8) mottles; single grained; loose; few fine yellowish red (5YR 5/8) accumulations (iron oxide); strong effervescence; moderately alkaline.

The thickness of the solum, or the depth to gravelly loamy sand or sand and gravel, ranges from 24 to 40 inches. The depth to free carbonates commonly is the same as the thickness of the solum, but in some pedons the lower part of the B horizon contains free carbonates. The thickness of the mollic epipedon ranges from 14 to 20 inches.

The A horizon has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 1 or 2. It is loam, clay loam, or silty clay loam.

The B horizon has hue of 2.5Y or 10YR, value of 4 or 5, and chroma of 2 to 4. It is clay loam or loam in the upper part and loam or sandy loam in the lower part. If the lower part is sandy loam, the content of clay is at least 18 percent or the sandy loam subhorizon is less than 5 inches thick. Some pedons have a 2BC horizon. This horizon is loamy coarse sand or loamy sand in which the content of gravel varies.

The 2C horizon has hue of 10YR or 2.5Y, value of 4 to 7, and chroma of 2 to 4. It is loamy sand, coarse sand, or the gravelly analogs of these textures. The content of gravel in this horizon ranges from 5 to 50 percent.

Cylinder Variant

The Cylinder Variant consists of somewhat poorly drained, calcareous soils on stream terraces and in glacial outwash areas. These soils formed in loamy material over sand and gravel. Permeability is moderate in the solum and very rapid in the substratum. Slope ranges from 0 to 2 percent.

Cylinder Variant soils are similar to Cylinder soils and commonly are adjacent to Biscay, Cylinder, and Talcot soils. Biscay and Cylinder soils are not calcareous. Cylinder soils are in positions on the landscape similar to those of the Cylinder Variant soils. Biscay and Talcot soils are on the more concave slopes and are lower on the landscape than the Cylinder Variant soils. Also, their B horizon is grayer.

Typical pedon of Cylinder Variant loam, 0 to 2 percent slopes, in an area of cropland; 300 feet east and 255 feet north of the southwest corner of sec. 9, T. 98 N., R. 38 W.

Ap—0 to 7 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; friable; about 5 percent gravel; strong effervescence; moderately alkaline; clear smooth boundary.

A—7 to 12 inches; black (10YR 2/1) and very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; weak fine and very fine granular structure; friable; about 5 percent gravel; strong effervescence; moderately alkaline; gradual smooth boundary.

AB—12 to 18 inches; very dark grayish brown (2.5Y 3/2) loam, grayish brown (2.5Y 5/2) dry; weak fine subangular blocky and granular structure; friable; common olive brown (2.5Y 4/4) and very dark gray (10YR 3/1) worm casts; about 5 percent gravel; strong effervescence; moderately alkaline; gradual wavy boundary.

Bw—18 to 22 inches; dark grayish brown (2.5Y 4/2) and light olive brown (2.5Y 5/4) sandy clay loam; weak fine and very fine subangular blocky structure; friable; about 10 percent gravel; strong effervescence; moderately alkaline; gradual wavy boundary.

BC—22 to 27 inches; light olive brown (2.5Y 5/4) gravelly sandy clay loam; common fine distinct olive yellow (2.5Y 6/6) mottles; very weak fine subangular blocky structure; very friable; about 20 percent gravel; strong effervescence; moderately alkaline; clear wavy boundary.

2C1—27 to 36 inches; light yellowish brown (2.5Y 6/4) and light brownish gray (2.5Y 6/2) gravelly loamy sand; single grained; loose; about 30 percent gravel; strong effervescence; moderately alkaline; clear wavy boundary.

2C2—36 to 60 inches; mottled light brownish gray (2.5Y 6/2) and brownish yellow (10YR 6/6 and 6/8) gravelly loamy sand and gravelly sand; single grained; loose; about 35 percent gravel; strong effervescence; moderately alkaline.

The thickness of the solum, or the depth to gravelly loamy sand or gravelly sand, commonly is 24 to 32 inches but ranges from 24 to 40 inches. Free carbonates commonly are throughout the solum, but in some pedons the lower part of the A horizon or part of the B horizon is not calcareous. The thickness of the mollic epipedon ranges from 14 to 20 inches.

The A horizon has hue of 10YR or 2.5Y, value of 2 or 3, and chroma of 1 or 2. It commonly has peds or worm casts with value of 4 and chroma of 2 to 4 in the lower part. It is loam or clay loam in which the content of gravel is as much as 10 percent.

The B horizon has hue of 2.5Y or 10YR, value of 4 to 6, and chroma of 2 or 3. It is loam or sandy clay loam. The 2B horizon, if it occurs, is gravelly sandy loam or gravelly loamy sand.

The 2C horizon has hue of 2.5Y of 10YR, value of 4 to 7, and chroma of 2 to 8. The higher chroma commonly is in the mottled colors. This horizon is loamy sand, sand, or the gravelly analogs of these textures. The content of gravel in this horizon ranges from 5 to 50 percent.

Dickman Series

The Dickman series consists of somewhat excessively drained soils on ridgetops, side slopes, and knolls in the uplands. These soils formed in loamy and sandy wind-reworked glacial outwash sediments. Permeability is moderately rapid in the upper part of the profile and rapid in the lower part. Slope ranges from 2 to 5 percent.

Dickman soils are similar to Estherville soils and are adjacent to Bolan and Ocheyedan soils. Estherville soils are loam in the upper part of the solum and contain gravel in the lower part. Bolan and Ocheyedan soils are on side slopes below the Dickman soils in some places and on ridgetops and side slopes above the Dickman soils in other places. Their A horizon typically is loam, and their B horizon is less sandy than that of the Dickman soils.

Typical pedon of Dickman fine sandy loam, 2 to 5 percent slopes, in an area of cropland; 1,860 feet east and 140 feet north of the southwest corner of sec. 31, T. 98 N., R. 38 W.

Ap—0 to 7 inches; very dark grayish brown (10YR 3/2) fine sandy loam, brown (10YR 5/3) dry; weak fine granular structure; friable; medium acid; clear smooth boundary.

AB—7 to 12 inches; very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) fine sandy loam, brown (10YR 5/3) dry; weak fine and very fine subangular blocky structure; very friable; medium acid; gradual wavy boundary.

Bw1—12 to 17 inches; dark yellowish brown (10YR 4/4) loamy fine sand; weak fine subangular blocky structure; very friable; medium acid; gradual wavy boundary.

Bw2—17 to 29 inches; yellowish brown (10YR 5/4) loamy fine sand; weak fine subangular blocky structure; very friable; slightly acid; gradual wavy boundary.

Bw3—29 to 37 inches; yellowish brown (10YR 5/4) loamy fine sand; weak fine subangular blocky structure; very friable; slightly acid; gradual wavy boundary.

BC—37 to 50 inches; light yellowish brown (10YR 6/4) loamy fine sand; weak medium subangular blocky structure; very friable; slightly acid; gradual wavy boundary.

C—50 to 60 inches; light yellowish brown (10YR 6/4) loamy sand; single grained; loose; neutral.

The thickness of the solum ranges from 30 to about 50 inches. The depth to free carbonates commonly is 60 inches or more. The thickness of the mollic epipedon ranges from 10 to 16 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is fine sandy loam or sandy loam. The B horizon has hue of 10YR, value of 3 or 4 in the upper part and 4 or 5 in the lower part, and chroma of 3 or 4. It is fine sandy loam, sandy loam, loamy sand, or loamy fine sand. It is neutral to medium acid. The BC and C horizons have hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 3 or 4. They are loamy fine sand, loamy sand, fine sand, or sand.

Estherville Series

The Estherville series consists of somewhat excessively drained soils on stream terraces and in glacial outwash areas. These soils formed in loamy material overlying sand and gravel (fig. 16). Permeability is moderately rapid in the upper part of the profile and rapid in the lower part. Slope ranges from 0 to 14 percent.

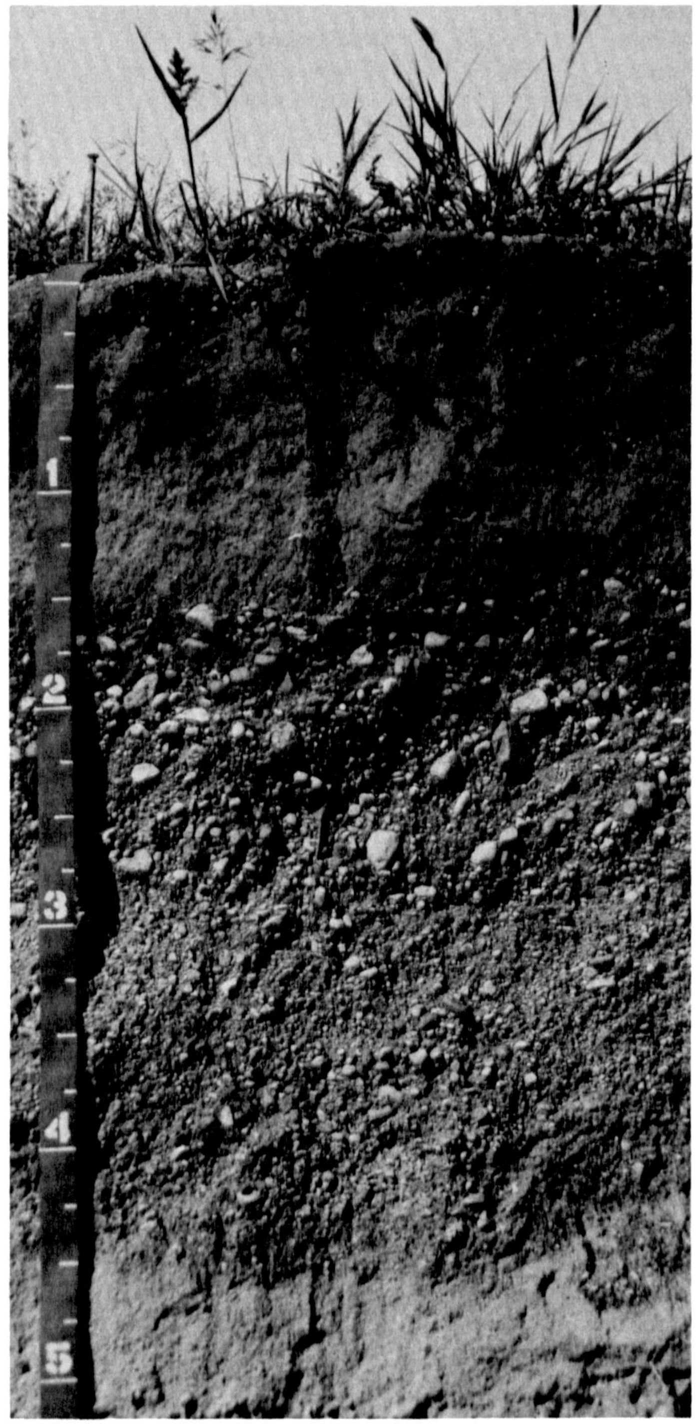


Figure 16.—Profile of Estherville loam. The finer textured material in the upper part of the profile is 15 to 24 inches thick. Depth is marked in feet.

Estherville soils are similar to Dickman soils and are adjacent to Salida and Wadena soils. Dickman soils have fine sandy loam or sandy loam in the upper part of the solum and do not have gravel in the lower part. Salida soils are calcareous in the A horizon or directly below it. They have a gravelly sandy loam or gravelly loamy sand A horizon. They are on the steeper slopes below the Estherville soils. Wadena soils are lower on the landscape than the nearly level Estherville soils and higher on the landscape than the gently sloping to strongly sloping Estherville soils. Also, they are deeper to the coarse textured substratum.

Typical pedon of Estherville loam, 2 to 5 percent slopes, in an area of cropland; 372 feet east and 720 feet south of the northwest corner of sec. 7, T. 99 N., R. 37 W.

Ap—0 to 7 inches; very dark gray (10YR 3/1) loam, gray (10YR 5/1) dry; weak fine and very fine granular structure; friable; medium acid; clear smooth boundary.

A—7 to 10 inches; very dark gray (10YR 3/1) loam, gray (10YR 5/1) dry; weak fine and very fine granular structure; friable; few brown (10YR 4/3) worm casts; medium acid; clear smooth boundary.

Bw1—10 to 14 inches; dark yellowish brown (10YR 4/4) sandy loam; weak fine and very fine subangular blocky structure; friable; common very dark gray (10YR 3/1) worm casts; about 10 percent gravel; slightly acid; gradual wavy boundary.

Bw2—14 to 18 inches; dark yellowish brown (10YR 4/4) gravelly sandy loam; weak fine and very fine subangular blocky structure; very friable; about 25 percent gravel; slightly acid; gradual wavy boundary.

2BC—18 to 26 inches; brown (7.5YR 4/4) gravelly loamy sand; weak medium and fine subangular blocky structure; very friable; about 30 percent gravel; neutral; gradual wavy boundary.

2C1—26 to 29 inches; yellowish brown (10YR 5/4) gravelly loamy sand; single grained; loose; about 40 percent gravel; sand, fine gravel, and lime cemented to the underside of the larger pebbles; strong effervescence; moderately alkaline; gradual wavy boundary.

2C2—29 to 60 inches; stratified yellowish brown (10YR 5/4 and 5/6), light brownish gray (10YR 6/2), strong brown (7.5YR 5/8), reddish yellow (7.5YR 6/8 and 5YR 6/8), and yellowish red (5YR 5/8) gravelly sand; single grained; loose; about 40 percent gravel; sand, fine gravel, and lime cemented to the underside of the larger pebbles; strong effervescence; moderately alkaline.

The thickness of the solum, the depth to gravelly loamy sand or gravelly sand, and the depth to free carbonates range from 15 to 24 inches. The thickness of the mollic epipedon ranges from 9 to 15 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is loam in which the content of clay is 18 to 25 percent.

The B horizon has hue of 10YR or 7.5YR and value and chroma of 3 or 4. In the upper part, it is sandy loam or loam in which the content of clay averages less than 18 percent. In the lower part it grades to gravelly loamy sand, gravelly sandy loam, or coarse sandy loam. It is neutral or slightly acid.

The 2C horizon has hue of 10YR, 7.5YR, or 5YR, value of 5 or 6, and chroma of 2 to 8. It typically is gravelly sand, gravelly loamy sand, or gravelly very coarse sand in which the content of gravel is 15 to 45 percent. In some strata, however, the content of gravel is less than 10 or more than 50 percent.

Everly Series

The Everly series consists of well drained, moderately permeable soils on upland ridgetops and side slopes. These soils formed in loamy sediments and in the underlying glacial till. Slope ranges from 0 to 9 percent.

Everly soils are similar to Clarion, Ocheyedan, and Sac soils and are adjacent to Letri and Wilmonton soils. The solum of Clarion soils contains less silt and clay than that of the Everly soils. Ocheyedan soils are stratified in the lower part of the solum. Sac soils formed partly in loess. They contain less sand in the upper part of the solum than the Everly soils. Letri soils have an olive or grayish B horizon. They are on the more concave slopes in drainageways below the Everly soils. Wilmonton soils are on the more concave slopes and are lower on the landscape than the Everly soils. Also, their B horizon has lower chroma or is more olive.

Typical pedon of Everly clay loam, 2 to 5 percent slopes, in an area of cropland; 2,495 feet west and 1,045 feet south of the northeast corner of sec. 31, T. 98 N., R. 36 W.

Ap—0 to 7 inches; black (10YR 2/1) clay loam, dark grayish brown (10YR 4/2) dry; weak fine and very fine granular structure; friable; slightly acid; clear smooth boundary.

A—7 to 11 inches; black (10YR 2/1) and very dark brown (10YR 2/2) clay loam, dark grayish brown (10YR 4/2) dry; moderate very fine subangular blocky and granular structure; friable; common black (10YR 2/1) worm casts; neutral; gradual smooth boundary.

Bw1—11 to 17 inches; very dark grayish brown (10YR 3/2) and brown (10YR 4/3) clay loam, dark grayish brown (10YR 4/2) and brown (10YR 5/3) dry; black (10YR 2/1) coatings on faces of peds; weak fine subangular blocky structure parting to moderate very fine subangular blocky; friable; common black (10YR 2/1) worm casts; neutral; gradual wavy boundary.

Bw2—17 to 23 inches; dark yellowish brown (10YR 4/4) clay loam; very dark grayish brown (10YR 3/2) and brown (10YR 4/3) coatings on faces of peds; weak fine prismatic structure parting to moderate very fine subangular blocky; friable; few black (10YR 2/1) and very dark grayish brown (10YR 3/2) worm casts; mildly alkaline; clear wavy boundary.

Bw3—23 to 29 inches; dark yellowish brown (10YR 4/4) clay loam; few fine distinct brownish yellow (10YR 6/6 and 6/8) and gray (10YR 6/1) mottles; weak fine prismatic and subangular blocky structure; friable; few very dark grayish brown (10YR 3/2) and brown (10YR 4/3) worm casts; few fine and medium concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

2BC—29 to 36 inches; yellowish brown (10YR 5/4) loam; many fine and medium distinct brownish yellow (10YR 6/6 and 6/8) and light gray (10YR 6/1) and few very fine prominent yellowish red (5YR 5/8) mottles; weak fine prismatic structure; firm; few very fine black accumulations (manganese oxide); few fine and medium concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

2C1—36 to 48 inches; brownish yellow (10YR 6/6 and 6/8) and light gray (10YR 6/1) loam; few fine prominent yellowish red (5YR 5/8) mottles; weak fine prismatic structure; firm; few very fine black accumulations (manganese oxide); few fine concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

2C2—48 to 60 inches; brownish yellow (10YR 6/6 and 6/8) and yellowish brown (10YR 5/4) loam; many fine distinct light gray (10YR 6/1) and few fine prominent yellowish red (5YR 5/8) mottles; massive with angular blocks; firm; few very fine black accumulations (manganese oxide); few fine concretions and soft masses of lime; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 26 to 40 inches. Free carbonates commonly are in the lower part of the B horizon or in the 2B horizon. The depth to glacial till ranges from 18 to 36 inches. In some pedons a thin stone line or pebble band is between the loamy sediments and the glacial till. The lower part of the solum has a few coarse fragments. The thickness of the mollic epipedon ranges from 10 to 20 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. The Bw2 horizon has hue of 10YR, value of 4 or 5, and chroma of 3 or 4. It commonly is clay loam, but it is loam in some pedons. The 2B and 2C horizons are loam or clay loam. They generally have hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 3 or 4. The mottles or mottled colors in these horizons commonly have higher or lower chroma.

Fostoria Series

The Fostoria series consists of somewhat poorly drained, moderately permeable soils on uplands. These soils formed in loamy glacial outwash material. Slope ranges from 1 to 3 percent.

Fostoria soils are similar to Crippin, Nicollet, and Wilmonton soils and are adjacent to Bolan, Ocheyedan, and Wilmonton soils. Crippin soils are calcareous. Nicollet soils have coarse fragments in the solum. Wilmonton soils formed in silty sediments and in the underlying glacial till. They have coarse fragments in the lower part of the solum and contain more clay in the solum than the Fostoria soils. Also, they generally are lower on the landscape. Bolan soils are on ridges and side slopes and are higher on the landscape than the Fostoria soils. Also, the lower part of their B horizon and the C horizon contain more sand. Ocheyedan soils are on the more convex slopes and are higher on the landscape than the Fostoria soils. Also, their B horizon is browner.

Typical pedon of Fostoria loam, 1 to 3 percent slopes, in an area of cropland; 465 feet north and 135 feet west of the southeast corner of sec. 35, T. 98 N., R. 38 W.

Ap—0 to 7 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak fine subangular blocky and granular structure; friable; neutral; clear smooth boundary.

A1—7 to 13 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to weak very fine subangular blocky and granular; friable; neutral; gradual smooth boundary.

A2—13 to 17 inches; black (10YR 2/1) loam, dark grayish brown (10YR 4/2) dry; weak medium and fine subangular blocky structure; friable; few very dark grayish brown (2.5Y 3/2) worm casts; neutral; clear smooth boundary.

A3—17 to 20 inches; very dark grayish brown (2.5Y 3/2) loam, grayish brown (2.5Y 5/2) dry; weak medium subangular blocky structure parting to weak fine and very fine subangular blocky; friable; common dark grayish brown (2.5Y 4/2) worm casts; neutral; clear smooth boundary.

Bw1—20 to 24 inches; dark grayish brown (2.5Y 4/2) and light olive brown (2.5Y 5/4) loam; weak fine prismatic and subangular blocky structure; friable; common very dark grayish brown (2.5Y 3/2) worm casts; few fine black accumulations (manganese oxide); few fine strong brown (7.5YR 5/6) stains (iron oxide); mildly alkaline; clear smooth boundary.

Bw2—24 to 28 inches; light olive brown (2.5Y 5/4) loam; few fine faint yellowish brown (10YR 5/6) mottles;

weak fine prismatic and subangular blocky structure; friable; few fine black accumulations (manganese oxide); mildly alkaline; gradual wavy boundary.

BC—28 to 31 inches; light olive brown (2.5Y 5/4) loam; common fine faint yellowish brown (10YR 5/6) mottles; weak fine prismatic structure parting to weak fine and very fine subangular blocky; friable; common fine black accumulations (manganese oxide); slight effervescence; mildly alkaline; clear wavy boundary.

C1—31 to 42 inches; light brownish gray (2.5Y 6/2) silt loam; common fine distinct yellowish brown (10YR 5/6 and 5/8) mottles; massive; friable; common fine black accumulations (manganese oxide); common medium and fine concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

C2—42 to 53 inches; olive gray (5Y 5/2) silt loam; common fine and medium distinct yellowish brown (10YR 5/6) mottles; massive; friable; few fine concretions and soft masses of lime; strong effervescence; moderately alkaline; abrupt smooth boundary.

2C3—53 to 60 inches; mottled yellowish brown (10YR 5/4) and light brownish gray (2.5Y 6/2) clay loam; common fine distinct strong brown (7.5YR 5/6 and 5/8) mottles; massive; friable; few fine and medium concretions and soft masses of lime; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 30 to 48 inches. The depth to free carbonates ranges from 24 to 48 inches. The thickness of the mollic epipedon ranges from 12 to 24 inches.

The A horizon is neutral in hue or has hue of 10YR. It has value of 2 or 3 and chroma of 0 to 3. It is neutral or slightly acid. It is dominantly loam, but the range includes both silt loam high in content of fine sand and clay loam.

The B horizon has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 2 to 4. It has mottles with chroma of 6 or 8 in the upper part and 2 to 6 in the lower part. It typically is loam, but in some pedons it is silt loam in the lower part.

The C horizon has hue of 5Y or 2.5Y, value of 5 or 6, and chroma of 2 to 4. It typically is silt loam, but the range includes loam and thin layers of sandy loam. The 2C horizon is loam or clay loam. The depth to this horizon ranges from 48 to more than 60 inches.

Harps Series

The Harps series consists of poorly drained, moderately permeable, calcareous soils on the narrow rims of upland depressions and on slight rises within flat outwash areas. These soils formed in loamy glacial till or in the local alluvium derived from till. Slope ranges from 0 to 2 percent.

Harps soils are similar to Canisteo soils and are adjacent to Canisteo, Crippin, and Okoboji soils. Canisteo and Crippin soils are not so calcareous as the Harps soils. Crippin soils are on low knolls and ridges and are higher on the landscape than the Harps soils. Also, their B horizon is browner. Canisteo soils are in swales above the Harps soils. Okoboji soils have a noncalcareous solum. They are in depressions below the Harps soils.

Typical pedon of Harps loam, 0 to 2 percent slopes, in an area of cropland; 820 feet east and 785 feet north of the center of sec. 23, T. 98 N., R. 35 W.

Apk—0 to 7 inches; black (10YR 2/1) loam, dark gray (10YR 4/1) dry; weak fine subangular blocky and granular structure; friable; violent effervescence; moderately alkaline; abrupt smooth boundary.

Ak1—7 to 16 inches; black (10YR 2/1) clay loam, gray (10YR 5/1) dry; weak medium subangular blocky structure parting to weak fine subangular blocky and granular; friable; strong effervescence; moderately alkaline; gradual smooth boundary.

Ak2—16 to 20 inches; very dark gray (10YR 3/1) clay loam, gray (10YR 6/1) dry; weak medium and fine subangular blocky structure; friable; strong effervescence; moderately alkaline; clear wavy boundary.

BAgk—20 to 25 inches; dark gray (5Y 4/1) clay loam; few fine prominent yellowish brown (10YR 5/6 and 5/8) mottles; weak fine subangular blocky structure; friable; strong effervescence; moderately alkaline; gradual wavy boundary.

Bgk1—25 to 32 inches; light olive gray (5Y 6/2) loam; about 10 percent dark gray (5Y 4/1) peds; common fine prominent yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6) mottles; weak medium and fine subangular blocky structure; friable; common fine black accumulations (manganese oxide); violent effervescence; moderately alkaline; gradual wavy boundary.

Bgk2—32 to 38 inches; light olive gray (5Y 6/2) loam; about 10 percent dark gray (5Y 4/1) peds; common fine prominent yellowish brown (10YR 5/6 and 5/8) and strong brown (7.5YR 5/6 and 5/8) mottles; weak medium and fine subangular blocky structure; friable; few very fine black accumulations (manganese oxide); strong effervescence; moderately alkaline; gradual wavy boundary.

Cg1—38 to 48 inches; mottled light olive gray (5Y 6/2), olive (5Y 5/3), and light olive brown (2.5Y 5/6) loam; common fine and medium prominent yellowish brown (10YR 5/6) and strong brown (7.5YR 5/6) mottles; massive; friable; common black accumulations (manganese oxide); strong effervescence; moderately alkaline; gradual wavy boundary.

Cg2—48 to 60 inches; grayish brown (2.5Y 5/2) loam; common medium and coarse prominent strong brown (7.5YR 5/6 and 5/8) and yellowish red (5YR 5/6 and 5/8) mottles; massive; friable; common black accumulations (manganese oxide); few fine concretions and soft masses of lime; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 30 to 48 inches. The thickness of the mollic epipedon ranges from about 10 to 24 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1. It is loam or clay loam. The B horizon has hue of 2.5Y or 5Y and chroma of 1 or 2. It is loam, clay loam, or sandy clay loam. The C horizon has colors similar to those in the B horizon, but colors with higher chroma are common, especially if the dominant colors are mottled.

Kingston Series

The Kingston series consists of somewhat poorly drained, moderately permeable soils on uplands. These soils formed in silty lacustrine sediments. Slope ranges from 1 to 3 percent.

Kingston soils are similar to Collinwood soils and are adjacent to Ocheyedan and Madelia soils. Collinwood soils contain more clay in the B horizon than the Kingston soils. Ocheyedan soils are on the more convex slopes and are higher on the landscape than the Kingston soils. Also, their B horizon is browner. Madelia soils are on the more concave slopes and are lower on the landscape than the Kingston soils. Also, their B horizon is grayer or more olive.

Typical pedon of Kingston silty clay loam, 1 to 3 percent slopes, in an area of cropland; 1,985 feet west and 105 feet south of the center of sec. 17, T. 98 N., R. 36 W.

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

A1—6 to 12 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine and very fine granular structure; friable; neutral; gradual smooth boundary.

A2—12 to 18 inches; very dark gray (10YR 3/1) and black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to weak fine and very fine granular; friable; few fine black accumulations (manganese oxide); neutral; gradual wavy boundary.

BA—18 to 25 inches; dark grayish brown (2.5Y 4/2) silty clay loam; very dark grayish brown (2.5Y 3/2) and dark grayish brown (2.5Y 4/2) coatings on faces of peds; weak fine and very fine subangular blocky structure; friable; common fine black accumulations (manganese oxide); neutral; gradual wavy boundary.

Bw1—25 to 33 inches; light olive brown (2.5Y 5/4) silt loam; few fine distinct light gray (10YR 6/1) and brownish yellow (10YR 6/6) mottles; weak medium subangular blocky structure parting to weak fine and very fine subangular blocky; friable; common fine black accumulations (manganese oxide); mildly alkaline; gradual smooth boundary.

Bw2—33 to 39 inches; light yellowish brown (2.5Y 6/4) silt loam; common fine distinct light gray (10YR 6/1) and brownish yellow (10YR 6/6) mottles; weak medium subangular blocky structure; friable; common fine black accumulations (manganese oxide); mildly alkaline; clear smooth boundary.

Cg—39 to 60 inches; light brownish gray (2.5Y 6/2) silt loam; common fine and medium brownish yellow (10YR 6/6) mottles; massive; friable; common fine black accumulations (manganese oxide); common fine concretions and soft masses of lime; strong effervescence; moderately alkaline.

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

The A horizon generally has hue of 10YR, value of 2 or 3, and chroma of 1, but in some pedons chroma is 2 in the lower part. This horizon is silty clay loam or silt loam. The B horizon has hue of 10YR or 2.5Y and value of 3 to 6. It has chroma of 2 in the upper part and 2 to 6 in the lower part. It is silty clay loam or silt loam. The Cg horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 2 to 4. It typically is silt loam, but in some pedons part or all of this horizon is silty clay loam.

Letri Series

The Letri series consists of poorly drained, moderately slowly permeable soils in broad till areas and swales on uplands. These soils formed in silty sediments and in the underlying glacial till. Slope is 0 to 1 percent.

Letri soils are similar to Webster soils and are adjacent to Everly and Wilmonton soils. Webster soils are friable in the lower part of the B horizon and in the C horizon. Everly and Wilmonton soils are higher on the landscape than the Letri soils. Also, their B horizon has higher chroma or browner hue.

Typical pedon of Letri silty clay loam, 0 to 1 percent slopes, in an area of cropland; 2,300 feet north and 150 feet west of the southeast corner of sec. 32, T. 98 N., R. 36 W.

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

A1—8 to 12 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure parting to moderate fine and very fine granular; friable; neutral; clear smooth boundary.

A2—12 to 20 inches; very dark gray (10YR 3/1) and black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to moderate very fine subangular blocky and granular; friable; few dark grayish brown (2.5Y 4/2) worm casts; neutral; gradual wavy boundary.

2Bg1—20 to 26 inches; olive gray (5Y 5/2) clay loam; common fine prominent brownish yellow (10YR 6/6 and 6/8) mottles; weak fine prismatic structure parting to weak fine and very fine subangular blocky; firm; few very dark gray (10YR 3/1) worm casts and root channels; common fine black accumulations (manganese oxide); few fine concretions and soft masses of lime; strong effervescence; moderately alkaline; clear wavy boundary.

2Bg2—26 to 32 inches; mottled light brownish gray (2.5Y 6/2) and brownish yellow (10YR 6/6 and 6/8) clay loam; weak medium and fine prismatic structure; firm; common fine black accumulations (manganese oxide); few fine concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

2C—32 to 60 inches; mottled brownish yellow (10YR 6/6 and 6/8) and light brownish gray (2.5Y 6/2) clay loam; massive; firm; common fine black accumulations (manganese oxide); few fine concretions and soft masses of lime; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 20 to 36 inches. The depth to free carbonates ranges from 16 to 30 inches. The thickness of the mollic epipedon ranges from 14 to 24 inches.

The A horizon is neutral in hue or has hue of 10YR, 2.5Y, or 5Y. It has value of 2 or 3 and generally has chroma of 0 or 1. In a few pedons, however, chroma is 2. In these pedons the hue is 5Y. This horizon is dominantly silty clay loam, but the range includes clay loam. The B horizon, if it occurs, has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. It is clay loam or silty clay loam. The 2B and 2C horizons have colors similar to those of the B horizon, but higher chroma is common in the mottles or mottled colors. These horizons are clay loam or loam.

Madelia Series

The Madelia series consists of poorly drained, moderately permeable soils in broad, plane areas and swales on uplands. These soils formed in stratified silty lacustrine sediments. Slope ranges from 0 to 2 percent.

Madelia soils are similar to Marcus soils and are adjacent to Kingston and Waldorf soils. Marcus soils contain more clay in the upper part of the solum than the Madelia soils. Kingston soils are higher on the landscape than the Madelia soils. Also, their B horizon has higher chroma or browner hue. Waldorf soils are in positions on the landscape similar to those of the Madelia soils. Their B horizon contains more clay than that of the Madelia soils.

Typical pedon of Madelia silty clay loam, 0 to 2 percent slopes, in an area of cropland; 810 feet north and 2,640 feet east of the southwest corner of sec. 18, T. 98 N., R. 36 W.

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

A—8 to 12 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky and moderate fine and very fine granular structure; friable; neutral; gradual smooth boundary.

AB—12 to 17 inches; very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine and very fine subangular blocky and granular structure; few dark grayish brown (2.5Y 4/2) worm casts; neutral; gradual smooth boundary.

Bg1—17 to 21 inches; dark gray (2.5Y 4/1) and grayish brown (2.5Y 5/2) silty clay loam; common fine distinct light olive brown (2.5Y 5/4) mottles; weak fine and very fine subangular blocky structure; friable; few very dark gray (2.5Y 3/1) worm casts; few fine black accumulations (manganese oxide); mildly alkaline; gradual wavy boundary.

Bg2—21 to 28 inches; grayish brown (2.5Y 5/2) silty clay loam; common fine prominent gray (10YR 6/1) and brownish yellow (10YR 6/6) mottles; weak medium and fine subangular blocky structure; friable; few very dark gray (2.5Y 3/1) and dark gray (2.5Y 4/1) worm casts; common fine black accumulations (manganese oxide); few fine and medium soft masses of lime; mildly alkaline; clear wavy boundary.

Cg1—28 to 32 inches; mottled olive (5Y 5/4) and gray (2.5Y 6/1) silty clay loam; common fine prominent brownish yellow (10YR 6/8) mottles; weak medium subangular blocky structure; friable; common fine black accumulations (manganese oxide); few fine concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

Cg2—32 to 43 inches; mottled gray (2.5Y 6/1) and light yellowish brown (2.5Y 6/4) stratified silt loam in which the content of sand increases with increasing depth; few fine distinct brownish yellow (10YR 6/8) mottles; massive; friable; common fine black accumulations (manganese oxide); few fine concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

Cg3—43 to 60 inches; gray (2.5Y 6/1) silty clay loam in which the content of sand varies; common fine prominent brownish yellow (10YR 6/6 and 6/8) and reddish yellow (7.5YR 6/6 and 6/8) mottles; massive; friable; common fine black accumulations (manganese oxide); few fine concretions and soft masses of lime; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 20 to 36 inches. It is the same as the depth to free carbonates in some pedons, but in other pedons free carbonates are in the lower few inches of the solum. The thickness of the mollic epipedon ranges from 15 to 24 inches.

The A horizon is neutral in hue or has hue of 10YR or 2.5Y. It has value of 2 or 3 and chroma of 0 or 1. It is silty clay loam or silt loam. The B horizon has hue of 2.5Y, value of 4 or 5, and chroma of 1 or 2 or has hue of 5Y and chroma as high as 3. It commonly has distinct or prominent mottles if chroma is 2 or 3. The Bg horizon is silty clay loam or silt loam. The Cg horizon has hue of 2.5Y or 5Y and value of 5 or 6. It is stratified silt loam or silty clay loam in which the content of sand varies.

Marcus Series

The Marcus series consists of poorly drained, moderately slowly permeable soils in drainageways and broad areas on uplands. These soils formed in loess. Slope ranges from 0 to 2 percent.

Marcus soils are similar to Madelia soils and are adjacent to Primghar, Ransom, and Sac soils. Madelia soils contain less clay in the upper part of the solum than the Marcus soils. Ransom soils formed in loess and in the underlying loamy glacial till. Primghar and Ransom soils are on the less concave slopes and are higher on the landscape than the Marcus soils. Also, their B horizon has higher chroma or browner hue. Sac soils are well drained. They are on convex slopes and are lower on the landscape than the Marcus soils. Also, their B horizon is browner.

Typical pedon of Marcus silty clay loam, 0 to 2 percent slopes, in an area of cropland; 1,280 feet west and 265 feet north of the southeast corner of sec. 18, T. 98 N., R. 37 W.

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

A1—8 to 12 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky structure parting to moderate fine and very fine granular; friable; slightly acid; gradual smooth boundary.

A2—12 to 16 inches; black (10YR 2/1) and very dark gray (10YR 3/1) silty clay loam, black (10YR 2/1) kneaded, dark gray (10YR 4/1) dry; black (N 2/0) coatings on faces of peds; few fine faint very dark grayish brown (2.5Y 3/2) mottles; weak fine subangular blocky structure parting to moderate very fine subangular blocky and granular; friable; neutral; gradual smooth boundary.

Bg1—16 to 21 inches; dark gray (2.5Y 4/1) and olive gray (5Y 5/2) silty clay loam, dark gray (2.5Y 4/1) kneaded, gray (2.5Y 5/1) and light brownish gray (2.5Y 6/2) dry; black (10YR 2/1) and very dark gray (10YR 3/1) coatings on faces of peds; weak fine subangular blocky structure parting to moderate very fine subangular blocky; friable; few fine black accumulations (manganese oxide); neutral; gradual smooth boundary.

Bg2—21 to 25 inches; olive gray (5Y 5/2) silty clay loam; common fine distinct light yellowish brown (2.5Y 6/4) and few fine prominent brownish yellow (10YR 6/6 and 6/8) mottles; weak fine prismatic structure parting to moderate fine and very fine subangular blocky; friable; common fine black accumulations (manganese oxide); neutral; gradual smooth boundary.

Bg3—25 to 32 inches; olive gray (5Y 5/2) silty clay loam; common fine distinct light yellowish brown (2.5Y 6/4) and common fine prominent brownish yellow (10YR 6/6 and 6/8) mottles; weak fine prismatic structure parting to weak fine subangular blocky; friable; common fine black accumulations (manganese oxide); neutral; gradual smooth boundary.

Bg4—32 to 40 inches; light olive gray (5Y 6/2) silt loam; common fine prominent brownish yellow (10YR 6/6 and 6/8) mottles; weak fine prismatic structure parting to weak fine subangular blocky; friable; common fine black accumulations (manganese oxide); mildly alkaline; gradual wavy boundary.

BCg—40 to 46 inches; light olive gray (5Y 6/2) silt loam; common fine prominent brownish yellow (10YR 6/6 and 6/8) and reddish yellow (7.5YR 6/6 and 6/8) mottles; weak fine prismatic structure; friable; common fine black accumulations (manganese oxide); few fine concretions and soft masses of lime; mildly alkaline; clear wavy boundary.

2Cg1—46 to 58 inches; light brownish gray (2.5Y 6/2) stratified loam, sandy loam, and loamy sand; many fine and medium distinct brownish yellow (10YR 6/6 and 6/8) mottles; massive; friable; few fine black accumulations (manganese oxide); few fine concretions and soft masses of lime; strong effervescence; moderately alkaline; clear wavy boundary.

2Cg2—58 to 60 inches; light brownish gray (2.5Y 6/2) clay loam; many fine distinct light yellowish brown (10YR 6/4) and few fine distinct reddish yellow (7.5YR 6/8 and 5YR 6/8) mottles; massive; friable; common fine black accumulations (manganese oxide); very fine concretions of lime; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 30 to 54 inches. The depth to free carbonates ranges from 24 to 48 inches. The thickness of the mollic epipedon ranges from 12 to 24 inches.

The A horizon is neutral in hue or has hue of 10YR. It has value of 2 or 3 and chroma of 0 or 1. It is silty clay loam in which the content of clay ranges from 34 to 38 percent. The Bg horizon has hue of 5Y or 2.5Y, value of 4 to 6, and chroma of 1 to 3. It generally is silty clay loam but in some pedons is silt loam in the lower part. It is neutral or mildly alkaline. The C horizon, if it occurs, and the 2C horizon have hue of 2.5Y or 5Y, value of 4 to 6, and chroma of 1 to 4. The 2C horizon dominantly is loam or clay loam but in most pedons has strata of coarser textures in the upper part. The depth to this horizon ranges from 40 to 60 inches.

Millington Series

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

Millington soils are adjacent to Calco, Coland, and Spillville soils. Calco soils contain more clay and less sand than the Millington soils. They generally are on the less channeled bottom land. Coland and Spillville soils have a noncalcareous solum. They are adjacent to upland side slopes.

Typical pedon of Millington loam, channeled, 0 to 2 percent slopes, in an area of pasture; 1,005 feet west and 240 feet north of the southeast corner of sec. 14, T. 98 N., R. 37 W.

A1—0 to 14 inches; very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; weak fine and very fine granular structure; friable; strong effervescence; mildly alkaline; gradual smooth boundary.

A2—14 to 21 inches; very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; few dark gray (10YR 4/1) lenses of loamy sand and sand; weak medium and fine granular structure; friable; strong effervescence; mildly alkaline; gradual smooth boundary.

Bw—21 to 34 inches; very dark gray (10YR 3/1) loam; few dark gray (10YR 4/1) lenses of loamy sand and sand; common fine distinct strong brown (7.5YR 5/6 and 5/8) mottles; weak very fine subangular blocky structure; friable; few snail shell fragments in the lower part; strong effervescence; mildly alkaline; gradual smooth boundary.

C1—34 to 42 inches; very dark gray (5Y 3/1) loam; few dark gray (10YR 4/1) lenses of loamy sand and sand; common fine and medium distinct strong brown (7.5YR 5/6 and 5/8) mottles; weak medium and fine subangular blocky structure; friable; few snail shell fragments; strong effervescence; mildly alkaline; gradual smooth boundary.

C2—42 to 48 inches; very dark gray (5Y 3/1) loam; few dark gray (10YR 4/1) lenses of sandy loam and loamy sand; common fine distinct strong brown (7.5YR 5/6 and 5/8) mottles; weak medium and fine subangular blocky structure; friable; common snail shell fragments; slight effervescence; mildly alkaline; clear smooth boundary.

C3—48 to 60 inches; dark gray (10YR 4/1) loamy sand; single grained; loose; few snail shells and snail shell fragments; slight effervescence; mildly alkaline.

The thickness of the solum ranges from about 24 to 40 inches. The thickness of the mollic epipedon ranges from 14 to 24 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It typically is loam, but subhorizons are silt loam or clay loam in some pedons. The C horizon is neutral in hue or has hue of 10YR to 5Y. It has chroma of 0 or 1. It ranges from clay loam to sandy loam.

Nicollet Series

The Nicollet series consists of somewhat poorly drained, moderately permeable soils in broad, smooth areas, in small drainageways, and on low knolls and ridges in the uplands. These soils formed in loamy glacial till. Slope ranges from 1 to 3 percent.

Nicollet soils are similar to Crippin, Fostoria, and Wilmonton soils and are adjacent to Clarion, Rolfe, and Webster soils. Crippin soils are calcareous. Fostoria soils do not have coarse fragments in the solum. Wilmonton soils do not have coarse fragments in the upper part of the solum. Clarion soils are on the more convex slopes and are higher on the landscape than the Nicollet soils. Also, their B horizon is browner. Rolfe soils are in depressions and are lower on the landscape than the Nicollet soils. Also, they have a B horizon that is grayer or more olive and have an E horizon. Webster soils are on the more concave slopes and are lower on the landscape than the Nicollet soils. Also, their B horizon is grayer or more olive.

Typical pedon of Nicollet loam, 1 to 3 percent slopes, in an area of cropland; 200 feet north and 230 feet east of the southwest corner of sec. 36, T. 99 N., R. 35 W.

Ap—0 to 7 inches; black (10YR 2/1) loam, dark grayish brown (10YR 4/2) dry; weak fine and very fine granular structure; friable; medium acid; clear smooth boundary.

A—7 to 13 inches; black (10YR 2/1) clay loam, dark grayish brown (10YR 4/2) dry; weak fine and very fine granular structure; friable; medium acid; gradual smooth boundary.

BA—13 to 18 inches; very dark grayish brown (2.5Y 3/2) and dark grayish brown (2.5Y 4/2) clay loam, grayish brown (2.5Y 5/2) dry; weak fine and very fine subangular blocky and granular structure; friable; few very fine brown (7.5YR 4/4) iron stains; slightly acid; gradual wavv boundary.

Bw1—18 to 22 inches; light olive brown (2.5Y 5/4) and dark grayish brown (2.5Y 4/2) loam; very dark grayish brown (2.5Y 3/2) coatings on faces of peds; few fine distinct brownish yellow (10YR 6/6 and 6/8) mottles; weak fine and very fine subangular blocky structure; friable; few very dark grayish brown (2.5Y 3/2) worm casts; common fine black accumulations (manganese oxide); few very fine brown (7.5YR 4/4) iron stains; neutral; gradual wavy boundary.

Bw2—22 to 30 inches; light olive brown (2.5Y 5/4) loam; many fine faint light brownish gray (2.5Y 6/2) and common fine distinct brownish yellow (10YR 6/6 and 6/8) mottles; weak fine prismatic and subangular blocky structure; friable; common fine black accumulations (manganese oxide); few very fine brown (7.5YR 4/4) and strong brown (7.5YR 5/6) iron stains; neutral; clear wavy boundary.

BCg—30 to 36 inches; light brownish gray (2.5Y 6/2) and light yellowish brown (2.5Y 6/4) loam; common fine distinct brownish yellow (10YR 6/6 and 6/8) mottles; weak fine prismatic structure; friable; common fine black accumulations (manganese oxide); few very fine strong brown (7.5YR 5/6) iron stains; few fine and medium concretions and soft masses of lime; strong effervescence; mildly alkaline; gradual wavy boundary.

Cg1—36 to 44 inches; light brownish gray (2.5Y 6/2) loam; many fine distinct light yellowish brown (2.5Y 6/4) and common fine prominent brownish yellow (10YR 6/6 and 6/8) mottles; massive; friable; common fine black accumulations (manganese oxide); few very fine yellowish red (5YR 4/6) iron stains; common fine concretions and soft masses of lime; strong effervescence; moderately alkaline; diffuse wavy boundary.

Cg2—44 to 60 inches; light brownish gray (2.5Y 6/2) loam; many fine and medium prominent brownish yellow (10YR 6/6 and 6/8) mottles; massive; friable; common fine black accumulations (manganese oxide); few fine yellowish red (5YR 4/6) iron stains; common fine soft masses of lime; strong effervescence; moderately alkaline.

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

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is loam, clay loam, or silty clay loam high in content of sand.

The B horizon has hue of 10YR or 2.5Y, value of 3 to 6, and chroma of 2 to 4. It commonly has mottles or mottled colors with chroma of 2 to 8 in the lower part. It is loam, clay loam, or silty clay loam high in content of sand. It is slightly acid or netural in the upper part and neutral or mildly alkaline in the lower part.

The C horizon has hue of 10YR, 2.5Y, or 5Y and chroma of 2 to 4 and has higher or lower chroma in mottles or mottled colors. It is loam or clay loam.

Ocheyedan Series

The Ocheyedan series consists of well drained, moderately permeable soils on upland ridgetops and side slopes. These soils formed in loamy and silty sediments. Slope ranges from 0 to 5 percent.

Ocheyedan soils are similar to Clarion and Everly soils and are adjacent to Bolan, Dickman, Fostoria, and Kingston soils. Clarion soils have coarse fragments in the solum. Everly soils have coarse fragments in the lower part of the solum. Bolan and Dickman soils contain more sand and less clay than the Ocheyedan soils. Also, they generally are higher on the landscape. Fostoria and Kingston soils are lower on the landscape than the Ocheyedan soils. Also, their B horizon has lower chroma or is more olive.

Typical pedon of Ocheyedan loam, 2 to 5 percent slopes, in an area of cropland; 1,015 feet north and 130 feet east of the southwest corner of sec. 36, T. 98 N., R. 38 W.

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

A—10 to 15 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; black (10YR 2/1) coatings on faces of peds; weak fine and very fine subangular blocky and granular structure; friable; medium acid; gradual smooth boundary.

BA—15 to 20 inches; brown (10YR 4/3) loam, yellowish brown (10YR 5/4) dry; very dark grayish brown (10YR 3/2) and dark brown (10YR 3/3) coatings on faces of peds; weak fine and very fine subangular blocky structure; friable; medium acid; gradual smooth boundary.

Bw1—20 to 24 inches; brown (10YR 4/3) and yellowish brown (10YR 5/4) loam; weak fine and very fine subangular blocky structure; friable; slightly acid; gradual wavy boundary.

Bw2—24 to 30 inches; yellowish brown (10YR 5/4) loam; weak fine subangular blocky structure; friable; slightly acid; gradual wavy boundary.

Bw3—30 to 34 inches; yellowish brown (10YR 5/4) sandy loam; weak fine subangular blocky structure; very friable; slightly acid; clear wavy boundary.

Bw4—34 to 37 inches; yellowish brown (10YR 5/4) loam; weak fine subangular blocky structure; friable; slightly acid; clear wavy boundary.

BC—37 to 45 inches; light olive brown (2.5Y 5/3) silt loam; common fine faint yellowish brown (10YR 5/4) and light brownish gray (2.5Y 6/2) mottles; weak medium subangular blocky structure; friable; slightly acid; gradual wavy boundary.

C1—45 to 55 inches; light brownish gray (2.5Y 6/2) silt loam; common fine distinct brownish yellow (10YR 6/6 and 6/8) and reddish yellow (7.5YR 6/6 and 6/8) mottles; massive; friable; few fine black accumulations (manganese oxide); few fine concretions and soft masses of lime; strong effervescence in the lower 5 inches; mildly alkaline; clear wavy boundary.

C2—55 to 60 inches; yellowish brown (10YR 5/4) loam; common fine distinct gray (10YR 6/1), brownish yellow (10YR 6/6 and 6/8), and reddish yellow (7.5YR 6/6 and 6/8) mottles; massive; firm; common fine and medium concretions and soft masses of lime; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 38 to 48 inches. The thickness of the mollic epipedon ranges from 10 to 16 inches. The content of clay between depths of 10 and 40 inches is more than 18 percent.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is loam in which the content of clay ranges from 18 to 26 percent. The Bw horizon has hue of 10YR, value of 4 or 5, and chroma of 3 or 4. It is neutral or slightly acid. It commonly is loam, but in most pedons it has subhorizons of sandy loam or sandy clay loam. The C horizon has hue of 10YR or 2.5Y, value of 4 to 6, and chroma of 1 to 6. It is silt loam, loam, or sandy loam.

Okoboji Series

The Okoboji series consists of very poorly drained, moderately slowly permeable soils in upland depressions. These soils formed in local alluvial sediments derived from glacial till. Slope is 0 to 1 percent.

Okoboji soils are adjacent to Canisteo, Crippin, Harps, and Webster soils. Canisteo, Crippin, and Webster soils have an A horizon that is less than 24 inches thick. They are higher on the landscape than the Okoboji soils. Canisteo and Harps soils are calcareous. Harps soils are on the rims of depressions surrounding the Okoboji soils.

Typical pedon of Okoboji silty clay loam, 0 to 1 percent slopes, in an area of cropland; 2,630 feet north and 125 feet west of the southeast corner of sec. 24, T. 98 N., R. 35 W.

Ap—0 to 7 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky and granular structure; friable; neutral; clear smooth boundary.

A1—7 to 15 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak medium and fine subangular blocky structure; friable; neutral; gradual smooth boundary.

A2—15 to 23 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine prismatic and subangular blocky structure; friable; neutral; gradual wavy boundary.

A3—23 to 32 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine prismatic structure parting to weak fine and very fine subangular blocky; friable; neutral; gradual wavy boundary.

BA—32 to 38 inches; very dark gray (5Y 3/1) silty clay loam, gray (5Y 5/1) dry; weak fine prismatic and subangular blocky structure; friable; neutral; clear wavy boundary.

Bg—38 to 45 inches; gray (5Y 5/1) silty clay loam; about 10 percent very dark gray (5Y 3/1) peds; few fine and medium prominent yellowish brown (10YR 5/6 and 5/8) mottles; weak fine prismatic and subangular blocky structure; friable; few fine black accumulations (manganese oxide); neutral; gradual wavy boundary.

BCg—45 to 56 inches; gray (5Y 5/1) silty clay loam; common fine and medium prominent yellowish brown (10YR 5/6 and 5/8) and strong brown (7.5YR 5/6 and 5/8) mottles; weak medium and fine prismatic structure parting to weak fine subangular blocky; friable; few fine black accumulations (manganese oxide); neutral; gradual wavy boundary.

Cg—56 to 60 inches; olive gray (5Y 5/2) clay loam; common fine distinct yellowish brown (10YR 5/6 and 5/8) and strong brown (7.5YR 5/6 and 5/8) mottles; massive; friable; few fine black accumulations (manganese oxide); neutral.

The thickness of the solum ranges from 40 to 60 inches. The thickness of the mollic epipedon ranges from 24 to 48 inches.

The A horizon is neutral in hue or has hue of 10YR. It has value of 2 and chroma of 0 or 1. It is silty clay loam or mucky silt loam. The Bg horizon is neutral in hue or has hue of 5Y, 2.5Y, or 10YR. It has value of 2 to 5 and chroma of 0 to 2. It typically has mottles with value of 4 to 6 and chroma of 3 to 8. The Cg horizon has colors similar to those in the lower part of the Bg horizon. It commonly is silty clay loam, but the range includes strata of loam or clay loam.

Primghar Series

The Primghar series consists of somewhat poorly drained, moderately permeable soils on uplands. These soils formed in loess. Slope ranges from 0 to 4 percent.

Primghar soils are similar to Ransom soils and are adjacent to Marcus, Ransom, Sac, and Spicer soils.

Ransom and Sac soils formed in loess and in the underlying loamy glacial till, which contains coarse fragments. Ransom soils are on the more convex slopes. Sac soils are on the more convex slopes and are higher on the landscape than the Primghar soils. Also, their B horizon is browner. Marcus and Spicer soils are on the more concave slopes and are lower on the landscape than the Primghar soils. Also, their B horizon is grayer or more olive.

Typical pedon of Primghar silty clay loam, 2 to 4 percent slopes, in an area of cropland; 1,280 feet east and 150 feet north of the southwest corner of sec. 33, T. 98 N., R. 38 W.

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; friable; medium acid; clear smooth boundary.

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

A2—15 to 20 inches; black (10YR 2/1) and very dark grayish brown (2.5Y 3/2) silty clay loam, grayish brown (2.5Y 5/2) dry; black (10YR 2/1) coatings on faces of peds; weak fine subangular blocky and weak fine and very fine granular structure; friable; neutral; gradual wavy boundary.

BA—20 to 24 inches; dark grayish brown (2.5Y 4/2) and light olive brown (2.5Y 5/4) silty clay loam; very dark gray (10YR 3/1) coatings on faces of peds; weak fine and very fine subangular blocky structure; friable; common black (10YR 2/1) and very dark grayish brown (2.5Y 3/2) worm casts; few very fine strong brown (7.5YR 5/8) accumulations (iron oxide); neutral; gradual wavy boundary.

Bw1—24 to 29 inches; light olive brown (2.5Y 5/4) silty clay loam; very dark grayish brown (2.5Y 3/2) coatings on faces of peds; weak fine and very fine subangular blocky structure; friable; common very dark gray (2.5Y 3/1) and very dark grayish brown (2.5Y 3/2) worm casts; few very fine strong brown (7.5YR 5/8) and reddish yellow (7.5YR 6/8) accumulations (iron oxide); neutral; gradual wavy boundary.

Bw2—29 to 34 inches; light olive brown (2.5Y 5/4) silty clay loam; common fine distinct light gray (2.5Y 7/2) and brownish yellow (10YR 6/6 and 6/8) mottles; weak fine prismatic and subangular blocky structure; friable; few very dark gray (2.5Y 3/1) and very dark grayish brown (2.5Y 3/2) worm casts; mildly alkaline; clear wavy boundary.

BC—34 to 39 inches; mottled gray (10YR 5/1) and yellowish brown (10YR 5/6 and 5/8) silt loam; weak fine prismatic structure; friable; common very fine black accumulations (manganese oxide); common fine concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

C1—39 to 48 inches; mottled gray (10YR 5/1) and brownish yellow (10YR 6/6 and 6/8) silt loam; massive; friable; common very fine black accumulations (manganese oxide); few fine concretions and soft masses of lime; strong effervescence; moderately alkaline; clear wavy boundary.

2C2—48 to 60 inches; mottled light gray (10YR 6/1) and brownish yellow (10YR 6/6 and 6/8) clay loam; massive; firm; common very fine black accumulations (manganese oxide); few fine concretions and soft masses of lime; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 30 to 50 inches. The depth to free carbonates ranges from 24 to 50 inches. The thickness of the mollic epipedon ranges from 16 to 24 inches.

The A horizon is neutral in hue or has hue of 10YR. It has value of 1 to 3 and chroma of 0 to 2.

The B horizon has hue of 10YR or 2.5Y. It has value of 4 or 5 and chroma of 2 in the upper part and value of 4 or 5 and chroma of 2 to 4 in the lower part. It commonly has mottles or mottled colors with chroma of 2 to 8. It is silty clay loam grading to silt loam with increasing depth. It is slightly acid or neutral in the upper part and mildly alkaline or moderately alkaline in the lower part.

The C horizon commonly has colors similar to those in the lower part of the B horizon. The 2C horizon typically is clay loam, but a gravelly loam or coarser textured layer 1 to 6 inches thick commonly is between the silt loam loess and the underlying glacial till. The depth to this horizon ranges from 40 to 54 inches.

Ransom Series

The Ransom series consists of somewhat poorly drained, moderately permeable soils on uplands. These soils formed in 24 to 40 inches of loess and in the underlying loamy glacial till. Slope ranges from 1 to 3 percent.

Ransom soils are similar to Primghar soils and are adjacent to Marcus, Primghar, Sac, and Spicer soils. Primghar soils formed in loess that is more than 40 inches thick. Marcus and Spicer soils are on the more concave slopes and are lower on the landscape than the Ransom soils. Also, their B horizon is grayer or more olive. Sac soils have a B horizon that is browner than that of the Ransom soils. They are well drained. They are on the convex slopes below the Ransom soils.

Typical pedon of Ransom silty clay loam, 1 to 3 percent slopes, in an area of cropland; 2,545 feet south and 150 feet west of the northeast corner of sec. 24, T. 98 N., R. 38 W.

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; moderate fine and very fine granular structure; friable; medium acid; clear smooth boundary.

A—7 to 16 inches; black (10YR 2/1) and very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to moderate very fine granular; friable; slightly acid; clear smooth boundary.

AB—16 to 20 inches; very dark grayish brown (2.5Y 3/2) silty clay loam, grayish brown (2.5Y 5/2) dry; weak fine and very fine subangular blocky structure; friable; few dark grayish brown (2.5Y 4/2) worm casts; neutral; gradual wavy boundary.

Bw1—20 to 24 inches; olive brown (2.5Y 4/4) silty clay loam; few fine distinct light brownish gray (2.5Y 6/2) and brownish yellow (10YR 6/6 and 6/8) mottles; weak fine and very fine subangular blocky structure; friable; few very dark grayish brown (2.5Y 3/2) and dark grayish brown (2.5Y 4/2) worm casts; few fine black accumulations (manganese oxide); neutral; gradual wavy boundary.

Bw2—24 to 30 inches; olive brown (2.5Y 4/4) silt loam; few fine distinct light brownish gray (2.5Y 6/2) and brownish yellow (10YR 6/6 and 6/8) mottles; weak fine and very fine subangular blocky structure; friable; few fine black accumulations (manganese oxide); mildly alkaline; clear wavy boundary.

2BC—30 to 36 inches; light olive brown (2.5Y 5/4) loam; common fine distinct light brownish gray (2.5Y 6/2) and brownish yellow (10YR 6/6 and 6/8) mottles; weak fine prismatic structure; firm; few fine black accumulations (manganese oxide); few fine concretions and soft masses of lime; strong effervescence; mildly alkaline; gradual wavy boundary.

2C—36 to 60 inches; light olive brown (2.5Y 5/4) clay loam; common fine distinct gray (10YR 6/1) and brownish yellow (10YR 6/6 and 6/8) mottles; few fine distinct reddish yellow (7.5YR 6/6 and 6/8) mottles below a depth of about 42 inches; massive; firm; few fine black accumulations (manganese oxide); few fine concretions and soft masses of lime; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 26 to 40 inches. The depth to free carbonates ranges from 22 to 36 inches. The thickness of the mollic epipedon ranges from 14 to 20 inches. The depth to glacial till ranges from 24 to 40 inches.

The A horizon has hue of 10YR, value of 2 to 4, and chroma of 1 or 2. It is silty clay loam in which the content of clay is 32 to 36 percent.

The upper part of the B horizon has hue of 2.5Y or 10YR, value of 4, and chroma of 2 or 3 and has mottles that have value of 4 or more and chroma of 2 or less. The Bw horizon commonly has value that increases to 5 or 6 with increasing depth and chroma that increases to 3 or 4. This horizon is silty clay loam or silt loam. It is slightly acid to mildly alkaline.

The 2C horizon has value of 5 or 6 and chroma of 2 to 6. It is loam or clay loam. In some pedons sandy or gravelly layers as much as 6 inches thick are between the loess and the loam or clay loam glacial till.

Rolfe Series

The Rolfe series consists of very poorly drained, slowly permeable soils in upland depressions. These soils formed in local alluvium derived from till. Slope is 0 to 1 percent.

Rolfe soils are adjacent to Nicollet, Waldorf, and Webster soils. None of the adjacent soils have a dark gray or gray E horizon. They are in the higher areas surrounding the Rolfe soils. Also, the solum of the Nicollet and Webster soils contains more sand and less clay than that of the Rolfe soils, and the A horizon of the Waldorf soils contains more clay.

Typical pedon of Rolfe silty clay loam, 0 to 1 percent slopes, in an area of cropland; 170 feet west and 160 feet south of the northeast corner of sec. 10, T. 98 N., R. 36 W.

Ap—0 to 10 inches; black (10YR 2/1) silty clay loam, grayish brown (10YR 5/2) dry; moderate very fine subangular blocky and granular structure; friable; few very fine reddish yellow (7.5YR 6/8) iron stains; slightly acid; clear smooth boundary.

E—10 to 17 inches; gray (10YR 5/1) silty clay loam, light gray (10YR 7/1) dry; common fine prominent brownish yellow (10YR 6/6 and 6/8) and reddish yellow (7.5YR 6/6 and 6/8) mottles; weak medium and fine platy structure; friable; medium acid; clear smooth boundary.

Btg1—17 to 21 inches; very dark gray (10YR 3/1) and grayish brown (10YR 5/2) silty clay, gray (10YR 5/1) and light gray (10YR 7/2) dry; very dark gray (10YR 3/1) coatings on faces of peds; common fine prominent reddish yellow (7.5YR 6/6 and 6/8) mottles; weak fine subangular blocky structure parting to strong very fine subangular blocky; firm; common thin clay films on faces of peds; common fine black accumulations (manganese oxide); medium acid; clear wavy boundary.

Btg2—21 to 26 inches; grayish brown (10YR 5/2) silty clay; dark gray (10YR 4/1) coatings on faces of peds; many fine and medium prominent reddish yellow (7.5YR 6/6 and 6/8) mottles; weak medium subangular blocky structure parting to strong fine and very fine subangular blocky; firm; common thin clay films on faces of peds; common fine black accumulations (manganese oxide); medium acid; gradual wavy boundary.

Btg3—26 to 31 inches; grayish brown (2.5Y 5/2) silty clay; dark gray (10YR 4/1) and gray (10YR 5/1) coatings on faces of peds; common fine prominent reddish yellow (7.5YR 6/6 and 6/8) mottles; weak fine prismatic structure parting to strong fine and very fine subangular blocky; firm; common thin clay films on faces of peds; common fine black accumulations (manganese oxide); medium acid; gradual wavy boundary.

Btg4—31 to 40 inches; gray (5Y 5/1) silty clay; common fine prominent brownish yellow (10YR 6/6 and 6/8) and reddish yellow (7.5YR 6/6 and 6/8) and few fine prominent strong brown (7.5YR 5/8) mottles; weak medium prismatic structure parting to moderate fine prismatic and subangular blocky; firm; few thin clay films on faces of peds; common fine black accumulations (manganese oxide); slighlty acid; gradual wavy boundary.

Btg5—40 to 46 inches; olive gray (5Y 5/2) silty clay; common fine prominent brownish yellow (10YR 6/6 and 6/8) and reddish yellow (7.5YR 6/6 and 6/8) and few fine prominent strong brown (7.5YR 5/8) mottles; weak medium prismatic structure parting to weak fine prismatic and subangular blocky; firm; common fine black accumulations (manganese oxide); slightly acid; gradual wavy boundary.

BCg—46 to 52 inches; olive gray (5Y 5/2) clay loam; common fine prominent brownish yellow (10YR 6/6 and 6/8) and reddish yellow (7.5YR 6/6 and 6/8) mottles; weak medium prismatic and fine angular blocky structure; firm; common fine black accumulations (manganese oxide); neutral; clear wavy boundary.

Cg—52 to 60 inches; light olive gray (5Y 6/2) and grayish brown (2.5Y 5/2) stratified clay loam, loam, and sandy loam; common fine prominent brownish yellow (10YR 6/6 and 6/8) and reddish yellow (7.5YR 6/6 and 6/8) mottles; massive; friable; common fine black accumulations (manganese oxide); neutral.

The thickness of the solum ranges from about 40 to 55 inches. The depth to free carbonates commonly is the same as the thickness of the solum but in some pedons is a few inches more. The thickness of the mollic epipedon ranges from 10 to 16 inches.

The A1 or Ap horizon has value of 2 or 3. It commonly is silt loam or silty clay loam but in a few pedons is loam. The E horizon has value of 4 or 5. It is silt loam or silty clay loam.

The Bt horizon has hue of 5Y, 2.5Y, or 10YR, value of 3 to 6, and chroma of 1 or 2. It commonly is silty clay or silty clay loam, but the range includes clay loam or loam in the lower part.

The Cg horizon has colors similar to those of the B horizon. It is dominantly loam or clay loam but in many pedons has strata of other textures below a depth of 4 feet.

Sac Series

The Sac series consists of well drained, moderately permeable soils on uplands. These soils formed in loess and in the underlying loamy glacial till. Slope ranges from 2 to 5 percent.

Sac soils are similar to Everly soils and are adjacent to Primghar, Marcus, and Ransom soils. Everly soils contain more sand in the A horizon and the upper part of the B horizon than the Sac soils. Marcus, Primghar, and Ransom soils have a B horizon that is grayer than that of the Sac soils. Also, they are lower on the landscape. Marcus soils are in drainageways, and Primghar and Ransom soils are on slightly concave slopes.

Typical pedon of Sac silty clay loam, 2 to 5 percent slopes, in an area of cropland; 270 feet south and 120 feet east of the northwest corner of sec. 7, T. 98 N., R. 38 W.

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine and very fine granular structure; friable; medium acid; clear smooth boundary.

AB—7 to 13 inches; very dark gray (10YR 3/1) silty clay loam, grayish brown (10YR 5/2) dry; weak very fine subangular blocky structure parting to weak very fine granular; friable; common brown (10YR 4/3) worm casts; slightly acid; gradual smooth boundary.

Bw1—13 to 19 inches; brown (10YR 4/3) and yellowish brown (10YR 5/4) silty clay loam; very dark gray (10YR 3/1) coatings on faces of peds; weak fine subangular blocky structure parting to weak very fine subangular blocky and granular; friable; few very dark gray (10YR 3/1) worm casts; slightly acid; gradual wavy boundary.

Bw2—19 to 25 inches; yellowish brown (10YR 5/4) silty clay loam; weak fine and very fine subangular blocky structure; friable; few very dark gray (10YR 3/1) and very dark grayish brown (10YR 3/2) worm casts; few very fine brownish yellow (10YR 6/6 and 6/8) iron stains; neutral; gradual wavy boundary.

Bw3—25 to 30 inches; yellowish brown (10YR 5/4) silt loam; few fine distinct light brownish gray (2.5Y 6/2) and few fine faint light yellowish brown (10YR 6/4) mottles; weak fine prismatic structure parting to weak fine subangular blocky; friable; few fine black accumulations (manganese oxide); neutral; clear wavy boundary.

2BC—30 to 40 inches; yellowish brown (10YR 5/4) loam; many fine distinct brownish yellow (10YR 6/6 and 6/8) and light gray (10YR 6/1) mottles; weak fine prismatic structure; firm; few fine black accumulations (manganese oxide); common fine and medium concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

2C—40 to 60 inches; light olive brown (2.5Y 5/4) loam; many fine distinct brownish yellow (10YR 6/6 and 6/8) and light gray (10YR 6/1) mottles; massive; firm; few fine black accumulations (manganese oxide) and few yellowish red (5YR 5/8) accumulations (iron oxide); few fine concretions and soft masses of lime; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 30 to 48 inches. Free carbonates are in the lower part of the B horizon in many pedons. The thickness of loess over the glacial till ranges from 24 to 40 inches. The thickness of the mollic epipedon ranges from 10 to 16 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 to 3. The Bw horizon has hue of 10YR, value of 4 to 6, and chroma of 3 or 4. It is slightly acid to mildly alkaline. It is dominantly silty clay loam but is silt loam in the lower part in pedons where glacial till is at a depth of more than 30 inches and in pedons on the more convex, upper side slopes and ridgetops. The 2C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 3 or 4. It commonly has high and low chroma mottles. It typically is loam but is clay loam in some pedons.

Salida Series

The Salida series consists of excessively drained, very rapidly permeable soils on upland side slopes and the edges of stream terraces and glacial outwash terraces. These soils formed in glacial outwash material. Slope ranges from 5 to 40 percent.

Salida soils are adjacent to Estherville and Wadena soils. The adjacent soils are higher on the landscape than the Salida soils. Also, their solum is thicker and finer textured.

Typical pedon of Salida gravelly sandy loam, 24 to 40 percent slopes, in an area of pasture; 1,335 feet south and 170 feet west of the northeast corner of sec. 26, T. 98 N., R. 37 W.

A1—0 to 3 inches; black (10YR 2/1) gravelly sandy loam, dark gray (10YR 4/1) dry; weak fine and very fine granular structure; friable; about 25 percent gravel; weak effervescence; moderately alkaline; clear smooth boundary.

A2—3 to 7 inches; black (10YR 2/1) gravelly loamy sand, dark gray (10YR 4/1) dry; weak fine granular structure; very friable; about 40 percent gravel; strong effervescence; moderately alkaline; gradual wavy boundary.

Bw—7 to 15 inches; dark yellowish brown (10YR 4/4) gravelly sand; single grained; loose; about 35 percent gravel; lime cemented to the underside of pebbles; strong effervescence; moderately alkaline; diffuse wavy boundary.

C—15 to 60 inches; dark yellowish brown (10YR 4/4) and yellowish brown (10YR 5/4) gravelly coarse sand; single grained; loose; about 45 percent gravel; few strong brown (7.5YR 5/6 and 5/8) and yellowish red (5YR 5/6 and 5/8) iron bands; lime cemented to the underside of pebbles in the upper 12 inches; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 7 to 20 inches. Free carbonates typically are in all horizons, but some pedons do not have free carbonates in the surface layer.

The A horizon is 7 to 10 inches thick. It has hue of 10YR, value of 2 or 3, and chroma of 1 to 3. It is gravelly sandy loam or gravelly loamy sand.

The Bw horizon is as much as 10 inches thick and occurs in most pedons. It has hue of 10YR and value and chroma of 3 or 4. It is gravelly loamy sand or gravelly sand. It commonly has lime coatings on the underside of pebbles, and in some pedons sand and fine gravel are cemented to the underside of the coarser pebbles by the lime.

The C horizon has hue of 10YR, value of 3 to 6, and chroma of 2 to 8. It is gravelly coarse sand, sand and gravel, or coarse sand. It typically has lime coatings on the underside of the larger pebbles in the upper 10 to 20 inches.

Spicer Series

The Spicer series consists of poorly drained, moderately permeable, calcareous soils on uplands. These soils formed in silty lacustrine sediments or in loess. Slope ranges from 0 to 2 percent.

Spicer soils are adjacent to Primghar and Ransom soils. The adjacent soils are noncalcareous in the upper part of the solum. They are on the more convex slopes and are higher on the landscape than the Spicer soils. Also, their B horizon is browner or is less mottled.

Typical pedon of Spicer silty clay loam, 0 to 2 percent slopes, in an area of cropland; 1,200 feet north and 200 feet east of the southwest corner of sec. 8, T. 98 N., R. 37 W.

Ap—0 to 7 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak very fine granular structure; friable; strong effervescence; moderately alkaline; clear smooth boundary.

A1—7 to 11 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; friable; few snail shell fragments; strong effervescence; moderately alkaline; gradual smooth boundary.

A2—11 to 15 inches; very dark gray (10YR 3/1) and black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) and gray (10YR 5/1) dry; black (10YR 2/1) coatings on faces of peds; weak fine and very fine subangular blocky structure; friable; few snail shell fragments; strong effervescence; moderately alkaline; gradual wavy boundary.

Bw—15 to 19 inches; dark gray (2.5Y 4/1) and grayish brown (2.5Y 5/2) silty clay loam; very dark gray (10YR 3/1) coatings on faces of peds; few fine distinct light yellowish brown (2.5Y 6/4), olive yellow (2.5Y 6/6), and brownish yellow (10YR 6/8) mottles; weak fine and very fine subangular blocky structure; friable; common black accumulations (manganese oxide); few snail shell fragments; strong effervescence; moderately alkaline; gradual wavy boundary.

Bg1—19 to 24 inches; grayish brown (2.5Y 5/2) silty clay loam; dark grayish brown (2.5Y 4/2) coatings on faces of peds; few fine prominent strong brown (7.5YR 5/8) and reddish yellow (7.5YR 6/8) mottles; weak fine prismatic structure parting to weak fine and very fine subangular blocky; friable; few very dark gray (10YR 3/1) worm casts; common black accumulations (manganese oxide); common very fine concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

Bg2—24 to 30 inches; olive gray (5Y 5/2) silty clay loam; common fine distinct brownish yellow (10YR 6/6 and 6/8) mottles; weak fine prismatic structure parting to weak fine subangular blocky; friable; few very dark gray (10YR 3/1) and dark grayish brown (2.5Y 4/2) channel fillings; common black accumulations (manganese oxide); common fine concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual smooth boundary.

Bg3—30 to 36 inches; olive gray (5Y 5/2) silt loam; common fine distinct brownish yellow (10YR 6/6 and 6/8) mottles; very weak fine prismatic structure; friable; few fine black accumulations (manganese oxide); common fine concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual smooth boundary.

Cg1—36 to 50 inches; light olive gray (5Y 6/2) silt loam in which the content of very fine sand is high; common fine distinct brownish yellow (10YR 6/6 and 6/8) mottles; massive; friable; few fine black accumulations (manganese oxide); few fine concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual smooth boundary.

Cg2—50 to 60 inches; mottled light olive gray (5Y 6/2) and brownish yellow (10YR 6/6 and 6/8) silt loam; massive; friable; few fine black accumulations (manganese oxide); few fine soft masses of lime; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 22 to 48 inches. The thickness of the mollic epipedon ranges from 12 to 24 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1. In some pedons it has mottles with higher value and chroma in the lower part. The B horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. It has mottles with higher value and chroma. It is silty clay loam or silt loam in which the content of clay ranges from 22 to 30 percent and that of sand coarser than very fine sand ranges from 5 to 15 percent. The C horizon has hue of 2.5Y or 5Y, value of 5 or 6, and chroma of 1 or 2. It has mottles with chroma of 3 to 8. It commonly is silt loam or silty clay loam but has coarser textured layers in some pedons.

Spillville Series

The Spillville series consists of somewhat poorly drained, moderately permeable soils on bottom land and foot slopes. These soils formed in loamy alluvium. Slope ranges from 0 to 5 percent.

Spillville soils are similar to Terril soils and are adjacent to Calco, Coland, Millington, and Terril soils. Terril soils have an A horizon that is thinner than that of the Spillville soils and have chroma of 3 within a depth of 30 to 36 inches. They are on foot slopes above the Spillville soils. Calco, Coland, and Millington soils are poorly drained and are on bottom land below the Spillville soils. Also, Coland soils contain more clay and less sand than the Spillville soils, and Calco and Millington soils are calcareous.

Typical pedon of Spillville loam, 0 to 2 percent slopes, in an area of cropland; 2,200 feet south and 290 feet east of the northwest corner of sec. 8, T. 99 N., R. 37 W.

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

A1—8 to 22 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky and granular structure; friable; neutral; gradual smooth boundary.

A2—22 to 34 inches; very dark gray (10YR 3/1) loam, dark gray (10YR 4/1) dry; weak medium and fine subangular blocky and granular structure; friable; neutral; gradual smooth boundary.

AC—34 to 42 inches; very dark gray (10YR 3/1) and very dark grayish brown (2.5Y 3/2) loam, gray (10YR 5/1) dry; weak medium and fine subangular blocky structure; friable; neutral; gradual smooth boundary.

C1—42 to 52 inches; dark grayish brown (2.5Y 4/2) loam; few olive brown (2.5Y 4/4) coatings on faces of peds; common fine and medium distinct light olive brown (2.5Y 5/6) mottles; massive; friable; few pebbles; common very fine soft masses of lime; slight effervescence; mildly alkaline; gradual smooth boundary.

C2—52 to 60 inches; olive brown (2.5Y 4/4) loam; common fine and medium distinct yellowish brown (10YR 5/4 and 5/6) mottles; massive; very friable; few pebbles; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 36 to 54 inches. The depth to free carbonates ranges from 42 to 60 inches. The thickness of the mollic epipedon ranges from 30 to more than 48 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly loam, but the range includes silt loam and clay loam. The C horizon dominantly has hue of 10YR or 2.5Y and value of 3 to 5. In some pedons it has value of 3 and chroma of 1. It is sandy loam, loam, or silt loam.

Storden Series

The Storden series consists of well drained, moderately permeable, calcareous soils on uplands. These soils formed in loamy glacial till. Slope ranges from 5 to 40 percent.

Storden soils are adjacent to Clarion and Terril soils. Clarion soils have noncalcareous A and Bw horizons. They are on the less convex slopes above the Storden soils. Terril soils have a noncalcareous solum and have a mollic epipedon that is at least 24 inches thick. They are on concave foot slopes and convex alluvial fans below the Storden soils.

Typical pedon of Storden loam, 9 to 14 percent slopes, moderately eroded, in an area of cropland; 1,485 feet south and 640 feet west of the northeast corner of sec. 4, T. 99 N., R. 38 W.

Ap—0 to 6 inches; dark grayish brown (10YR 4/2) loam, brown (10YR 5/3) dry; mixed with yellowish brown (10YR 5/4) and very dark grayish brown (10YR 3/2) streaks and pockets; weak medium and fine subangular blocky and granular structure; friable; few fine concretions and soft masses of lime; strong effervescence; mildly alkaline; abrupt smooth boundary.

C1—6 to 12 inches; yellowish brown (10YR 5/4 and 5/6) loam; massive; friable; common fine and medium black accumulations (manganese oxide); common fine and medium brownish yellow (10YR 6/8) and reddish yellow (7.5YR 6/8) iron stains; common fine and medium filaments, concretions, and soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

C2—12 to 24 inches; yellowish brown (10YR 5/6) loam; massive; friable; common fine black accumulations (manganese oxide); common fine and medium strong brown (7.5YR 5/8) and reddish yellow (7.5YR 6/6 and 6/8) iron stains; common fine and medium filaments, concretions, and soft masses of lime; strong effervescence; moderately alkaline; diffuse wavy boundary.

C3—24 to 34 inches; yellowish brown (10YR 5/4) loam; massive; friable; few fine black accumulations (manganese oxide); common fine and medium strong brown (7.5YR 5/8) and reddish yellow (7.5YR 6/6 and 6/8) iron stains; common fine filaments, concretions, and soft masses of lime; strong effervescence; moderately alkaline; diffuse wavy boundary.

C4—34 to 60 inches; light olive brown (2.5Y 5/4) loam; few fine distinct yellowish brown (10YR 5/6 and 5/8) mottles; massive; friable; few fine black accumulations (manganese oxide); common fine strong brown (7.5YR 5/8) and reddish yellow (7.5YR 6/8) iron stains; common fine filaments, concretions, and soft masses of lime; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 5 to 14 inches. The A horizon dominantly has hue of 10YR, value of 4 or 5, and chroma of 2 or 3, but in some pedons it has value of 3 to a depth of as much as 5 inches. The AB horizon, if it occurs, is as much as 4 inches thick. It has hue of 10YR, value of 4, and chroma of 3 or 4. The C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 2 to 6. If a lower chroma occurs, it is in the upper part of this horizon. The lower part of this horizon has mottles with hue of 2.5Y, 10YR, or 7.5Y, value of 5 or 6, and chroma of 2 to 8.

Storden loam, 9 to 14 percent slopes, Storden loam, 14 to 18 percent slopes, and Storden loam, 18 to 40 percent slopes, are taxadjuncts to the Storden series because they have a mollic epipedon.

Talcot Series

The Talcot series consists of poorly drained, calcareous soils that are moderately permeable in the solum and rapidly permeable in the substratum. These soils are on stream terraces and glacial outwash terraces. They formed in silty and loamy material overlying sand and gravel. Slope ranges from 0 to 2 percent.

Talcot soils are similar to Biscay soils and are adjacent to Biscay, Cylinder, Cylinder Variant, and Wadena soils. Biscay soils are not calcareous in the A horizon or in the upper part of the B horizon. They are in positions on the landscape similar to those of the Talcot soils or are lower on the landscape. Cylinder, Cylinder Variant, and Wadena soils are on the more convex slopes and are higher on the landscape than the Talcot soils. Also, their B horizon is browner.

Typical pedon of Talcot silty clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes, in an area of cropland; 1,640 feet east and 190 feet north of the southwest corner of sec. 9, T. 98 N., R. 38 W.

Ap—0 to 8 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; friable; strong effervescence; moderately alkaline; clear smooth boundary.

A1—8 to 14 inches; black (10YR 2/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine and very fine granular structure; friable; strong effervescence; moderately alkaline; gradual smooth boundary.

A2—14 to 18 inches; black (10YR 2/1) and about 20 percent very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to moderate very fine subangular blocky and granular; friable; strong effervescence; moderately alkaline; gradual wavy boundary.

AB—18 to 24 inches; very dark gray (10YR 3/1) and dark grayish brown (2.5Y 4/2) clay loam, gray (10YR 5/1) and light brownish gray (2.5Y 6/2) dry, very dark gray (10YR 3/1) kneaded; few fine distinct light brownish gray (2.5Y 6/2) and few fine prominent brownish yellow (10YR 6/6 and 6/8) mottles; weak fine subangular blocky structure; friable; few snail shells and shell fragments; strong effervescence; moderately alkaline; gradual wavy boundary.

Bg—24 to 31 inches; olive gray (5Y 5/2) and dark grayish brown (2.5Y 4/2) clay loam; very dark gray (10YR 3/1) coatings on faces of peds; few fine distinct light brownish gray (2.5Y 6/2) and few fine prominent brownish yellow (10YR 6/6 and 6/8) mottles; weak fine prismatic and subangular blocky structure; friable; common fine black accumulations (manganese oxide); strong effervescence; moderately alkaline; clear wavy boundary.

BCg—31 to 35 inches; olive gray (5Y 5/2) loam in which the content of sand is high; few fine distinct light olive brown (2.5Y 5/4) and few fine prominent brownish yellow (10YR 6/6 and 6/8) mottles; weak fine prismatic structure; friable; about 10 percent gravel; common fine black accumulations (manganese oxide); strong effervescence; moderately alkaline; clear wavy boundary.

2C1—35 to 39 inches; yellowish brown (10YR 5/6) gravelly loamy sand; few fine distinct reddish yellow (7.5YR 6/6 and 6/8) mottles; single grained; loose; about 20 percent gravel; strong effervescence; moderately alkaline; clear wavy boundary.

2C2—39 to 45 inches; strong brown (7.5YR 5/8) loamy sand; single grained; loose; about 10 percent gravel; strong effervescence; moderately alkaline; clear wavy boundary.

2C3—45 to 52 inches; light brownish gray (2.5Y 6/2) gravelly sand; single grained; loose; about 20 percent gravel; strong effervescence; moderately alkaline; clear wavy boundary.

2C4—52 to 60 inches; pale brown (2.5Y 6/3) gravelly coarse sand; single grained; loose; about 30 percent gravel; strong effervescence; moderately alkaline.

The thickness of the solum, or the depth to the 2C horizon, ranges from 32 to 40 inches. The solum typically has free carbonates throughout, but in some pedons the lower part of the B horizon does not have free carbonates. The thickness of the mollic epipedon ranges from about 14 to 24 inches.

The A horizon is neutral in hue or has hue of 10YR, 2.5Y, or 5Y. It has value of 2 or 3 and chroma of 0 or 1. It is silty clay loam or clay loam. The B horizon has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. It commonly is clay loam or loam but in some pedons is sandy clay loam or sandy loam in the lower part. The 2C horizon commonly is stratified loamy sand, sand, coarse sand, or the gravelly analogs of these textures. The content of gravel in this horizon generally is 10 to 35 percent but in some strata is less than 10 percent. The strata vary widely in color and texture.

Terril Series

The Terril series consists of moderately well drained, moderately permeable soils on foot slopes, upland side slopes, and alluvial fans. These soils formed in local loamy alluvium derived from glacial till. Slope ranges from 2 to 9 percent.

Terril soils are similar to Spillville soils and are adjacent to Spillville and Storden soils. Spillville soils have a mollic epipedon that is 30 to more than 48 inches thick and have chroma of less than 3 in the lower part of the solum. They are on bottom land and in drainageways below the Terril soils. Storden soils are on side slopes and are higher on the landscape than the Terril soils. Also, their A horizon and solum are thinner.

Typical pedon of Terril loam, 2 to 5 percent slopes, in an area of cropland; 2,225 feet west and 850 feet south of the northeast corner of sec. 17, T. 98 N., R. 35 W.

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

A1—10 to 14 inches; black (10YR 2/1) loam, very dark gray (10YR 3/1) dry; weak fine and very fine granular structure; friable; slightly acid; gradual smooth boundary.

A2—14 to 24 inches; black (10YR 2/1) and very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) dry; weak fine and very fine subangular blocky and granular structure; friable; slightly acid; gradual wavy boundary.

BA—24 to 30 inches; very dark grayish brown (10YR 3/2) loam, dark grayish brown (10YR 4/2) and brown (10YR 5/3) dry; black (10YR 2/1) coatings on faces of peds; weak fine and very fine subangular blocky and granular structure; friable; slightly acid; gradual wavy boundary.

Bw1—30 to 37 inches; brown (10YR 4/3) and dark yellowish brown (10YR 4/4) clay loam; very dark grayish brown (10YR 3/2) coatings on faces of peds; weak medium and fine subangular blocky structure; friable; slightly acid; gradual wavy boundary.

Bw2—37 to 41 inches; dark yellowish brown (10YR 4/4) clay loam; brown (10YR 4/3) coatings on faces of peds; weak fine prismatic and subangular blocky structure; friable; neutral; gradual wavy boundary.

BC—41 to 46 inches; dark yellowish brown (10YR 4/4) loam; weak fine prismatic structure; friable; few very fine yellowish red (5YR 4/6) accumulations (iron oxide); neutral; clear wavy boundary.

C1—46 to 56 inches; yellowish brown (10YR 5/4) loam; few fine distinct light brownish gray (2.5Y 6/2) mottles; massive; friable; few fine yellowish red (5YR 4/6) accumulations (iron oxide); common fine and medium concretions and soft masses of lime; slight effervescence; moderately alkaline; diffuse wavy boundary.

C2—56 to 60 inches; light olive brown (2.5Y 5/4) loam; many fine distinct light brownish gray (2.5Y 6/2) mottles; massive; friable; few fine yellowish red (5YR 4/6) accumulations (iron oxide); common fine and medium concretions and soft masses of lime; slight effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 36 to 60 inches. The thickness of the mollic epipedon ranges from 24 to 36 inches.

The A horizon has hue of 10YR or 2.5Y. It has value of 2 and chroma of 1 or 2 in the upper part and value of 2 or 3 and chroma of 3 in the lower part. It is dominantly loam, but the range includes silt loam high in content of sand. The BC horizon is below a depth of 40 inches. It has value of 4 and chroma of 3 or 4. It is loam or clay loam. It is neutral to moderately alkaline. The C horizon is loam or clay loam glacial till or alluvium. It has hue of 10YR, value of 4 to 6, and chroma of 3 or 4. It has slight to strong effervescence.

Wadena Series

The Wadena series consists of well drained soils on stream terraces and glacial outwash plains. These soils formed in loamy material overlying sand and gravel. Permeability is moderate in the solum and rapid in the substratum. Slope ranges from 0 to 9 percent.

Wadena soils are similar to Bolan soils and are adjacent to Cylinder, Estherville, Salida, and Talcot soils. Bolan soils do not have gravel in the C horizon. Their B horizon contains less clay than that of the Wadena soils. Cylinder and Talcot soils are in concave areas and are lower on the landscape than the Wadena soils. Also, their B horizon is grayer and more olive. Estherville soils are on the more convex slopes and are lower on the landscape than the Wadena soils. Also, their B horizon is less clayey. Saldia soils contain more sand and gravel in the solum than the Wadena soils. They have a calcareous A horizon. They are on the edges of stream terraces or glacial outwash plains below the Wadena soils.

Typical pedon of Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes, in an area of cropland; 2,375 feet north and 185 feet east of the southwest corner of sec. 25, T. 98 N., R. 37 W.

Ap—0 to 7 inches; very dark brown (10YR 2/2) loam, dark grayish brown (10YR 4/2) dry; weak fine subangular blocky and granular structure; friable; medium acid; clear smooth boundary.

A—7 to 12 inches; very dark grayish brown (10YR 3/2) and very dark brown (10YR 2/2) loam, dark grayish brown (10YR 4/2) and brown (10YR 5/3) dry; weak fine subangular blocky and granular structure; friable; medium acid; clear smooth boundary.

AB—12 to 15 inches; very dark grayish brown (10YR 3/2) and brown (10YR 4/3) loam, brown (10YR 5/3) dry; weak medium and fine subangular blocky structure; friable; slightly acid; clear wavy boundary.

Bw1—15 to 20 inches; dark yellowish brown (10YR 4/4) clay loam; brown (10YR 4/3) coatings on faces of peds; weak medium and fine subangular blocky structure; friable; few very dark grayish brown (10YR 3/2) worm casts; slightly acid; gradual wavy boundary.

Bw2—20 to 24 inches; dark yellowish brown (10YR 4/4) loam; weak medium subangular blocky structure; friable; about 2 percent gravel; neutral; clear wavy boundary.

2BC—24 to 31 inches; brown (7.5YR 4/4) sandy loam; weak fine subangular blocky structure; very friable; about 3 percent gravel; neutral; gradual wavy boundary.

2C—31 to 60 inches; light yellowish brown (10YR 6/4) gravelly sand; single grained; loose; about 40 percent gravel; strong effervescence beginning at a depth of about 36 inches; lime cemented to the underside of the larger pebbles within a depth of 52 inches; moderately alkaline.

The thickness of the solum ranges from 24 to 40 inches. The depth to free carbonates ranges from 30 to 50 inches. The content of gravel ranges from 0 to 10 percent in the loamy mantle and from 5 to 45 percent in the underlying material. The thickness of the mollic epipedon ranges from about 12 to 20 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is loam or clay loam.

The Bw horizon has hue of 10YR in the upper part and 10YR or 7.5YR in the lower part. It has value of 3 to 5 and chroma of 3 or 4. It is loam or clay loam in the upper part and loam or sandy loam in the lower part. If the lower part is sandy loam, the content of clay is at least 18 percent or the sandy loam subhorizon is less than 5 inches thick. In most gently sloping areas, the 2BC horizon is loamy coarse sand or loamy sand.

The 2C horizon has hue of 10YR or 7.5YR, value of 4 to 6, and chroma of 2 to 4. It commonly is stratified gravelly sand in which the content of gravel is 15 to 45 percent. In some strata, however, the content of gravel is less than 10 or more than 50 percent.

Waldorf Series

The Waldorf series consists of poorly drained, moderately slowly permeable soils in lacustrine areas on uplands. These soils formed in silty and clayey lacustrine sediments. Slope ranges from 0 to 2 percent.

Waldorf soils are similar to Madelia soils and are adjacent to Collinwood, Collinwood Variant, Madelia, and Rolfe soils. Madelia soils contain less clay in the B horizon than the Waldorf soils. They are in positions on the landscape similar to those of the Waldorf soils. Collinwood soils generally are more sloping than the Waldorf soils and are higher on the landscape. Also, their B horizon is less gray and less olive. Collinwood Variant soils have a brown and yellowish brown B horizon. They are higher on the landscape than the Waldorf soils. Rolfe soils have an E horizon. They are in depressions below the Waldorf soils.

Typical pedon of Waldorf silty clay loam, 0 to 2 percent slopes, in an area of cropland; 1,750 feet south and 125 feet west of the northeast corner of sec. 24, T. 99 N., R. 38 W.

Ap—0 to 10 inches; black (10YR 2/1) silty clay loam, very dark gray (10YR 3/1) dry; moderate fine and very fine angular blocky and subangular blocky structure; friable; slightly acid; clear smooth boundary.

AB—10 to 16 inches; very dark gray (10YR 3/1) silty clay, dark gray (10YR 4/1) dry; black (10YR 2/1) coatings on faces of peds; many fine distinct dark grayish brown (2.5Y 4/2) and few fine prominent yellowish brown (10YR 5/6 and 5/8) mottles; moderate very fine subangular blocky structure; firm; neutral; clear smooth boundary.

Bg1—16 to 22 inches; dark grayish brown (2.5Y 4/2) silty clay, gray (2.5Y 5/1) dry; very dark gray (10YR 3/1) and very dark grayish brown (2.5Y 3/2) coatings on faces of peds; common fine distinct yellowish brown (10YR 5/6 and 5/8) mottles; weak fine subangular blocky and moderate very fine subangular blocky structure; firm; few black (10YR 2/1) worm casts; few fine black accumulations (manganese oxide); neutral; gradual wavy boundary.

Bg2—22 to 28 inches; olive gray (5Y 5/2) silty clay; dark gray (5Y 4/1) coatings on faces of peds; common fine prominent yellowish brown (10YR 5/6 and 5/8) mottles; weak fine prismatic and subangular blocky structure parting to moderate very fine subangular blocky; firm; few very dark gray (10YR 3/1) worm casts; few fine black accumulations (manganese oxide); neutral; gradual wavy boundary.

Bg3—28 to 32 inches; olive gray (5Y 5/2) silty clay; olive gray (5Y 4/2) coatings on faces of peds; common fine and medium prominent yellowish brown (10YR 5/6 and 5/8) and strong brown (7.5YR 5/6 and 5/8) mottles; weak fine prismatic and subangular blocky structure; firm; few fine black accumulations (manganese oxide); neutral; clear wavy boundary.

Bg4—32 to 38 inches; olive gray (5Y 5/2) silty clay loam; gray (5Y 5/1) coatings on faces of peds; common fine and medium prominent yellowish brown (10YR 5/6 and 5/8) and strong brown (7.5YR 5/6 and 5/8) mottles; weak fine prismatic structure; friable; few fine black accumulations (manganese oxide); few fine soft masses of lime; strong effervescence; mildly alkaline; gradual wavy boundary.

Cg1—38 to 48 inches; olive gray (5Y 5/2) silty clay loam; gray (5Y 5/1) coatings on faces of peds; common fine and medium prominent yellowish brown (10YR 5/6 and 5/8) and strong brown (7.5YR 5/6 and 5/8) mottles; weak fine prismatic structure; friable; few fine black accumulations (manganese oxide); common fine and medium concretions and soft masses of lime; strong effervescence; moderately alkaline; diffuse wavy boundary.

Cg2—48 to 60 inches; olive gray (5Y 5/2) silty clay loam; gray (5Y 5/1) vertical cleavage planes; common fine and medium strong brown (7.5YR 5/6 and 5/8) mottles; massive; friable; few fine black accumulations (manganese oxide); common fine and medium concretions and soft masses of lime; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 30 to 60 inches. The depth to free carbonates ranges from 25 to 50 inches. The thickness of the mollic epipedon ranges from 16 to 24 inches.

The A horizon is neutral in hue or has hue of 10YR. It has value of 2 or 3 and chroma of 0 or 1. It is silty clay loam or silty clay. The Bg horizon has hue of 2.5Y or 5Y and has value of 3 or 4 in the upper part and 4 to 6 in the lower part. It typically has chroma of 1 or 2 but in mottles or mottled colors has chroma of 4 to 8. It is silty clay or silty clay loam in which the content of clay is lowest in the lower part. The C or 2C horizon has colors similar to those in the lower part of the Bg horizon. It is silty clay loam, silt loam, or loam.

Webster Series

The Webster series consists of poorly drained, moderately permeable soils in smooth till areas and swales on uplands. These soils formed in loamy glacial till or in local alluvium derived from till. Slope ranges from 0 to 2 percent.

Webster soils are similar to Letri soils and are adjacent to Canisteo, Clarion, Nicollet, Okoboji, and Rolfe soils. Letri soils are firm in the lower part of the B horizon and in the C horizon. Canisteo soils are calcareous. They are in positions on the landscape similar to those of the Webster soils. Clarion and Nicollet soils are higher on the landscape than the Webster soils. Also, their B horizon is browner. Okoboji and Rolfe soils are in depressions and are lower on the landscape than the Webster soils. Also, the A horizon of the Okoboji soils is thicker, and Rolfe soils have an E horizon.

Typical pedon of Webster silty clay loam, 0 to 2 percent slopes, in an area of cropland; 2,470 feet east and 330 feet north of the southwest corner of sec. 30, T. 100 N., R. 37 W.

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

A—7 to 12 inches; black (N 2/0) silty clay loam, very dark gray (10YR 3/1) dry; weak fine subangular blocky and moderate fine and very fine granular structure; friable; neutral; gradual smooth boundary.

AB—12 to 17 inches; very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; black (N 2/0) coatings on faces of peds; weak fine subangular blocky and moderate very fine subangular blocky and granular structure; friable; common dark grayish brown (2.5Y 4/2) and light olive brown (2.5Y 5/4) worm casts; few very fine prominent yellowish red (5YR 5/8) iron oxide stains; neutral; gradual wavy boundary.

Bg1—17 to 23 inches; mottled dark grayish brown (2.5Y 4/2) and light olive brown (2.5Y 5/4) silty clay loam; very dark gray (10YR 3/1) coatings on faces of peds; few fine distinct light brownish gray (2.5Y 6/2) and few fine prominent brownish yellow (10YR 6/6 and 6/8) and reddish yellow (7.5YR 6/6 and 6/8) mottles; weak fine and very fine subangular blocky structure; friable; common very fine black accumulations (manganese oxide); neutral; gradual wavy boundary.

Bg2—23 to 28 inches; grayish brown (2.5Y 5/2) clay loam; dark grayish brown (2.5Y 4/2) and grayish brown (2.5Y 5/2) coatings on faces of some peds; many fine and medium distinct brownish yellow (10YR 6/6 and 6/8) mottles; weak medium and fine subangular blocky structure; friable; few very dark gray (10YR 3/1) root channels; common very fine black accumulations (manganese oxide); neutral; gradual wavy boundary.

BCg—28 to 35 inches; light olive gray (5Y 6/2) clay loam; many fine and medium distinct brownish yellow (10YR 6/6 and 6/8) and reddish yellow (7.5YR 6/6 and 6/8) mottles; weak medium and fine subangular blocky structure; friable; common very fine black accumulations (manganese oxide); mildly alkaline; clear irregular boundary.

Cg1—35 to 48 inches; light olive gray (5Y 6/2) loam; many fine and medium distinct brownish yellow (10YR 6/6 and 6/8) mottles; massive; friable; common very fine black accumulations (manganese oxide); common fine soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

Cg2—48 to 60 inches; light olive gray (5Y 6/2) and brownish yellow (10YR 6/6 and 6/8) loam; few fine distinct reddish yellow (7.5Y 6/6 and 6/8) mottles; massive; friable; common very fine black accumulations (manganese oxide); few fine soft masses of lime; strong effervescence; moderately alkaline.

The thickness of the solum ranges from 24 to 40 inches. The depth to free carbonates is the same as the thickness of the solum or is as much as 6 to 8 inches less. The thickness of the mollic epipedon ranges from about 16 to 24 inches.

The A horizon is neutral in hue or has hue of 10YR. It has value of 2 or 3 and chroma of 0 or 1. It is clay loam or silty clay loam in which the content of sand is moderate. The B horizon dominantly has hue of 2.5Y or 5Y, value of 4 or 5, and chroma of 1 or 2. In most pedons, however, it has mottles or mottled colors with redder hue, value of 5 or 6, and chroma of 1 to 8. It is loam, clay loam, or silty clay loam.

Wilmonton Series

The Wilmonton series consists of somewhat poorly drained, moderately slowly permeable soils on uplands. These soils formed in silty sediments and in the underlying glacial till. Slope ranges from 1 to 3 percent.

Wilmonton soils are similar to Fostoria and Nicollet soils and are adjacent to Bolan, Everly, Fostoria, and Letri soils. Fostoria soils typically have a solum of loam and a C horizon of silt loam. Nicollet soils formed in glacial till and have coarse fragments in the solum. Bolan and Everly soils are on the more convex slopes and are higher on the landscape than the Wilmonton soils. Also, Bolan soils contain more sand, and Everly soils have a browner B horizon. Letri soils are in swales and are lower on the landscape than the Wilmonton soils. Also, their B horizon is grayer.

Typical pedon of Wilmonton silty clay loam, 1 to 3 percent slopes, in an area of cropland; 2,600 feet east and 85 feet south of the northwest corner of sec. 24, T. 98 N., R. 37 W.

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

A—8 to 12 inches; black (10YR 2/1) and very dark gray (10YR 3/1) silty clay loam, dark gray (10YR 4/1) dry; weak fine subangular blocky structure parting to moderate fine and very fine granular; friable; slightly acid; gradual smooth boundary.

AB—12 to 18 inches; very dark grayish brown (2.5Y 3/2) and very dark gray (10YR 3/1) silty clay loam, dark grayish brown (2.5Y 4/2) dry; black (10YR 2/1) coatings on faces of peds; weak fine subangular blocky structure parting to moderate very fine subangular blocky and granular; friable; common black (10YR 2/1) worm casts; neutral; gradual wavy boundary.

2Bw1—18 to 24 inches; dark grayish brown (2.5Y 4/2) clay loam; about 30 percent light olive brown (2.5Y 5/4) in the lower part; very dark grayish brown (2.5Y 3/2) coatings on faces of peds; weak fine subangular blocky structure parting to moderate very fine subangular blocky; friable; few black (10YR 2/1) and very dark gray (10YR 3/1) worm casts; few fine black accumulations (manganese oxide); neutral; clear wavy boundary.

2Bw2—24 to 30 inches; light olive brown (2.5Y 5/4) clay loam; dark grayish brown (2.5Y 4/2) coatings on faces of peds; few fine distinct yellowish brown (10YR 5/6) mottles; weak medium subangular blocky structure parting to weak fine and very fine subangular blocky; firm; few fine black accumulations (manganese oxide); mildly alkaline; clear wavy boundary.

2BC—30 to 36 inches; light olive brown (2.5Y 5/4) and brownish yellow (10YR 6/6) loam; weak medium subangular blocky structure; firm; few fine black accumulations (manganese oxide); few fine and medium concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

2C1—36 to 48 inches; light brownish gray (2.5Y 6/2) loam; common fine distinct brownish yellow (10YR 6/6) mottles; massive; firm; few fine black accumulations (manganese oxide); few fine strong brown (7.5YR 5/6) and yellowish red (5YR 5/6) iron stains; few fine and medium concretions and soft masses of lime; strong effervescence; moderately alkaline; gradual wavy boundary.

2C2—48 to 60 inches; mottled brownish yellow (10YR 6/6 and 6/8) and light brownish gray (2.5Y 6/2) loam; massive; firm; few fine black accumulations (manganese oxide); few fine concretions and soft masses of lime; strong effervescence; moderately alkaline.

The thickness of the solum and the depth to free carbonates range from 20 to 40 inches. The lower part of the solum commonly has free carbonates. The thickness of the mollic epipedon ranges from 14 to 22 inches.

The A horizon has hue of 10YR, value of 2 or 3, and chroma of 1 or 2. It is dominantly silty clay loam, but the range includes clay loam and loam. The Bw horizon is dominantly clay loam or silty clay loam but commonly grades to loam in the lower part. It has hue of 10YR or 2.5Y, value of 3 to 5, and chroma of 2 to 4. It has mottles with chroma of 2 to 8. In some pedons the upper part of this horizon has value of 4 and chroma of 2 and does not have mottles. The 2C horizon has hue of 10YR or 2.5Y, value of 5 or 6, and chroma of 2 to 4. The mottled colors or mottles in this horizon have chroma of 2 to 8.

Formation of the Soils

This section describes the major factors of soil formation and relates them to the soils in Dickinson County. It also explains some of the processes of horizon development.

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 properties and the chemical and mineralogical composition of the parent material, the climate under which the soil material has accumulated and existed since accumulation, the plant and animal life on and in the soil, the relief, and the length of time that the forces of soil formation have acted on the soil material. Human activities also affect soil formation.

Climate and plant and animal life are the active factors of soil formation. They act on unconsolidated, organic and mineral parent material and slowly change it into a natural body that has genetically related horizons. The effects of climate and plant and animal life are conditioned by relief. The parent material affects the kind of soil profile that forms and the rate at which it forms. In extreme cases it almost entirely determines profile formation. Finally, time is needed for changing the parent material into a soil. The amount of time needed is determined by the rate of the soil-forming processes. A long period generally is needed for the formation of distinct horizons. The factors of soil formation are so closely interrelated in their effects on the soil that few generalizations can be made regarding the effect of any one factor unless conditions are specified for the others.

Parent Material

Nearly all of the soils in Dickinson County formed in glacial drift, alluvium, loess, or, to a lesser extent, eolian sand. These materials were transported to the county from areas where they weathered from rocks. A very minor parent material is organic sediments.

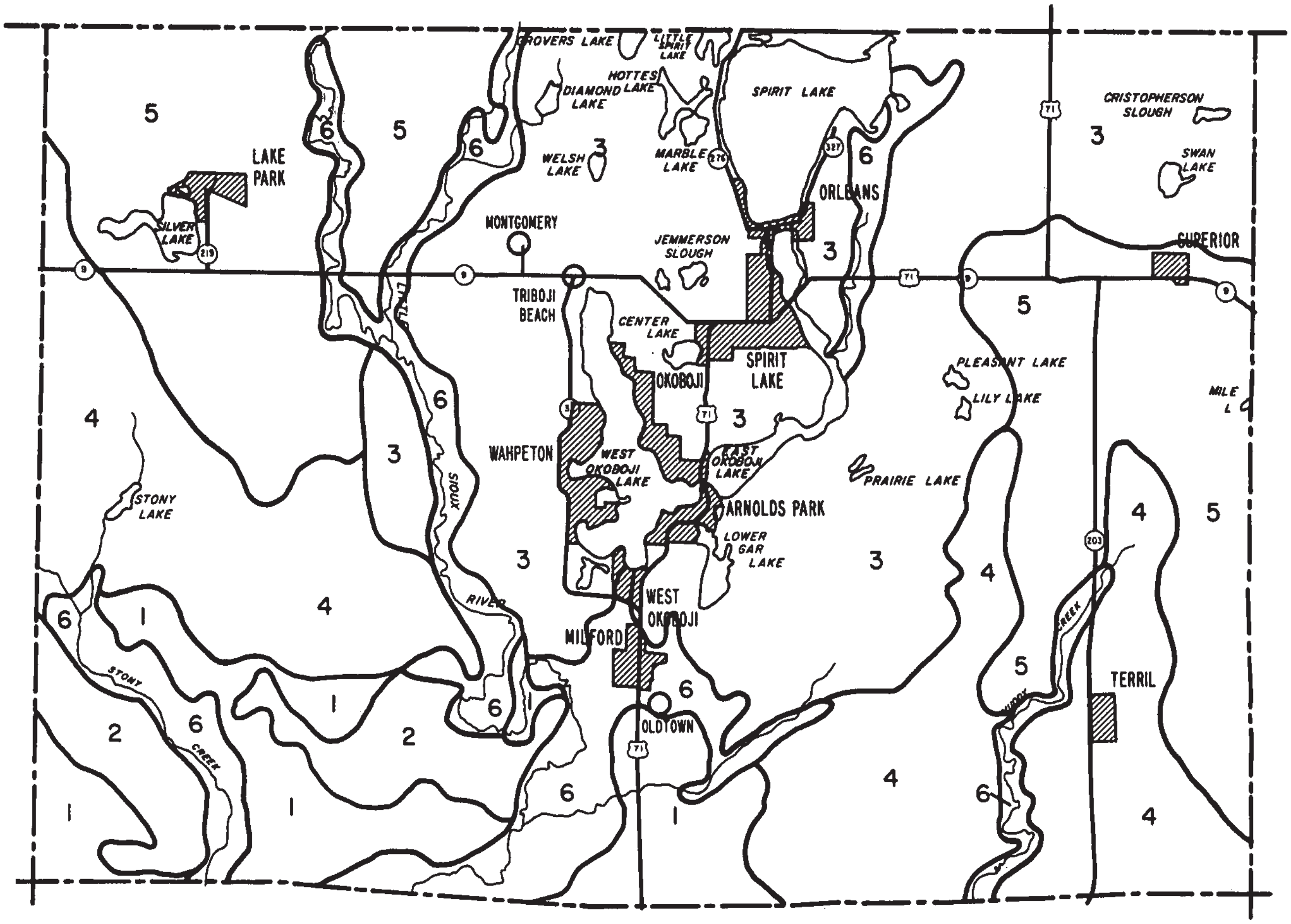
Glacial drift is material deposited by glaciers. The two main kinds of glacial drift in Dickinson County are glacial till and glacial outwash. Glacial drift covers all of the county and is the most extensive parent material. Soils that formed partly or entirely in glacial drift make up more than 80 percent of the county.

Four episodes of glaciation probably occurred in what is now Dickinson County. The first two, the Nebraskan and the Kansan, deposited drift throughout the entire county, but these deposits were buried during more recent episodes of glaciation. These episodes are the Tazewell substage and the Cary substage of the Wisconsin glacial period. Tazewell glacial drift covered all of the county but is exposed in only a few places in the southwestern part. The fourth episode, the Cary substage, deposited the glacial drift that is the modern surface throughout most of the county (fig. 17).

In many of the soils on uplands in the southwestern part of the county, the lower part of the solum formed in Tazewell glacial till. For example, Letri, Sac, Ransom, and Wilmonton soils have a B horizon that formed in Tazewell glacial till. This horizon is loam or clay loam. According to radiocarbon dates, this glacial till was deposited about 20,000 years ago (*14*). It contains more clay, has a higher bulk density, and is firmer than the Cary glacial till.

Cary glacial till is the most extensive parent material in the post-Tazewell part of the county. It was deposited on ground moraines and end moraines. It typically is loam, but layers of sandy loam are not uncommon, especially on the ground moraines. Geologic erosion has beveled side slopes and filled the lower adjacent areas of the original glacial till landscape. The textural differences between the surficial till on side slopes and the local sediment in downslope areas reflect the sorting that occurred as a result of this erosion. For example, Clarion soils on ridgetops and side slopes contain less clay and have a higher content of coarse fragments than the lower lying adjacent Nicollet and Webster soils. Soil material is sorted by water in areas where Clarion soils are rapidly eroding. In most of these areas, gravel, cobbles, and stones are concentrated on the surface because the water has removed the finer soil particles. Although glacial till is considered to be relatively unsorted sediment, Cary and post-Cary geologic erosion and recent accelerated erosion have produced textural variations in the surficial materials. The texture of the Cary glacial till varies more on ground moraines than on end moraines.

Cary glacial outwash is the second most extensive Cary-age parent material. It was deposited by flowing glacial melt water. It makes up the outwash terrace that extends from the south end of West Okoboji Lake to



LEGEND

1 18 to more than 60 inches of sediment over Tazewell or older till.

2 24 to 60 inches of loess over Tazewell till.

3 Cary till and sediments; Altamont end moraine.

4 Cary till and sediments; Bemis end moraine.

5 Cary till and sediments; ground moraine area.

6 Cary outwash terraces; Recent alluvium.

Figure 17.—Surficial geology map of Dickinson County, Iowa.

Clay County. It also is behind the Cary terminal moraine, where it is below end moraines and in glaciofluvial features, such as kames, eskers, and lateral moraines. Soils that formed in Cary outwash make up about 9 percent of the county. Wadena, Estherville, and Cylinder are the most extensive of these soils. The surficial outwash material typically is loam, but in some areas it is silty clay loam, clay loam, sandy loam, or loamy sand. It typically has only a few coarse fragments in all areas except for those that are steeply sloping. In most areas the surficial outwash is about 15 to 40 inches thick and is underlain by stratified sandy and gravelly outwash.

Cary glacial sediments also are underlain by the older Tazewell glacial till and silt loam sediments in part of the area south and west of the Cary terminal moraine. Wilmonton, Everly, and Ocheyedan are the major soils that formed in these sediments. The surficial sediment typically is clay loam or loam, but it is silty clay loam in areas where it has been sorted by water and is sandy loam underlain by loamy sand and sand in a few areas where it has been sorted by wind.

Cary glacial lacustrine sediments are south and west of the Cary terminal moraine, which is southeast of Milford. They also are in scattered areas north and east of the moraine. These sediments, which evidently were originally on top of the Cary glacial ice, were deposited in various areas of the present landscape. A depression or trough in the glacial ice filled with these sediments, and a ridge formed when the glacial ice melted. Many glacial lacustrine areas in the Cary ground moraines are smoother and have slopes that are less irregular than the glacial till areas in the Cary ground moraines. In other areas the glacial lacustrine sediments are surrounded by glacial till in landscape traps evident on the present landscape. Soils that formed in Cary glacial lacustrine sediments make up about 4 percent of the county. Collinwood, Collinwood Variant, and Waldorf are the major soils that formed in these sediments. The sediments typically are silty clay loam or silty clay.

Alluvium is material deposited by water. The major areas of alluvium in the county are along the larger streams, but smaller areas of local alluvium are in upland drainageways and depressions. Soils that formed in alluvium make up about 13 percent of the county. Coland, Okoboji, Terril, and Spillville are the major soils that formed in alluvium.

Most of the alluvium in the county is silty clay loam, clay loam, or loam. The texture of the alluvium varies partly because the texture of the upland soils that contribute runoff and alluvium varies. Also, the texture is affected by the landscape position of the site receiving the alluvium. The alluvium in the smaller upland drainageways, on toe slopes surrounding upland depressions, and in areas adjacent to bottom land tends to be coarser textured than that in areas on bottom land. Spillville loam is the major alluvial soil in these areas. The alluvium in the less sloping areas, such as the areas of Okoboji silty clay loam, 0 to 1 percent slopes, in depressions, typically contains less sand and more clay than that in the more sloping areas. The texture varies more on the bottom land than in the uplands. Generally, alluvium adjacent to a present or former stream channel has the highest content of sand and the lowest content of clay. An example is the alluvium in which Millington loam, channeled, 0 to 2 percent slopes, formed.

Loess, a silty material deposited by wind, is a relatively minor parent material in the county. It was deposited from about 20,000 to 14,000 years ago, according to radiocarbon dating (*14*). Soils that formed partly or entirely in loess make up about 5 percent of the county. The loess is about 2 to 5 feet thick in most places and is underlain by Tazewell-age glacial till. Ransom, Sac, and Primghar are the major soils that formed partly or entirely in loess. Unlike most of the other parent materials in the county, loess has a uniform silt loam and silty clay loam texture. It contains more sand than is typical of loess in areas where deposits of loess are extensive. In most areas of the loess, the content of sand is 5 to 10 percent. Most of the sand is fine and very fine. The content of sand tends to be highest in areas near loamy or sandy sediments.

Organic sediments are a very minor parent material in the county. Blue Earth muck, ponded, 0 to 1 percent slopes, is the only soil that formed in organic sediments, and it makes up less than 1 percent of the county. The organic sediments are only in undrained sloughs because those in drained sloughs generally have been burned by fires. The plant growth and resulting organic accumulation are restricted in most of the undrained sloughs by the fluctuating water depth. The thicker organic material is in fens on side slopes in areas where ground water from the adjacent uplands reaches the surface.

Eolian, or wind-deposited, sand is a very minor parent material on uplands in the county. Soils that formed partly or entirely in eolian sand make up less than 1 percent of the county. Dickman soils formed in eolian sand, and Bolan soils formed in loamy material underlain by eolian sand. The most probable source of the eolian sand is the nearby areas of glacial outwash.

Climate

Climate has had a major influence on soil formation. Soils form more rapidly in a warm climate than in a cold climate and more rapidly in a wet climate than in a dry climate. Except for climatic differences resulting from topography, the soils in Dickinson 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 soils in Dickinson County began about 13,000 years ago, after the glaciation in Iowa ended and the climate began a warming trend (*15*). Evidently, the climate in northern Iowa since that time has varied considerably (*27, 28*). From before 13,000 to about 11,000 years ago, the climate was cool and the vegetation was dominantly conifers. From about 11,000 to 9,000 years ago, the climate became warmer and the vegetation was mixed deciduous forest. From about 9,000 to 3,000 years ago, the climate became progressively warmer and drier. As a result, the forest vegetation was replaced by herbaceous prairie vegetation. From about 1645 until the present time, climatic changes in the northern hemisphere have lasted between 50 and several hundred years (*7*). Most of the soils in the county do not have characteristics that indicate that they were ever forested. Evidently, the rapid geologic erosion that accompanied major climate changes removed the soils that formed under forest vegetation.

The climate in Dickinson County is midcontinental suhumid. The climate differs very little from one part of the county to another. The annual mean temperature increases about 1 degree F from the northern part of the county to the southern part, and the annual precipitation increases slightly more than 1 inch from the northwest corner to the southeast corner (*18*).

The effect of climate on soils is modified by relief. The more sloping soils, such as Storden, formed under a drier microclimate than the gently sloping adjacent soils, such as Clarion. In areas of poorly drained soils, such as Canisteo and Webster, the microclimate is cooler and wetter than that in areas of the well drained adjacent soils, such as Clarion.

Climate indirectly affects soil formation through its effect on the kinds of plants and animals in and on the soil. It also directly affects soil formation. For example, temperature and moisture conditions affect the rate of weathering of parent material. The amount and seasonal distribution of precipitation determine the depth to which calcium carbonates, soluble salts, and clay are moved and the rate of erosion. Precipitation also affects the depth to the water table in poorly drained and somewhat poorly drained soils. 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 it does in areas where the water table is at a lower depth.

Plant and Animal Life

Living organisms affect soil formation. Micro-organisms and burrowing animals, such as worms and crayfish, influence soil properties. Plants, however, generally cause the most marked differences among soils. Grasses have a dense system of roots in the topsoil and have some roots deep in the subsoil. These roots die and commonly are replaced. The dead roots add organic matter to the soil. Grass roots also transport calcium and other plant nutrients from the subsoil to the topsoil. Tree roots live longer than grass roots. Also, they are larger and fewer in number. Soils that formed under grasses typically have a thicker, darker, and more fertile topsoil than soils that formed under trees. Also, they are less acid and have a subsoil that generally is thinner and less well developed.

The soils in Dickinson County formed mainly under prairie grasses. Only about 1,980 acres was forest between 1832 and 1859 (*24*). Herbaceous prairie vegetation probably began to replace forest vegetation about 8,000 years ago. Erosion evidently removed the soils that formed under forest vegetation.

Trees have influenced recent formation in some of the gently sloping to very steep soils near the Little Sioux River. These soils are not extensive, however, and were not separated in mapping.

The large burrowing animals, such as badgers, foxes, and pocket gophers, have the most obvious influence on soil formation. They drastically affect soil formation in small areas. Small animals, such as earthworms and in places ants, have a widespread influence on soil formation. Earthworms move up and down in soils as the soil moisture and temperature change. In most soils examined in the county, earthworms had moved material from one horizon to another.

Human Activities

The natural formation of the soils in Dickinson County changed when the prairie was drained and cultivated and the lakes, sloughs, and depressions were drained. Accelerated erosion in cultivated areas of the more sloping soils caused the most significant changes. In most areas of the moderately sloping and strongly sloping Clarion soils that have been cultivated for 10 years or more, subsoil material is mixed with the plow layer. In areas where those soils have not been cultivated for more than a few years, the darker topsoil is 10 to 14 inches thick.

In many soils in Dickinson County, accelerated erosion is the main cause for a reduction in the content of organic matter. Even without accelerated erosion, however, the content decreases under some cropping systems (*5*). The most significant decrease is in areas where the soils in lakes, sloughs, and depressions have been drained and cultivated. In a few areas fires burned the organic layers after the sloughs were drained.

Tillage and applications of fertilizer, lime, and pesticides have changed the biotic, chemical, and physical properties of the soils in cultivated areas. Most of these management practices have increased the productivity of the soils, but the long term effect of some of these practices is unknown.

Relief

Relief affects the formation of soils mainly through its effect on drainage, runoff, erosion, and the depth to the water table. The soils in Dickinson County range from level to very steep. Soils that formed in the same kind of parent material have different properties mainly because of relief.

Aspect affects soil formation. South-facing slopes generally are warmer and drier than north-facing slopes. In most areas in the county, other relief characteristics, such as the length and shape of slopes, affect soil formation more than aspect.

The topography in most of the county resulted from the movement and melting of the Cary glacial ice. This glacial topography has few natural upland drainageways or streams and has many potholes and other depressions. Geologic erosion of the older Tazewell glacial till surface resulted in the topography in the southwestern part of the county. This topography generally is characterized by a well defined surface drainage pattern.

Several distinct types of Cary glacial topography are in the more recently glaciated part of the county. They include end moraines, ground moraines, lacustrine and outwash plains, and stream terraces.

End moraine topography formed in areas where the margin of glacial ice seasonally advanced and retreated, forming a series of aligned ridges, hills, swales, and depressions. Clarion and Nicollet are the dominant soils on the end moraines.

Ground moraine topography formed in areas where the glacial ice melted. Because the ice melted unevenly, the landscape is characterized by randomly oriented knobs and ridges interspersed with broad, smooth areas, depressions, and swales. Canisteo and Nicollet are the dominant soils on the ground moraines.

Lacustrine and outwash plains and stream terraces formed as a result of action by glacial melt water. They typically have low relief. Kingston and Madelia are the dominant soils on the lacustrine plains. Wadena and Estherville are the dominant soils on the outwash plains. Cylinder and Talcot are the dominant soils on the stream terraces.

Geologic erosion of the older Tazewell glacial till surface resulted in the topography in the southwestern part of the county. Loess and other sediments covered the glacial till. The present topography is similar to that of the surface of the underlying glacial till, but it is somewhat less pronounced. Ransom soils are dominant in the loess covered areas, and Wilmonton soils are dominant in the sediment covered areas.

Relief affects soil formation through its effect on the gravitational energy of water running off the surface or percolating through the profile (*16*). The color and thickness of the A and B horizons are affected by relief. As the slope becomes less steep and less convex, more water becomes available for soil formation. As a result, the A horizon is thickened and darkened and the B horizon generally is thickened. For example, Nicollet soils commonly are less sloping and are in less convex positions on the landscape than the adjacent Clarion soils. Their A horizon is thicker and darker than that of the Clarion soils. Also, their B horizon generally is thicker than that of some Clarion soils. In places, however, the thickness of the solum of the Nicollet soils is limited by the depth to the seasonal high water table. The solum of the moderately sloping and strongly sloping Clarion soils commonly is thinner than that of the gently sloping Clarion soils.

The gravitational energy of water has differentially redistributed particles of different sizes in most glacial landscapes in the county. A higher proportion of the smaller sized particles has been moved downslope, leaving a higher proportion of the coarser particles on the higher parts of the landscape. As a result, Clarion soils, which are on ridgetops and side slopes, typically contain more sand, gravel, cobbles, and stones than Webster soils, which are on the lower parts of the landscape. This is a natural process, but accelerated erosion of the topsoil in some areas of Clarion soils results in an increasingly high content of gravel, cobbles, and stones.

Nearly level soils on the low parts of the landscape generally have a thick, dark A horizon. Examples are Spillville and Terril soils on foot slopes, Okoboji and Webster soils in upland depressions and swales, and Coland and Calco soils on bottom land.

Topography also affects the color of the B horizon through its effect on subsurface drainage. Well drained soils on ridgetops and side slopes, such as Clarion soils, do not have ground water within a depth of 6 feet. They have a brown subsoil because the iron compounds are oxidized and distributed throughout the soil. Poorly drained soils in swales, such as Webster soils, have a seasonal high water table within a depth of 1 to 3 feet. They have a gray or mottled subsoil because the iron compounds are reduced and in some areas have been removed.

Time

Time enables relief, climate, and plant and animal life to change the parent material. One hundred to several hundred years are needed for topsoil to form, and a period eight to ten times longer is needed for a subsoil to become well developed (*4, 11, 19*). Similar soils form in different kinds of parent material if the other factors of soil formation are active for a long period. Soil formation, however, generally is interrupted by geological events that expose new parent material.

In Dickinson County the bedrock has been covered by glacial drift from the Nebraskan and Kansan glaciers and more recently by Wisconsinan loess and glacial drift. Except for the soils on modern surfaces, the soils that formed in each of these materials eroded away or was buried by more recent material.

Radiocarbon dating has been used to determine the age of wood, bones, and other organic carbon material in the Wisconsinan loess and glacial drift. It indicates that the loess in the southwestern part of Dickinson County was deposited after about 20,000 years ago (*14*).

The glacial sediments adjacent to the loess were deposited more recently. In many areas they overlie silty sediments that appear to be loess. The silty glacial sediments east of the loess mantled areas were deposited when the Cary glacial ice was melting, about 13,000 years ago (*14*). The landscape that formed at that time may have been similar to the modern landscape, but it was subject to periods of erosion. Much of the deposition that forms the modern stream terraces occurred at this time. The alluvium above the sand and gravel fill along the Little Sioux River in Cherokee County is about 10,000 years old (*10*). Organic carbon dating, pollen and plant macrofossils, and sediment analysis from Millers Bay on West Okoboji Lake and other northern Iowa locations indicate periods of rapid geologic erosion up to about 3,000 years ago (*27, 28*). As a result, the soils on the less stable uplands in Dickinson County are likely to be no more than 3,000 years old. Examples are the gently sloping to strongly sloping Clarion and Everly soils.

Younger soils are in the more rapidly eroding areas or in areas that receive sediment. Examples of soils in the more rapidly eroding areas in the county are the steep and very steep Storden and Salida soils on side slopes. Examples of soils that receive sediment are the nearly level Coland, Calco, and Spillville soils on bottom land. In areas where erosion or deposition has accelerated since settlement, soil formation is retarded because the soils are losing or receiving a large amount of soil material. Examples are the strongly sloping Clarion soils, which are eroding, and the level Okoboji soils, which are receiving sediment.

Processes of Horizon Development

The five factors of soil formation result in horizon differentiation through their effect on the soil-forming processes. These processes are additions, removals, transfers, and transformations (*19*). Each of these processes determines what kind of soil forms and how rapidly soil formation progresses. For example, as most soils form, organic matter is added, soluble salts 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.

These processes generally result in horizon differentiation, but in some soils one or more of the processes retards soil formation. An example of these soils is Clarion loam, 5 to 9 percent slopes, moderately eroded. Organic matter is being removed from this soil faster than it is being added, and the horizon to which clay is being transferred is close to the surface because erosion has removed part of the surface layer.

The addition of organic matter is one of the first evidences of horizon differentiation. The dark color of the surface layer in Storden and other soils is the result of the addition of organic matter.

The removal of soluble salts and calcium carbonates from the surface layer of the Storden soils has not progressed faster than normal, but accelerated erosion has removed the surface layer. In most other soils on uplands in the county, however, percolating water has removed soluble salts and calcium carbonates from the upper horizons. The depth at which the calcium carbonates precipitate is an indication of the usual depth to which water percolates or the depth of the water table in the moist part of the year. A B horizon develops as carbonates are moved downward. This has occurred, for example, in Clarion and Nicollet soils. In a few soils, such as Canisteo, Crippin, and Spicer, water moving upward in the profile has kept the carbonates in the weakly developed upper horizons.

Transfers are also important in the differentiation of horizons. An example of transfer is that of clay moving from the surface layer to the developing B horizon in Rolfe soils. The depth to which clay is moved is related to the depth of water percolation during the growing season (*16*). Transfers become removals when the substance is lost from the soil profile. A significant transfer during the cropping season in Dickinson County is that of nitrate nitrogen. The nitrate is transferred downward with percolating water and may be removed from the profile. Transfers from the lower horizons occur when plant roots take nitrogen and other elements upward. Evidence indicates that zinc and other elements that are relatively insoluble in water are transferred from the lower horizons to the surface by plants and are transferred from the surface to the B horizon along with clay as horizon differentiation progresses (*6*).

Transformations occur in all horizons, but the rate of transformation is most rapid in the surface layer. During the growing season, organic matter is transformed into mineral elements and primary minerals are transformed into secondary mineral elements. Most transformations make the elements more available to plants. For example, if the pH level is near 7, the primary mineral apatite is weathered to secondary phosphorus compounds (*12, 17*). If the pH level is high, however, phosphorus compounds that are not available to plants form. As a result, soils that have a pH level of more than 7, such as Canisteo soils, have a lower supply of available phosphorus than soils that have a pH level near 7, such as Okoboji and Webster soils.

Some elements must be transformed before they can be translocated by water in the soil. An example is iron. In well drained soils, such as Clarion and Everly, this element is not soluble in water in its oxidized form. In poorly drained soils, such as Canisteo and Webster, however, the iron is transformed to its reduced form and moves with the water. This process results in mottles and gray or olive gray colors.

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Glossary

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

Bedrock. The solid rock that underlies the soil and other unconsolidated material or that is exposed at the surface.

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.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Clay film. A thin coating of oriented clay on the surface of a soil aggregate or lining pores or root channels. Synonyms: clay coating, clay skin.

Coarse fragments. If round, mineral or rock particles 2 millimeters to 25 centimeters (10 inches) in diameter; if flat, mineral or rock particles (flagstone) 15 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.

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.

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.

Cutbanks cave (in tables). The walls of excavations tend to cave in or slough.

Diversion (or diversion terrace). A ridge of earth, generally a terrace, built to protect downslope areas by diverting runoff from its natural course.

Drainage class (natural). Refers to the 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.

Eolian soil material. Earthy parent material accumulated through wind action; commonly refers to sandy material in dunes or to loess in blankets on the surface.

Erosion. The wearing away of the land surface by water, wind, ice, or other geologic agents and by such processes as gravitational creep.

Erosion (geologic). Erosion caused by geologic processes acting over long geologic periods and resulting in the wearing away of mountains and the building up of such landscape features as flood plains and coastal plains. Synonym: natural erosion.

Erosion (accelerated). Erosion much more rapid than geologic erosion, mainly as a result of the activities of man or other animals or of a catastrophe in nature, for example, fire, that exposes the surface.

Esker (geology). A narrow, winding ridge of stratified gravelly and sandy drift deposited by a stream flowing in a tunnel beneath a glacier.

Excess fines (in tables). Excess silt and clay in the soil. The soil is not a source of gravel or sand for construction purposes.

Fast intake (in tables). The rapid movement of water into the soil.

Fen. A type of wetland on hillsides in which very alkaline ground water comes to the surface. The soil in the fens is a peaty mixture of undecayed plant debris and marl which is precipitated when the water reaches the surface.

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.

Flood plain. A nearly level alluvial plain that borders a stream and is subject to flooding unless protected artificially.

Foot slope. The inclined surface at the base of a hill.

Frost action (in tables). Freezing and thawing of soil moisture. Frost action can damage roads, buildings and other structures, and plant roots.

Glacial drift (geology). Pulverized and other rock material transported by glacial ice and then deposited. Also the sorted and unsorted material deposited by streams flowing from glaciers.

Glacial outwash (geology). Gravel, sand, and silt, commonly stratified, deposited by glacial melt water.

Glacial till (geology). Unsorted, nonstratified glacial drift consisting of clay, silt, sand, and boulders transported and deposited by glacial ice.

Glaciofluvial deposits (geology). Material moved by glaciers and subsequently sorted and deposited by streams flowing from the melting ice. The deposits are stratified and occur as kames, eskers, deltas, and outwash plains.

Glaciolacustrine deposits. Material ranging from fine clay to sand derived from glaciers and deposited in glacial lakes mainly by glacial melt water. Many deposits are interbedded or laminated.

Gleyed soil. Soil that formed under poor drainage, resulting in the reduction of iron and other elements in the profile and in gray colors and mottles.

Grassed waterway. A natural or constructed waterway, typically broad and shallow, seeded to grass as protection against erosion. Conducts surface water away from cropland.

Gravel. Rounded or angular fragments of rock up to 3 inches (2 millimeters to 7.6 centimeters) in diameter. An individual piece is a pebble.

Gravelly soil material. Material that is 15 to 50 percent, by volume, rounded or angular rock fragments, not prominently flattened, up to 3 inches (7.6 centimeters) in diameter.

Ground water (geology). Water filling all the unblocked pores of underlying material below the water table.

Gully. A miniature valley with steep sides cut by running water and through which water ordinarily runs only after rainfall. The distinction between a gully and a rill is one of depth. A gully generally is an obstacle to farm machinery and is too deep to be obliterated by ordinary tillage; a rill is of lesser depth and can be smoothed over by ordinary tillage.

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.

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.

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.

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.

Organic matter. Plant and animal residue in the soil in various stages of decomposition.

Outwash, glacial. Stratified sand and gravel produced by glaciers and carried, sorted, and deposited by glacial melt water.

Outwash plain. A landform of mainly sandy or coarse textured material of glaciofluvial origin. An outwash plain is commonly smooth; where pitted, it is generally low in relief.

Parent material. The unconsolidated organic and mineral material in which soil forms.

Peat. Unconsolidated material, largely undecomposed organic matter, that has accumulated under excess moisture. (See Fibric soil material.)

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

pH value. A numerical designation of acidity and alkalinity in soil. (See Reaction, soil.)

Piping (in tables). Formation of subsurface tunnels or pipelike cavities by water moving through the soil.

Plasticity index. The numerical difference between the liquid limit and the plastic limit; the range of moisture content within which the soil remains plastic.

Plastic limit. The moisture content at which a soil changes from semisolid to plastic.

Ponding. Standing water on soils in closed depressions. Unless the soils are artificially drained, the water can be removed only by percolation or evapotranspiration.

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.

Rooting depth (in tables). Shallow root zone. The soil is shallow over a layer that greatly restricts roots.

Runoff. The precipitation discharged into stream channels from an area. The water that flows off the surface of the land without sinking into the soil is called surface runoff. Water that enters the soil before reaching surface streams is called ground-water runoff or seepage flow from ground water.

Sand. As a soil separate, individual rock or mineral fragments from 0.05 millimeter to 2.0 millimeters in diameter. Most sand grains consist of quartz. As a soil textural class, a soil that is 85 percent or more sand and not more than 10 percent clay.

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.

Seepage (in tables). The movement of water through the soil. Seepage adversely affects the specified use.

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.

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.

Slope. The inclination of the land surface from the horizontal. Percentage of slope is the vertical distance divided by horizontal distance, then multiplied by 100. Thus, a slope of 20 percent is a drop of 20 feet in 100 feet of horizontal distance.

Slope (in tables). Slope is great enough that special practices are required to insure satisfactory performance of the soil for a specific use.

Small stones (in tables). Rock fragments less than 3 inches (7.6 centimeters) in diameter. Small stones adversely affect the specified use of the soil.

Soil. A natural, three-dimensional body at the earth's surface. It is capable of supporting plants and has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Soil separates. Mineral particles less than 2 millimeters in equivalent diameter and ranging between specified size limits. The names and sizes of separates recognized in the United States are as follows:

	Millimeters
Very coarse sand	2.0 to 1.0
Coarse sand	1.0 to 0.5
Medium sand	0.5 to 0.25
Fine sand	0.25 to 0.10
Very fine sand	0.10 to 0.05
Silt	0.05 to 0.002
Clay	less than 0.002

Solum. The upper part of a soil profile, above the C horizon, in which the processes of soil formation are active. The solum in soil consists of the A, E, and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and plant and animal activities are largely confined to the solum.

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 if rounded and 6 to 15 inches (15 to 38 centimeters) in length if flat.

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).

Subsoil. Technically, the B horizon; roughly, the part of the solum below plow depth.

Substratum. The part of the soil below the solum.

Subsurface layer. Any surface soil horizon (A, E, AB, or EB) below the surface layer.

Surface layer. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, ranging in depth from 4 to 10 inches (10 to 25 centimeters). Frequently designated as the "plow layer," or the "Ap horizon."

Surface soil. The A, E, AB, and EB horizons. Includes all subdivisions of these horizons.

Taxadjuncts. Soils that cannot be classified in a series recognized in the classification system. Such soils are named for a series they strongly resemble and are designated as taxadjuncts to that series because they differ in ways too small to be of consequence in interpreting their use and behavior.

Terminal moraine. A belt of thick glacial drift that generally marks the termination of important glacial advances.

Terrace. An embankment, or ridge, constructed across sloping soils on the contour or at a slight angle to the contour. The terrace intercepts surface runoff so that water soaks into the soil or flows slowly to a prepared outlet.

Terrace (geologic). An old alluvial plain, ordinarily flat or undulating, bordering a river, a lake, or the sea.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand, loamy sand, sandy loam, loam, silt loam, silt, sandy clay loam, clay loam, silty clay loam, sandy clay, silty clay,* and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Thin layer (in tables). Otherwise suitable soil material too thin for the specified use.

Till plain. An extensive flat to undulating area underlain by glacial till.

Topsoil. The upper part of the soil, which is the most favorable material for plant growth. It is ordinarily rich in organic matter and is used to topdress roadbanks, lawns, and land affected by mining.

Upland (geology). Land at a higher elevation, in general, than the alluvial plain or stream terrace; land above the lowlands along streams.

Variant, soil. A soil having properties sufficiently different from those of other known soils to justify a new series name, but occurring in such a limited geographic area that creation of a new series is not justified.

Tables

TABLE 1.--TEMPERATURE AND PRECIPITATION

[Data were recorded in the period 1951-77 at Milford, Iowa]

Month	Temperature						Precipitation				
				2 years in 10 will have--				2 years in 10 will have--			
	Average daily maximum	Average daily minimum	Average	Maximum temperature higher than--	Minimum temperature lower than--	Average number of growing degree days*	Average	Less than--	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----	22.7	2.7	12.7	46	-27	0	0.49	0.18	0.72	2	5.8
February---	30.0	9.7	19.9	54	-22	0	.99	.33	1.52	3	8.5
March------	39.4	20.1	29.8	71	-10	23	1.62	.78	2.29	4	9.1
April------	57.9	34.6	46.3	87	15	75	2.49	1.19	3.54	6	1.3
May--------	71.2	46.4	58.9	91	26	292	3.34	1.65	4.71	7	.0
June-------	80.5	56.5	68.6	97	40	558	4.38	2.46	5.95	7	.0
July-------	84.6	61.0	72.8	97	45	707	3.62	1.15	5.59	6	.0
August-----	82.4	58.7	70.6	96	43	639	3.36	1.61	4.79	6	.0
September--	72.9	48.8	60.9	93	30	327	3.32	1.07	5.11	6	.0
October----	62.5	38.4	50.4	88	17	132	1.90	.52	3.00	4	.3
November---	43.1	23.7	33.4	69	-5	0	1.18	.27	1.89	3	3.3
December---	28.5	10.5	19.5	53	-22	0	.74	.35	1.06	3	7.6
Yearly:											
Average--	56.3	34.3	45.3	---	---	---	---	---	---	---	---
Extreme--	---	---	---	100	-28	---	---	---	---	---	---
Total----	---	---	---	---	---	2,753	27.43	21.09	33.41	57	35.9

* 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° F).

TABLE 2.--FREEZE DATES IN SPRING AND FALL

[Data were recorded in the period 1951-77 at Milford, Iowa]

Probability	Temperature		
	24° F or lower	28° F or lower	32° F or lower
Last freezing temperature in spring:			
1 year in 10 later than--	May 2	May 12	May 18
2 years in 10 later than--	April 26	May 7	May 13
5 years in 10 later than--	April 15	April 25	May 4
First freezing temperature in fall:			
1 year in 10 earlier than--	September 25	September 17	September 8
2 years in 10 earlier than--	October 4	September 25	September 14
5 years in 10 earlier than--	October 20	October 10	September 27

TABLE 3.--GROWING SEASON

[Data were recorded in the period 1951-77 at Milford, Iowa]

Probability	Daily minimum temperature		
	Higher than 24° F	Higher than 28° F	Higher than 32° F
	Days	Days	Days
9 years in 10	157	138	120
8 years in 10	168	148	129
5 years in 10	188	166	146
2 years in 10	207	185	163
1 year in 10	218	195	171

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	10,330	4.3
27B	Terril loam, 2 to 5 percent slopes	1,990	0.8
27C	Terril loam, 5 to 9 percent slopes	1,015	0.4
28B	Dickman fine sandy loam, 2 to 5 percent slopes	340	0.1
32	Spicer silty clay loam, 0 to 2 percent slopes	1,700	0.7
55	Nicollet loam, 1 to 3 percent slopes	43,990	18.1
62C2	Storden loam, 5 to 9 percent slopes, moderately eroded	1,040	0.4
62D	Storden loam, 9 to 14 percent slopes	360	0.1
62D2	Storden loam, 9 to 14 percent slopes, moderately eroded	1,085	0.4
62E	Storden loam, 14 to 18 percent slopes	1,095	0.5
62G	Storden loam, 18 to 40 percent slopes	1,090	0.5
72	Estherville loam, 0 to 2 percent slopes	1,005	0.4
72B	Estherville loam, 2 to 5 percent slopes	2,730	1.1
72C2	Estherville loam, 5 to 14 percent slopes, moderately eroded	1,490	0.6
73D	Salida gravelly sandy loam, 5 to 14 percent slopes	390	0.2
73E	Salida gravelly sandy loam, 14 to 24 percent slopes	205	0.1
73G	Salida gravelly sandy loam, 24 to 40 percent slopes	365	0.2
77B	Sac silty clay loam, 2 to 5 percent slopes	2,855	1.2
91	Primghar silty clay loam, 0 to 2 percent slopes	960	0.4
91B	Primghar silty clay loam, 2 to 4 percent slopes	1,140	0.5
92	Marcus silty clay loam, 0 to 2 percent slopes	1,285	0.5
95	Harps loam, 0 to 2 percent slopes	780	0.3
107	Webster silty clay loam, 0 to 2 percent slopes	18,230	7.5
108	Wadena loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	3,850	1.6
108B	Wadena loam, 24 to 32 inches to sand and gravel, 2 to 5 percent slopes	1,965	0.8
108C	Wadena loam, 24 to 32 inches to sand and gravel, 5 to 9 percent slopes	260	0.1
135	Coland silty clay loam, 0 to 2 percent slopes	2,950	1.2
138B	Clarion loam, 2 to 5 percent slopes	40,610	16.7
138C	Clarion loam, 5 to 9 percent slopes	2,600	1.1
138C2	Clarion loam, 5 to 9 percent slopes, moderately eroded	19,565	8.1
138D	Clarion loam, 9 to 14 percent slopes	1,570	0.6
138D2	Clarion loam, 9 to 14 percent slopes, moderately eroded	3,285	1.4
201B	Coland-Spillville complex, 1 to 5 percent slopes	7,380	3.0
202	Cylinder loam, 24 to 32 inches to sand and gravel, 0 to 2 percent slopes	840	0.3
203	Cylinder loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	945	0.4
259	Biscay clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	395	0.2
274	Rolfe silty clay loam, 0 to 1 percent slopes	410	0.2
282	Ransom silty clay loam, 1 to 3 percent slopes	3,615	1.5
308	Wadena loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	785	0.3
308B	Wadena loam, 32 to 40 inches to sand and gravel, 2 to 5 percent slopes	605	0.2
330	Kingston silty clay loam, 1 to 3 percent slopes	2,100	0.9
331	Madelia silty clay loam, 0 to 2 percent slopes	1,295	0.5
384	Collinwood silty clay loam, 1 to 3 percent slopes	2,545	1.0
390	Waldorf silty clay loam, 0 to 2 percent slopes	3,730	1.5
397	Letri silty clay loam, 0 to 1 percent slopes	1,160	0.5
456	Wilmonton silty clay loam, 1 to 3 percent slopes	3,950	1.6
474B	Bolan loam, 2 to 5 percent slopes	850	0.4
474C2	Bolan loam, 5 to 9 percent slopes, moderately eroded	220	0.1
485	Spillville loam, 0 to 2 percent slopes	590	0.2
485B	Spillville loam, 2 to 5 percent slopes	1,575	0.6
507	Canisteo silty clay loam, 0 to 2 percent slopes	10,660	4.4
511	Blue Earth mucky silt loam, 0 to 1 percent slopes	2,485	1.0
559	Talcot silty clay loam, 32 to 40 inches to sand and gravel, 0 to 2 percent slopes	1,140	0.5
577	Everly clay loam, 0 to 2 percent slopes	350	0.1
577B	Everly clay loam, 2 to 5 percent slopes	3,625	1.5
577C2	Everly clay loam, 5 to 9 percent, moderately eroded	365	0.2
655	Crippin loam, 1 to 3 percent slopes	7,010	2.9
733	Calco silty clay loam, 0 to 2 percent slopes	1,880	0.8
878	Ocheyedan loam, 0 to 2 percent slopes	620	0.3
878B	Ocheyedan loam, 2 to 5 percent slopes	1,845	0.8
879	Fostoria loam, 1 to 3 percent slopes	1,210	0.5
1202	Cylinder Variant loam, 0 to 2 percent slopes	545	0.2
1384B	Collinwood Variant silty clay loam, 2 to 5 percent slopes	1,720	0.7
1384C	Collinwood Variant silty clay loam, 5 to 9 percent slopes	430	0.2
1458	Millington loam, channeled, 0 to 2 percent slopes	355	0.1
1511	Blue Earth muck, ponded, 0 to 1 percent slopes	1,770	0.7
5010	Pits, gravel	455	0.2
5040	Orthents, loamy	855	0.4
	Small water areas	445	0.2
	Total	242,880	100.0
	Large water areas	15,040	
	Total area of county	257,920	

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE

[Yields are those that can be expected under a high level of management. Absence of a yield indicates that the soil is not suited to the crop or the crop generally is not grown on the soil]

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
	Bu	Bu	Bu	Ton	AUM*	AUM*	AUM*
6------------------------ Okoboji	84	32	67	3.4	3.3	4.3	7.3
27B---------------------- Terril	118	45	94	5.0	4.2	7.0	8.3
27C---------------------- Terril	113	43	91	4.8	4.2	6.7	8.0
28B---------------------- Dickman	57	22	48	2.5	1.2	3.0	3.7
32----------------------- Spicer	94	36	80	4.0	---	5.3	6.0
55----------------------- Nicollet	120	40	80	4.5	3.5	5.8	6.5
62C2, 62D, 62D2---------- Storden	75	22	50	3.5	3.0	4.3	5.0
62E---------------------- Storden	60	---	40	3.0	2.5	3.8	4.5
62G---------------------- Storden	---	---	---	---	1.5	---	---
72----------------------- Estherville	50	17	40	2.0	2.0	2.7	3.0
72B---------------------- Estherville	45	15	35	2.0	2.0	1.8	2.5
72C2--------------------- Estherville	27	9	29	1.4	1.2	1.2	2.0
73D---------------------- Salida	35	14	40	2.5	1.5	3.0	3.7
73E, 73G----------------- Salida	---	---	---	---	0.8	2.0	2.7
77B---------------------- Sac	89	34	76	3.4	3.3	5.3	5.6
91----------------------- Primghar	103	39	88	3.9	3.8	5.8	6.5
91B---------------------- Primghar	101	38	86	3.8	3.7	5.7	6.3
92----------------------- Marcus	99	38	84	3.8	3.7	6.0	6.3
95----------------------- Harps	95	36	76	4.0	3.3	5.0	6.6
107---------------------- Webster	110	42	88	4.4	4.2	6.6	7.3
108---------------------- Wadena	72	27	60	2.7	2.7	4.1	4.8

See footnote at end of table.

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
	Bu	Bu	Bu	Ton	AUM*	AUM*	AUM*
108B------ Wadena	70	27	60	2.8	2.7	4.0	4.7
108C------ Wadena	62	24	53	2.5	2.3	3.5	4.2
135------ Coland	110	42	83	4.6	4.1	6.0	7.6
138B------ Clarion	110	42	88	4.6	4.2	6.7	7.6
138C------ Clarion	105	40	84	4.4	3.8	6.3	7.3
138C2------ Clarion	102	39	82	4.3	3.8	6.2	7.1
138D------ Clarion	96	36	77	4.0	3.7	5.7	6.6
138D2------ Clarion	93	35	74	3.9	3.7	5.5	6.5
201B------ Coland-Spillville	98	37	78	4.0	3.9	6.6	7.0
202------ Cylinder	88	33	70	3.7	3.3	5.3	6.1
203------ Cylinder	103	39	82	4.3	3.8	6.2	7.1
259------ Biscay	100	38	80	4.0	3.8	5.9	6.6
274------ Rolfe	86	33	69	3.0	3.3	4.5	5.0
282------ Ransom	100	38	80	3.8	3.8	5.4	6.1
308------ Wadena	92	35	74	3.7	3.7	5.5	6.2
308B------ Wadena	90	34	72	3.6	3.7	5.3	6.0
330------ Kingston	120	38	80	4.5	3.5	6.0	6.7
331------ Madelia	110	42	88	4.5	---	5.8	6.5
384------ Collinwood	115	35	80	4.0	3.5	5.3	6.0
390------ Waldorf	90	35	72	4.0	3.3	5.3	6.0
397------ Letri	100	35	85	---	---	---	---
456------ Wilmonton	119	45	94	5.0	4.2	7.7	8.4
474B------ Bolan	60	21	52	2.8	2.6	4.8	5.2

See footnote at end of table.

TABLE 5.--YIELDS PER ACRE OF CROPS AND PASTURE--Continued

Soil name and map symbol	Corn	Soybeans	Oats	Grass-legume hay	Kentucky bluegrass	Smooth bromegrass	Bromegrass-alfalfa
	Bu	Bu	Bu	Ton	AUM*	AUM*	AUM*
474C2----------------------- Bolan	48	17	46	2.4	2.0	4.6	4.0
485----------------------- Spillville	122	46	98	5.1	4.2	7.3	8.6
485B----------------------- Spillville	120	45	96	5.0	4.1	7.2	8.5
507----------------------- Canisteo	110	36	75	3.5	3.0	5.5	5.2
511----------------------- Blue Earth	95	35	76	3.8	3.5	3.8	4.5
559----------------------- Talcot	95	36	76	4.0	3.3	5.0	5.5
577----------------------- Everly	92	35	76	4.5	3.5	5.5	5.8
577B----------------------- Everly	89	34	75	4.4	3.3	5.3	5.6
577C2----------------------- Everly	81	31	69	3.5	3.3	4.8	5.1
655----------------------- Crippin	113	39	84	4.3	4.2	6.5	7.1
733----------------------- Calco	99	38	84	4.2	4.2	5.3	7.0
878----------------------- Ocheyedan	86	33	69	3.6	3.3	5.2	6.0
878B----------------------- Ocheyedan	84	32	67	3.5	3.3	5.0	5.8
879----------------------- Fostoria	96	36	77	4.0	3.7	5.8	6.6
1202----------------------- Cylinder Variant	81	31	71	3.1	3.6	5.0	5.8
1384B----------------------- Collinwood Variant	100	38	80	3.8	3.7	6.1	6.3
1384C----------------------- Collinwood Variant	95	36	76	3.6	3.5	5.8	6.0
1458. Millington							
1511. Blue Earth							
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 6.--CAPABILITY CLASSES AND SUBCLASSES

[Miscellaneous areas are excluded. Absence of an entry indicates no acreage]

Class	Total acreage	Major management concerns (Subclass)		
		Erosion (e)	Wetness (w)	Soil problem (s)
		Acres	Acres	Acres
I	66,350	---	---	---
II	122,655	61,510	53,175	7,970
III	46,850	33,625	13,225	---
IV	1,485	1,485	---	---
V	2,125	---	2,125	---
VI	205	205	---	---
VII	1,455	1,455	---	---
VIII	---	---	---	---

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS

[The symbol < means less than; > means more than. Absence of an entry indicates that trees generally do not grow to the given height on that soil]

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
6----------------- Okoboji	---	Northern white-cedar, Siberian peashrub, lilac, Tatarian honeysuckle.	Hackberry, eastern redcedar, bur oak, white spruce.	Honeylocust, golden willow, green ash.	Eastern cottonwood.
27B, 27C---------- Terril	---	Gray dogwood, Siberian peashrub, redosier dogwood, lilac.	Honeylocust, Russian-olive, Amur maple, blue spruce, northern white-cedar, eastern redcedar.	Eastern white pine, green ash.	---
28B--------------- Dickman	Siberian peashrub, Tatarian honeysuckle, lilac.	Eastern redcedar, hackberry, Manchurian crabapple.	Green ash, honeylocust, eastern white pine, jack pine, Russian-olive, bur oak.	---	---
32---------------- Spicer	---	Tatarian honeysuckle, lilac, Siberian peashrub, northern white-cedar.	Bur oak, hackberry, white spruce, eastern redcedar.	Golden willow, honeylocust, green ash.	Eastern cottonwood.
55---------------- Nicollet	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Northern white-cedar, white spruce, blue spruce, Amur maple.	Austrian pine, eastern white pine, green ash, hackberry.	Silver maple.
62C2, 62D, 62D2, 62E, 62G--------- Storden	American plum-----	Eastern redcedar, hackberry, Tatarian honeysuckle, Siberian peashrub.	Honeylocust, green ash, Russian-olive.	Siberian elm------	---
72, 72B, 72C2----- Estherville	Lilac, Tatarian honeysuckle, Siberian peashrub.	Eastern redcedar, hackberry, Manchurian crabapple.	Honeylocust, jack pine, eastern white pine, green ash, bur oak, Russian-olive.	---	---
73D, 73E, 73G. Salida					
77B--------------- Sac	---	Siberian peashrub, American plum, Tatarian honeysuckle, lilac.	Eastern redcedar, blue spruce, bur oak, hackberry, Russian-olive.	Ponderosa pine, honeylocust, green ash.	---
91, 91B----------- Primghar	Peking cotoneaster	American plum, lilac, Siberian peashrub.	Eastern redcedar, ponderosa pine, Manchurian crabapple.	Golden willow, honeylocust, green ash, hackberry.	Eastern cottonwood.
92---------------- Marcus	Lilac-------------	Siberian peashrub, Tatarian honeysuckle.	Eastern redcedar, blue spruce, ponderosa pine, hackberry.	Green ash, honeylocust, golden willow, silver maple.	Eastern cottonwood.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
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.
108, 108B, 108C Wadena	Siberian peashrub, lilac, Tatarian honeysuckle.	Eastern redcedar, hackberry, Manchurian crabapple.	Jack pine, honeylocust, bur oak, Russian-olive, green ash, eastern white pine.	---	---
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.
138B, 138C, 138C2, 138D, 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.	---
201B*:					
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.
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.
202, 203 Cylinder	---	Redosier dogwood, Tatarian honeysuckle, lilac.	Blue spruce, northern white-cedar, Amur maple, white spruce.	Austrian pine, eastern white pine, green ash, hackberry.	Silver maple.
259 Biscay	---	Redosier dogwood, American plum, Tatarian honeysuckle.	Northern white-cedar, Amur maple, white spruce, hackberry, tall purple willow.	Green ash, golden willow.	Eastern cottonwood.
274 Rolfe	---	Redosier dogwood, Tatarian honeysuckle, American plum.	Amur maple, northern white-cedar, hackberry, white spruce, tall purple willow.	Golden willow, green ash.	Silver maple, eastern cottonwood.

See footnote at end of table.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of-- <8	8-15	16-25	26-35	>35
282-----Ransom	---	Tatarian honeysuckle, redosier dogwood, lilac.	Amur maple, blue spruce, white spruce, northern white-cedar.	Green ash, honeylocust, eastern white pine, Austrian pine.	Silver maple.
308, 308B-----Wadena	Siberian peashrub, lilac, Tatarian honeysuckle.	Eastern redcedar, hackberry, Manchurian crabapple.	Jack pine, honeylocust, bur oak, Russian-olive, green ash, eastern white pine.	---	---
330-----Kingston	---	Lilac, Tatarian honeysuckle, redosier dogwood.	Northern white-cedar, white spruce, Amur maple, blue spruce.	Austrian pine, eastern white pine, green ash, hackberry.	Silver maple.
331-----Madelia	---	American plum, Tatarian honeysuckle, redosier dogwood.	Northern white-cedar, white spruce, hackberry, Amur maple, tall purple willow.	Golden willow, green ash.	Silver maple, eastern cottonwood.
384-----Collinwood	---	Northern white-cedar, Siberian peashrub, Tatarian honeysuckle, lilac, eastern redcedar.	White spruce, Austrian pine, green ash, hackberry, bur oak, Russian-olive.	Eastern white pine	---
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.
397-----Letri	---	Redosier dogwood, Tatarian honeysuckle, American plum.	Tall purple willow, hackberry, white spruce, northern white-cedar, Amur maple.	Green ash, golden willow.	Eastern cottonwood, silver maple.
456-----Wilmonton	---	Tatarian honeysuckle, redosier dogwood, lilac.	Amur maple, blue spruce, white spruce, northern white-cedar.	Hackberry, green ash, eastern white pine, Austrian pine.	Silver maple.
474B, 474C2-----Bolan	Lilac, Russian-olive, Tatarian honeysuckle, Siberian peashrub.	Eastern redcedar, Manchurian crabapple, hackberry.	Honeylocust, green ash, eastern white pine, bur oak.	---	---
485, 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.

See footnote at end of table.

TABLE 7.--WINDBREAKS AND ENVIRONMENTAL PLANTINGS--Continued

Soil name and map symbol	Trees having predicted 20-year average heights, in feet, of--				
	<8	8-15	16-25	26-35	>35
511. Blue Earth	---	Northern white-cedar, lilac, Tatarian honeysuckle, Siberian peashrub.	Hackberry, bur oak, white spruce, eastern redcedar.	Green ash, golden willow, green ash.	Eastern cottonwood.
559. Talcot	---	Northern white-cedar, Tatarian honeysuckle, Siberian peashrub, lilac.	Hackberry, white spruce, bur oak, eastern redcedar.	Green ash, golden willow, honeylocust.	Eastern cottonwood.
577, 577B, 577C2. Everly	---	Redosier dogwood, Siberian peashrub, gray dogwood, lilac.	Blue spruce, Russian-olive, eastern redcedar, Amur maple, hackberry, northern white-cedar.	Green ash, eastern white pine.	---
655. Crippin	---	Northern white-cedar, Tatarian honeysuckle, Siberian peashrub, lilac.	Hackberry, white spruce, eastern redcedar, bur oak.	Golden willow, green ash, honeylocust.	Eastern cottonwood.
733. Calco	Lilac	Siberian peashrub, Tatarian honeysuckle.	Hackberry, ponderosa pine, eastern redcedar, Russian-olive.	Green ash, honeylocust, green ash, golden willow.	Eastern cottonwood.
878, 878B. Ocheyedan	---	Redosier dogwood, Siberian peashrub, gray dogwood, lilac.	Northern white-cedar, hackberry, Russian-olive, Amur maple, blue spruce.	Eastern white pine, ponderosa pine, green ash.	---
879. Fostoria	---	Tatarian honeysuckle, redosier dogwood, lilac.	Amur maple, blue spruce, white spruce, northern white-cedar.	Hackberry, green ash, eastern white pine, Austrian pine.	Silver maple.
1202. Cylinder Variant	---	Tatarian honeysuckle, Siberian peashrub, lilac, northern white-cedar.	Bur oak, hackberry, eastern redcedar, white spruce.	Green ash, golden willow, honeylocust.	Eastern cottonwood.
1384B, 1384C. Collinwood Variant	---	Redosier dogwood, gray dogwood, Siberian peashrub, lilac.	Northern white-cedar, blue spruce, Russian-olive, hackberry, Amur maple, eastern redcedar.	Eastern white pine, green ash.	---
1458. Millington	---	Northern white-cedar, Tatarian honeysuckle, lilac, Siberian peashrub.	Hackberry, white spruce, bur oak, eastern redcedar.	Honeylocust, golden willow, green ash.	Eastern cottonwood.
1511. Blue Earth					
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, erodes easily.	Severe: ponding.
27B------------------ Terril	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
27C------------------ Terril	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
28B------------------ Dickman	Slight----------	Slight----------	Moderate: slope.	Slight----------	Moderate: droughty.
32------------------- Spicer	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
55------------------- Nicollet	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
62C2----------------- Storden	Slight----------	Slight----------	Severe: slope.	Slight----------	Slight.
62D, 62D2------------ Storden	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: slope.
62E------------------ Storden	Severe: slope.	Severe: slope.	Severe: slope.	Moderate: slope.	Severe: slope.
62G------------------ Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
72------------------- Estherville	Slight----------	Slight----------	Moderate: small stones.	Slight----------	Moderate: droughty.
72B------------------ Estherville	Slight----------	Slight----------	Moderate: slope, small stones.	Slight----------	Moderate: droughty.
72C2----------------- Estherville	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight----------	Moderate: droughty, slope.
73D------------------ Salida	Moderate: slope, small stones.	Moderate: slope, small stones.	Severe: slope, small stones.	Slight----------	Severe: droughty.
73E------------------ Salida	Severe: slope.	Severe: slope.	Severe: slope, small stones.	Moderate: slope.	Severe: droughty, slope.
73G------------------ Salida	Severe: slope.	Severe: slope.	Severe: slope, small stones.	Severe: slope.	Severe: droughty, slope.
77B------------------ Sac	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.
91------------------- Primghar	Slight----------	Slight----------	Slight----------	Slight----------	Slight.
91B------------------ Primghar	Slight----------	Slight----------	Moderate: slope.	Slight----------	Slight.

TABLE 8.--RECREATIONAL DEVELOPMENT--Continued

Soil name and map symbol	Camp areas	Picnic areas	Playgrounds	Paths and trails	Golf fairways
92: Marcus	Severe: wetness.	Moderate: wetness, percs slowly.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
95: Harps	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
107: Webster	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
108: Wadena	Slight	Slight	Moderate: small stones.	Slight	Slight.
108B: Wadena	Slight	Slight	Moderate: slope, small stones.	Slight	Slight.
108C: Wadena	Slight	Slight	Severe: slope.	Slight	Slight.
135: Coland	Severe: flooding, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, flooding.
138B: Clarion	Slight	Slight	Moderate: slope.	Slight	Slight.
138C, 138C2: Clarion	Slight	Slight	Severe: slope.	Slight	Slight.
138D, 138D2: Clarion	Moderate: slope.	Moderate: slope.	Severe: slope.	Slight	Moderate: slope.
201B*:					
Coland	Severe: flooding, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness, flooding.
Spillville	Severe: flooding.	Slight	Moderate: flooding.	Slight	Moderate: flooding.
202, 203: Cylinder	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Slight	Slight.
259: Biscay	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
274: Rolfe	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: excess humus, ponding.	Severe: ponding, excess humus.	Severe: ponding.
282: Ransom	Slight	Slight	Moderate: slope.	Slight	Slight.
308: Wadena	Slight	Slight	Moderate: small stones.	Slight	Slight.
308B: Wadena	Slight	Slight	Moderate: slope, small stones.	Slight	Slight.
330: Kingston	Slight	Slight	Moderate: 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
331 Madelia	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
384 Collinwood	Moderate: wetness.	Moderate: wetness.	Moderate: slope, wetness.	Slight	Slight.
390 Waldorf	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.
397 Letri	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.
456 Wilmonton	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: slope, percs slowly.	Slight	Slight.
474B Bolan	Slight	Slight	Moderate: slope.	Slight	Slight.
474C2 Bolan	Slight	Slight	Severe: slope.	Slight	Slight.
485 Spillville	Severe: flooding.	Slight	Moderate: flooding.	Slight	Moderate: flooding.
485B Spillville	Slight	Slight	Moderate: slope.	Slight	Slight.
507 Canisteo	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
511 Blue Earth	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Severe: ponding.
559 Talcot	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: wetness.
577 Everly	Slight	Slight	Slight	Slight	Slight.
577B Everly	Slight	Slight	Moderate: slope.	Slight	Slight.
577C2 Everly	Slight	Slight	Severe: slope.	Slight	Slight.
655 Crippin	Moderate: wetness.	Moderate: wetness.	Moderate: slope, wetness.	Slight	Slight.
733 Calco	Severe: flooding, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Moderate: flooding, wetness.
878 Ocheyedan	Slight	Slight	Slight	Slight	Slight.
878B Ocheyedan	Slight	Slight	Moderate: slope.	Slight	Slight.
879 Fostoria	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	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
1202------------------ Cylinder Variant	Moderate: wetness.	Moderate: wetness.	Moderate: wetness.	Slight----------	Slight.
1384B----------------- Collinwood Variant	Moderate: percs slowly.	Moderate: percs slowly.	Moderate: slope, percs slowly.	Slight----------	Slight.
1384C----------------- Collinwood Variant	Moderate: percs slowly.	Moderate: percs slowly	Severe: slope.	Slight----------	Slight.
1458------------------ Millington	Severe: flooding, wetness, excess humus.	Severe: wetness, excess humus.	Severe: excess humus, wetness, flooding.	Severe: wetness, excess humus.	Severe: wetness, flooding.
1511------------------ Blue Earth	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 POTENTIALS

[See text for definitions of "good," "fair," "poor," and "very poor." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herba-ceous plants	Hardwood trees	Conif-erous 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.
27B Terril	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
27C Terril	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
28B Dickman	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
32 Spicer	Good	Good	Fair	Fair	Poor	Good	Good	Good	Fair	Good.
55 Nicollet	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
62C2, 62D, 62D2, 62E Storden	Fair	Good	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
62G Storden	Poor	Fair	Good	Fair	Poor	Very poor.	Very poor.	Fair	Fair	Very poor.
72, 72B, 72C2 Estherville	Fair	Fair	Fair	Fair	Fair	Very poor.	Very poor.	Fair	Fair	Very poor.
73D Salida	Poor	Poor	Poor	Poor	Poor	Very poor.	Very poor.	Poor	Poor	Very poor.
73E, 73G Salida	Very poor.	Very poor.	Poor	Very poor.	Very poor.	Very poor.	Very poor.	Very poor.	Very poor.	Very poor.
77B Sac	Good	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
91, 91B Primghar	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
92 Marcus	Good	Good	Good	Fair	Poor	Good	Fair	Good	Fair	Fair.
95 Harps	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
107 Webster	Good	Good	Good	Fair	Poor	Good	Good	Good	Fair	Good.
108, 108B Wadena	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
108C Wadena	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.
135 Coland	Good	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.
138B Clarion	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
138C, 138C2, 138D, 138D2 Clarion	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.

TABLE 9.--WILDLIFE HABITAT POTENTIALS--Continued

Soil name and map symbol	Potential for habitat elements							Potential as habitat for--		
	Grain and seed crops	Grasses and legumes	Wild herbaceous plants	Hardwood trees	Coniferous plants	Wetland plants	Shallow water areas	Openland wildlife	Woodland wildlife	Wetland wildlife
201B*:										
Coland	Good	Good	Good	Fair	Fair	Good	Good	Good	Fair	Good.
Spillville	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
202, 203 Cylinder	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
259 Biscay	Good	Good	Good	Good	Fair	Good	Good	Good	Fair	Good.
274 Rolfe	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	Fair	Good.
282 Ransom	Good	Good	Fair	Good	Good	Poor	Poor	Good	Good	Poor.
308, 308B Wadena	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
330 Kingston	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
331 Madelia	Good	Good	Good	Good	Fair	Good	Good	Good	Fair	Good.
384 Collinwood	Fair	Fair	Fair	Good	Good	Poor	Fair	Fair	Good	Poor.
390 Waldorf	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
397 Letri	Fair	Fair	Fair	Fair	Fair	Good	Good	Fair	Fair	Good.
456 Wilmonton	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
474B Bolan	Fair	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
474C2 Bolan	Fair	Fair	Good	Good	Good	Very poor.	Very poor.	Fair	Good	Very poor.
485 Spillville	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
485B Spillville	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
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.
559 Talcot	Good	Good	Fair	Fair	Fair	Good	Good	Good	Fair	Good.
577, 577B Everly	Good	Good	Good	Good	Good	Poor	Very poor.	Good	Good	Very poor.
577C2 Everly	Fair	Good	Good	Good	Good	Very poor.	Very poor.	Good	Good	Very poor.

See footnote at end of table.

TABLE 9.--WILDLIFE HABITAT POTENTIALS--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
655 Crippin	Good	Good	Good	Good	Fair	Fair	Poor	Good	Good	Poor.
733 Calco	Good	Fair	Good	Poor	Very poor.	Good	Good	Fair	Poor	Fair.
878, 878B Ocheyedan	Good	Good	Good	Good	Good	Poor	Poor	Good	Good	Poor.
879 Fostoria	Good	Good	Good	Good	Good	Fair	Fair	Good	Good	Fair.
1202 Cylinder Variant	Good	Good	Good	Good	Fair	Fair	Fair	Good	Good	Fair.
1384B, 1384C Collinwood Variant	Good	Good	Good	Fair	Fair	Poor	Fair	Good	Fair	Fair.
1458 Millington	Good	Good	Good	Good	Fair	Good	Good	Good	Good	Poor.
1511 Blue Earth	Fair	Fair	Fair	Fair	Poor	Good	Good	Fair	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]

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.
27B Terril	Slight	Slight	Slight	Slight	Severe: low strength.	Slight.
27C Terril	Slight	Slight	Slight	Moderate: slope.	Severe: low strength.	Slight.
28B Dickman	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Moderate: droughty.
32 Spicer	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: frost action, low strength.	Moderate: wetness.
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.
62D, 62D2 Storden	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
62E, 62G Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.
72, 72B Estherville	Severe: cutbanks cave.	Slight	Slight	Slight	Slight	Moderate: droughty.
72C2 Estherville	Severe: cutbanks cave.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: droughty, slope.
73D Salida	Severe: cutbanks cave.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope.	Severe: droughty.
73E, 73G Salida	Severe: cutbanks cave, slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Severe: droughty, slope.
77B Sac	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
91, 91B Primghar	Moderate: wetness.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: low strength, frost action, shrink-swell.	Slight.
92 Marcus	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: low strength, frost action, shrink-swell.	Moderate: wetness.
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.

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
108, 108B----------- Wadena	Severe: cutbanks cave.	Slight-----------	Slight-----------	Slight-----------	Slight-----------	Slight.
108C--------------- Wadena	Severe: cutbanks cave.	Slight-----------	Slight-----------	Moderate: slope.	Slight-----------	Slight.
135---------------- Coland	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, low strength, frost action.	Moderate: wetness, flooding.
138B--------------- Clarion	Slight-----------	Slight-----------	Slight-----------	Slight-----------	Moderate: frost action.	Slight.
138C, 138C2-------- Clarion	Slight-----------	Slight-----------	Slight-----------	Moderate: slope.	Moderate: frost action.	Slight.
138D, 138D2-------- Clarion	Moderate: slope.	Moderate: slope.	Moderate: slope.	Severe: slope.	Moderate: slope, frost action.	Moderate: slope.
201B*:						
Coland------------	Severe: wetness.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, wetness, shrink-swell.	Severe: flooding, low strength, frost action.	Moderate: wetness, flooding.
Spillville--------	Moderate: flooding, wetness.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding.	Moderate: flooding.
202, 203----------- Cylinder	Severe: cutbanks cave, wetness.	Moderate: shrink-swell, wetness.	Severe: wetness.	Moderate: shrink-swell, wetness.	Severe: frost action.	Slight.
259---------------- Biscay	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
274---------------- Rolfe	Severe: ponding.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: ponding, shrink-swell.	Severe: low strength, ponding, frost action.	Severe: ponding.
282---------------- Ransom	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
308, 308B---------- Wadena	Severe: cutbanks cave.	Slight-----------	Slight-----------	Slight-----------	Slight-----------	Slight.
330---------------- Kingston	Moderate: wetness.	Slight-----------	Moderate: wetness.	Slight-----------	Severe: frost action.	Slight.
331---------------- Madelia	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
384---------------- Collinwood	Severe: wetness.	Severe: shrink-swell.	Severe: wetness, shrink-swell.	Severe: shrink-swell.	Severe: low strength, frost action.	Slight.
390---------------- Waldorf	Severe: wetness.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: wetness, shrink-swell.	Severe: low strength, wetness, frost action.	Severe: wetness.

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
397 Letri	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, wetness, frost action.	Severe: wetness.
456 Wilmonton	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness, shrink-swell.	Moderate: shrink-swell.	Severe: low strength, frost action.	Slight.
474B Bolan	Severe: cutbanks cave.	Slight	Slight	Slight	Moderate: frost action.	Slight.
474C2 Bolan	Severe: cutbanks cave.	Slight	Slight	Moderate: slope.	Moderate: frost action.	Slight.
485 Spillville	Moderate: flooding, wetness.	Severe: flooding.	Severe: flooding.	Severe: flooding.	Severe: low strength, flooding.	Moderate: flooding.
485B Spillville	Moderate: wetness.	Moderate: shrink-swell.	Moderate: wetness, shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Slight.
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.
559 Talcot	Severe: cutbanks cave, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: low strength, frost action.	Moderate: wetness.
577, 577B Everly	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell.	Severe: low strength.	Slight.
577C2 Everly	Slight	Moderate: shrink-swell.	Moderate: shrink-swell.	Moderate: shrink-swell, slope.	Severe: low strength.	Slight.
655 Crippin	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Severe: frost action, low strength.	Slight.
733 Calco	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: low strength, flooding.	Moderate: flooding, wetness.
878, 878B Ocheyedan	Slight	Slight	Slight	Slight	Moderate: frost action.	Slight.
879 Fostoria	Severe: wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Severe: frost action, low strength.	Slight.
1202 Cylinder Variant	Severe: cutbanks cave, wetness.	Moderate: wetness.	Severe: wetness.	Moderate: wetness.	Severe: frost action.	Slight.
1384B, 1384C Collinwood Variant	Moderate: too clayey.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: shrink-swell.	Severe: low strength, shrink-swell.	Slight.
1458 Millington	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Severe: low strength, wetness, flooding.	Severe: wetness, flooding.

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
1511 Blue Earth	Severe: excess humus, ponding.	Severe: ponding, low strength.	Severe: ponding.	Severe: ponding, low strength.	Severe: low strength, ponding, frost action.	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," "moderate," "good," "fair," and other terms. Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Septic tank absorption fields	Sewage lagoon areas	Trench sanitary landfill	Area sanitary landfill	Daily cover for landfill
6-------------------- Okoboji	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: hard to pack, ponding.
27B------------------ Terril	Slight------------	Moderate: seepage, slope.	Slight------------	Slight------------	Good.
27C------------------ Terril	Slight------------	Severe: slope.	Slight------------	Slight------------	Good.
28B------------------ Dickman	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
32------------------- Spicer	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
55------------------- Nicollet	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
62C2----------------- Storden	Slight------------	Severe: slope.	Slight------------	Slight------------	Good.
62D, 62D2------------ Storden	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
62E, 62G------------- Storden	Severe: slope.	Severe: slope.	Severe: slope.	Severe: slope.	Poor: slope.
72, 72B-------------- Estherville	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
72C2----------------- Estherville	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
73D------------------ Salida	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
73E, 73G------------- Salida	Severe: poor filter, slope.	Severe: seepage, slope.	Severe: seepage, slope, too sandy.	Severe: seepage, slope.	Poor: seepage, too sandy, small stones.
77B------------------ Sac	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight------------	Fair: too clayey.
91, 91B-------------- Primghar	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: hard to pack.
92------------------- Marcus	Severe: percs slowly, wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness, hard to pack.
95------------------- Harps	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: hard to pack, 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
107 Webster	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
108, 108B Wadena	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
108C Wadena	Severe: poor filter.	Severe: seepage, slope.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
135 Coland	Severe: flooding, wetness.	Severe: flooding, wetness, seepage.	Severe: flooding, wetness, seepage.	Severe: flooding, wetness.	Poor: wetness, hard to pack.
138B Clarion	Slight	Moderate: slope, seepage.	Slight	Slight	Good.
138C, 138C2 Clarion	Slight	Severe: slope.	Slight	Slight	Good.
138D, 138D2 Clarion	Moderate: slope.	Severe: slope.	Moderate: slope.	Moderate: slope.	Fair: slope.
201B*:					
Coland	Severe: flooding, wetness.	Severe: flooding, wetness, seepage.	Severe: flooding, wetness, seepage.	Severe: flooding, wetness.	Poor: wetness, hard to pack.
Spillville	Severe: wetness, flooding.	Severe: wetness, seepage, flooding.	Severe: wetness, seepage, flooding.	Severe: wetness, flooding.	Fair: wetness.
202, 203 Cylinder	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: too sandy, seepage.
259 Biscay	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, small stones.
274 Rolfe	Severe: ponding, percs slowly.	Severe: ponding.	Severe: ponding.	Severe: ponding.	Poor: ponding.
282 Ransom	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: too clayey, wetness.
308, 308B Wadena	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy, small stones.
330 Kingston	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness, too clayey.
331 Madelia	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.

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
384----------------- Collinwood	Severe: wetness, percs slowly.	Moderate: slope.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack.
390----------------- Waldorf	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness, too clayey.	Severe: wetness.	Poor: too clayey, hard to pack, wetness.
397----------------- Letri	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
456----------------- Wilmonton	Severe: wetness, percs slowly.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: too clayey, wetness.
474B---------------- Bolan	Severe: poor filter.	Severe: seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
474C2--------------- Bolan	Severe: poor filter.	Severe: slope, seepage.	Severe: seepage, too sandy.	Severe: seepage.	Poor: seepage, too sandy.
485----------------- Spillville	Severe: wetness, flooding.	Severe: wetness, seepage, flooding.	Severe: wetness, seepage, flooding.	Severe: wetness, flooding.	Fair: wetness.
485B---------------- Spillville	Severe: wetness.	Severe: seepage, wetness.	Severe: seepage, wetness.	Severe: wetness.	Fair: wetness.
507----------------- Canisteo	Severe: wetness.	Severe: seepage, wetness.	Severe: wetness.	Severe: wetness.	Poor: wetness.
511----------------- Blue Earth	Severe: ponding.	Severe: ponding.	Severe: ponding, excess humus.	Severe: ponding.	Poor: hard to pack, ponding.
559----------------- Talcot	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness, too sandy.	Severe: seepage, wetness.	Poor: seepage, too sandy, wetness.
577----------------- Everly	Moderate: percs slowly.	Moderate: seepage.	Moderate: too clayey.	Slight-----------	Fair: too clayey.
577B---------------- Everly	Moderate: percs slowly.	Moderate: seepage, slope.	Moderate: too clayey.	Slight-----------	Fair: too clayey.
577C2--------------- Everly	Moderate: percs slowly.	Severe: slope.	Moderate: too clayey.	Slight-----------	Fair: too clayey.
655----------------- Crippin	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
733----------------- Calco	Severe: wetness, flooding.	Severe: wetness.	Severe: wetness, flooding.	Severe: wetness, flooding.	Poor: wetness.
878----------------- Ocheyedan	Slight-----------	Moderate: seepage.	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
878B: Ocheyedan	Slight	Moderate: slope, seepage.	Slight	Slight	Good.
879: Fostoria	Severe: wetness.	Severe: wetness.	Severe: wetness.	Severe: wetness.	Fair: wetness.
1202: Cylinder Variant	Severe: wetness, poor filter.	Severe: seepage, wetness.	Severe: seepage, wetness.	Severe: seepage, wetness.	Poor: seepage.
1384B: Collinwood Variant	Severe: percs slowly.	Moderate: seepage, slope.	Severe: too clayey.	Slight	Poor: too clayey, hard to pack.
1384C: Collinwood Variant	Severe: percs slowly.	Severe: slope.	Severe: too clayey.	Slight	Poor: too clayey, hard to pack.
1458: Millington	Severe: flooding, wetness.	Severe: wetness.	Severe: flooding, wetness.	Severe: flooding, wetness.	Poor: wetness.
1511: Blue Earth	Severe: ponding.	Severe: ponding, excess humus.	Severe: ponding, excess humus.	Severe: 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," "poor," "probable," and "improbable." Absence of an entry indicates that the soil was not rated]

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
6 Okoboji	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
27B, 27C Terril	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
28B Dickman	Good	Probable	Improbable: too sandy.	Poor: thin layer.
32 Spicer	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
55 Nicollet	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
62C2 Storden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
62D, 62D2 Storden	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones, slope.
62E Storden	Fair: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
62G Storden	Poor: slope.	Improbable: excess fines.	Improbable: excess fines.	Poor: slope.
72, 72B, 72C2 Estherville	Good	Probable	Probable	Poor: small stones, area reclaim.
73D Salida	Good	Probable	Probable	Poor: small stones, area reclaim, too sandy.
73E Salida	Fair: slope.	Probable	Probable	Poor: small stones, area reclaim, too sandy.
73G Salida	Poor: slope.	Probable	Probable	Poor: small stones, area reclaim, too sandy.
77B Sac	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
91, 91B Primghar	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
92 Marcus	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
95 Harps	Fair: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: large stones.

TABLE 12.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
107 Webster	Fair: low strength, wetness, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Good.
108, 108B, 108C Wadena	Good	Probable	Probable	Poor: small stones, area reclaim.
135 Coland	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
138B, 138C, 138C2 Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
138D, 138D2 Clarion	Good	Improbable: excess fines.	Improbable: excess fines.	Fair: slope.
201B*:				
Coland	Fair: wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
Spillville	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
202, 203 Cylinder	Fair: wetness.	Probable	Probable	Fair: area reclaim, small stones, thin layer.
259 Biscay	Fair: wetness.	Probable	Probable	Fair: area reclaim, small stones, thin layer.
274 Rolfe	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer, wetness.
282 Ransom	Fair: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey, small stones.
308, 308B Wadena	Good	Probable	Probable	Poor: small stones, area reclaim.
330 Kingston	Fair: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
331 Madelia	Fair: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
384 Collinwood	Poor: low strength, shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Fair: too clayey.
390 Waldorf	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
397 Letri	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
456 Wilmonton	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.

See footnote at end of table.

TABLE 12.--CONSTRUCTION MATERIALS--Continued

Soil name and map symbol	Roadfill	Sand	Gravel	Topsoil
474B, 474C2 Bolan	Good	Probable	Improbable: too sandy.	Good.
485, 485B Spillville	Good	Improbable: excess fines.	Improbable: excess fines.	Good.
507 Canisteo	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
511 Blue Earth	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
559 Talcot	Fair: wetness.	Probable	Probable	Fair: small stones, area reclaim, thin layer.
577, 577B, 577C2 Everly	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Fair: small stones.
655 Crippin	Fair: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Good.
733 Calco	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
878, 878B Ocheyedan	Fair: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
879 Fostoria	Poor: low strength.	Improbable: excess fines.	Improbable: excess fines.	Good.
1202 Cylinder Variant	Fair: wetness.	Probable	Probable	Fair: small stones, area reclaim, thin layer.
1384B, 1384C Collinwood Variant	Fair: shrink-swell.	Improbable: excess fines.	Improbable: excess fines.	Poor: thin layer.
1458 Millington	Poor: low strength, wetness.	Improbable: excess fines.	Improbable: excess fines.	Poor: wetness.
1511 Blue Earth	Poor: low strength, 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]

Soil name and map symbol	Limitations for-- Pond reservoir areas	Limitations for-- Embankments, dikes, and levees	Features affecting-- Drainage	Features affecting-- Irrigation	Features affecting-- Terraces and diversions	Features affecting-- Grassed waterways
6: Okoboji	Moderate: seepage.	Severe: ponding.	Ponding, frost action.	Ponding, erodes easily.	Erodes easily, ponding.	Wetness, erodes easily.
27B, 27C: Terril	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Slope	Favorable	Favorable.
28B: Dickman	Severe: seepage.	Severe: seepage.	Deep to water	Droughty, soil blowing, slope.	Too sandy, soil blowing.	Droughty.
32: Spicer	Moderate: seepage.	Severe: wetness.	Frost action	Wetness	Wetness	Wetness.
55: Nicollet	Moderate: seepage.	Severe: piping.	Frost action	Wetness	Wetness	Favorable.
62C2: Storden	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Slope	Erodes easily	Erodes easily.
62D, 62D2, 62E, 62G: Storden	Severe: slope.	Moderate: piping.	Deep to water	Slope	Slope, erodes easily.	Slope, erodes easily.
72: Estherville	Severe: seepage.	Severe: seepage.	Deep to water	Droughty	Too sandy	Droughty.
72B: Estherville	Severe: seepage.	Severe: seepage.	Deep to water	Droughty, slope.	Too sandy	Droughty.
72C2: Estherville	Severe: seepage, slope.	Severe: seepage.	Deep to water	Droughty, slope.	Slope, too sandy.	Slope, droughty.
73D, 73E, 73G: Salida	Severe: seepage, slope.	Severe: seepage.	Deep to water	Droughty, fast intake, slope.	Slope, too sandy.	Slope, droughty.
77B: Sac	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Rooting depth, slope.	Erodes easily	Erodes easily, rooting depth.
91: Primghar	Moderate: seepage.	Severe: piping.	Deep to water	Favorable	Erodes easily	Erodes easily.
91B: Primghar	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope	Erodes easily	Erodes easily.
92: Marcus	Moderate: seepage.	Severe: hard to pack, wetness.	Frost action	Wetness	Wetness, erodes easily.	Wetness, erodes easily.
95: Harps	Moderate: seepage.	Severe: wetness.	Frost action	Wetness	Wetness	Wetness.
107: Webster	Moderate: seepage.	Severe: wetness.	Frost action	Wetness	Wetness	Wetness.
108: Wadena	Severe: seepage.	Severe: seepage, piping.	Deep to water	Favorable	Too sandy	Favorable.
108B, 108C: Wadena	Severe: seepage.	Severe: seepage, piping.	Deep to water	Slope	Too sandy	Favorable.

TABLE 13.--WATER MANAGEMENT--Continued

Soil name and map symbol	Limitations for--		Features affecting--			
	Pond reservoir areas	Embankments, dikes, and levees	Drainage	Irrigation	Terraces and diversions	Grassed waterways
135 Coland	Moderate: seepage.	Severe: wetness.	Flooding, frost action.	Wetness, flooding.	Wetness	Wetness.
138B, 138C, 138C2 Clarion	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope	Erodes easily	Erodes easily.
138D, 138D2 Clarion	Severe: slope.	Severe: piping.	Deep to water	Slope	Slope, erodes easily.	Slope, erodes easily.
201B*:						
Coland	Moderate: seepage.	Severe: wetness.	Flooding, frost action.	Wetness, flooding.	Wetness	Wetness.
Spillville	Moderate: seepage.	Moderate: piping, wetness.	Deep to water	Flooding	Favorable	Favorable.
202, 203 Cylinder	Severe: seepage.	Severe: seepage, piping.	Frost action, cutbanks cave.	Wetness	Wetness, too sandy.	Favorable.
259 Biscay	Severe: seepage.	Severe: seepage, wetness.	Frost action, cutbanks cave.	Wetness	Wetness, too sandy.	Wetness.
274 Rolfe	Moderate: seepage.	Severe: ponding.	Ponding, percs slowly, frost action.	Ponding, percs slowly.	Ponding	Wetness, percs slowly.
282 Ransom	Moderate: seepage.	Severe: piping.	Frost action	Wetness	Erodes easily, wetness.	Erodes easily.
308 Wadena	Severe: seepage.	Severe: seepage, piping.	Deep to water	Favorable	Too sandy	Favorable.
308B Wadena	Severe: seepage.	Severe: seepage, piping.	Deep to water	Slope	Too sandy	Favorable.
330 Kingston	Moderate: seepage.	Severe: piping.	Frost action	Wetness	Erodes easily, wetness.	Erodes easily.
331 Madelia	Moderate: seepage.	Severe: wetness, piping.	Frost action	Wetness	Erodes easily, wetness.	Wetness, erodes easily.
384 Collinwood	Slight	Severe: hard to pack.	Percs slowly, frost action.	Wetness, percs slowly.	Wetness, percs slowly.	Percs slowly.
390 Waldorf	Moderate: seepage.	Severe: hard to pack, wetness.	Frost action	Wetness	Wetness	Wetness.
397 Letri	Moderate: seepage.	Severe: piping, wetness.	Frost action	Wetness	Wetness	Wetness.
456 Wilmonton	Slight	Moderate: piping, wetness.	Frost action	Wetness	Erodes easily, wetness.	Erodes easily.
474B, 474C2 Bolan	Severe: seepage.	Severe: seepage, piping.	Deep to water	Slope	Too sandy	Favorable.
485 Spillville	Moderate: seepage.	Moderate: piping, wetness.	Deep to water	Flooding	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	Features affecting-- Drainage	Irrigation	Terraces and diversions	Grassed waterways
485B: Spillville	Moderate: seepage, slope.	Moderate: thin layer, piping, wetness.	Deep to water	Slope	Favorable	Favorable.
507: Canisteo	Severe: seepage.	Severe: wetness.	Frost action	Wetness	Wetness	Wetness.
511: Blue Earth	Moderate: seepage.	Severe: piping, excess humus, ponding.	Ponding, frost action.	Ponding	Ponding	Wetness.
559: Talcot	Severe: seepage.	Severe: seepage, wetness.	Frost action, cutbanks cave.	Wetness	Wetness, too sandy.	Wetness.
577: Everly	Moderate: seepage.	Moderate: piping.	Deep to water	Rooting depth	Favorable	Rooting depth.
577B, 577C2: Everly	Moderate: seepage, slope.	Moderate: piping.	Deep to water	Rooting depth, slope.	Favorable	Rooting depth.
655: Crippin	Moderate: seepage.	Moderate: wetness.	Frost action	Wetness	Wetness, erodes easily.	Erodes easily.
733: Calco	Moderate: seepage.	Severe: wetness.	Flooding, frost action.	Flooding, wetness.	Wetness	Wetness.
878: Ocheyedan	Moderate: seepage.	Severe: piping.	Deep to water	Favorable	Favorable	Favorable.
878B: Ocheyedan	Moderate: seepage, slope.	Severe: piping.	Deep to water	Slope	Favorable	Favorable.
879: Fostoria	Moderate: seepage.	Moderate: wetness, piping.	Frost action	Wetness	Wetness, erodes easily.	Erodes easily.
1202: Cylinder Variant	Severe: seepage.	Severe: seepage, piping.	Frost action, cutbanks cave.	Wetness	Wetness, too sandy.	Favorable.
1384B, 1384C: Collinwood Variant	Moderate: seepage, slope.	Moderate: thin layer, hard to pack.	Deep to water	Slope	Erodes easily	Erodes easily.
1458: Millington	Moderate: seepage.	Severe: piping, wetness.	Flooding, frost action.	Wetness, flooding.	Wetness	Wetness.
1511: Blue Earth	Moderate: seepage.	Severe: piping, excess humus, ponding.	Ponding, frost action.	Ponding, soil blowing.	Ponding, soil blowing.	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	0-7	Silty clay loam	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	7-32	Silty clay loam	CH	A-7	0	100	100	90-100	80-95	55-65	30-40
	32-56	Silty clay loam	CH	A-7	0	95-100	95-100	90-100	80-95	55-65	30-40
	56-60	Stratified loam to silty clay loam.	CL, CH	A-7	0-5	95-100	90-100	90-100	65-90	40-55	20-30
27B, 27C--------- Terril	0-24	Loam-------------	CL	A-6	0-5	100	95-100	70-90	60-80	30-40	10-20
	24-60	Clay loam, loam	CL	A-6	0-5	100	100	85-95	65-85	25-40	10-20
28B-------------- Dickman	0-12	Fine sandy loam	SM, SM-SC	A-2, A-4	0	95-100	95-100	55-95	30-50	20-30	2-8
	12-29	Sandy loam, fine sandy loam, loamy fine sand.	SM, SM-SC	A-2, A-4	0	95-100	85-100	55-95	25-45	15-25	2-8
	29-60	Stratified fine sand to coarse sand.	SP-SM	A-3, A-2	0	95-100	75-95	50-80	5-10	---	NP
32---------------- Spicer	0-15	Silty clay loam	ML	A-7, A-6	0	100	100	95-100	90-100	35-50	10-20
	15-30	Silt loam, silty clay loam.	ML	A-7, A-6	0	100	100	95-100	85-100	35-50	10-20
	30-60	Silt loam, silty clay loam.	ML	A-4, A-6	0	100	100	95-100	85-100	30-40	5-12
55---------------- Nicollet	0-18	Loam, clay loam	OL, ML, CL	A-6, A-7	0	95-100	95-100	85-95	55-85	35-50	10-25
	18-30	Clay loam, loam	CL	A-6, A-7	0-5	95-100	95-100	80-95	55-80	35-50	15-25
	30-60	Loam-------------	CL, ML	A-6, A-4	0-5	95-100	90-100	75-90	50-75	30-40	5-15
62C2, 62D, 62D2, 62E, 62G--------- Storden	0-6	Loam-------------	ML, CL	A-4, A-6	0-5	95-100	95-100	70-85	55-70	30-40	5-15
	6-60	Loam-------------	CL-ML, CL	A-4, A-6	0-5	95-100	85-97	70-85	55-70	20-40	5-15
72, 72B, 72C2---- Estherville	0-10	Loam-------------	CL-ML, CL	A-4, A-6	0-5	90-100	80-100	50-75	50-60	25-40	4-15
	10-18	Sandy loam, loam, gravelly sandy loam.	SM, SM-SC, SC	A-2, A-4, A-1	0-5	85-100	80-95	40-75	15-45	20-30	2-8
	18-60	Coarse sand, gravelly loamy sand, gravelly sand.	SP, SP-SM, SM	A-1	0-10	55-90	50-85	10-40	2-25	---	NP
73D, 73E, 73G---- Salida	0-7	Gravelly sandy loam, gravelly loamy sand.	SM, SP-SM	A-2, A-1	0-5	85-95	60-75	30-60	12-20	---	NP
	7-15	Gravelly loamy sand, gravelly coarse sand, gravelly sand.	SP, SW, GP, GP-GM	A-1	0-5	50-90	40-60	10-30	0-5	---	NP
	15-60	Gravelly coarse sand, very gravelly sand, gravelly sand.	SP, SW, GP, GP-GM	A-1	0-5	20-70	20-60	5-30	0-5	---	NP
77B-------------- Sac	0-13	Silty clay loam	ML, CL, MH, CH	A-7	0	100	100	95-100	90-100	40-55	15-25
	13-30	Silty clay loam	CL	A-7	0	100	100	95-100	90-100	40-50	15-25
	30-60	Clay loam, loam	CL	A-6	0-5	95-100	90-100	75-90	65-80	30-40	11-20
91, 91B---------- Primghar	0-20	Silty clay loam	MH, CH	A-7	0	100	100	95-100	90-100	50-60	20-30
	20-34	Silty clay loam	CL, CH	A-7	0	100	100	95-100	90-100	40-55	20-30
	34-48	Silt loam--------	CL	A-6	0	100	100	95-100	90-100	30-40	11-20
	48-60	Clay loam, gravelly loam, loam.	CL, CL-ML	A-4, A-6	0-5	80-100	75-95	70-95	55-75	25-40	5-15

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	
92 Marcus	0-16	Silty clay loam	MH, CH	A-7	0	100	100	95-100	90-100	50-65	20-35
	16-32	Silty clay loam, silty clay.	CH, MH	A-7	0	100	100	95-100	90-100	50-65	20-35
	32-46	Silt loam	CL	A-7	0	100	100	95-100	85-95	40-50	20-30
	46-60	Loam, clay loam, sandy loam.	CL, SM-SC	A-6	0-5	90-100	85-100	60-90	30-75	20-40	5-25
95 Harps	0-20	Loam, clay loam	CL, CL-ML, SC, CH	A-6, A-7	0-5	100	95-100	80-90	55-80	30-55	15-35
	20-38	Loam, clay loam, sandy clay loam.	CL, CH	A-6, A-7	0-5	95-100	95-100	80-90	55-80	30-60	15-35
	38-60	Loam	CL	A-6	0-5	95-100	90-100	70-80	50-75	25-40	10-25
107 Webster	0-17	Silty clay loam	CL, CH	A-7, A-6	0-5	100	95-100	85-95	70-90	35-60	15-30
	17-35	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
	35-60	Loam, sandy loam, clay loam.	CL	A-6	0-5	95-100	90-100	75-85	50-75	30-40	10-20
108, 108B, 108C Wadena	0-15	Loam	ML, CL-ML	A-4	0	95-100	80-100	75-95	50-65	25-40	2-10
	15-24	Loam, clay loam, sandy loam.	SM-SC, CL-ML, CL, SC	A-4, A-6	0	95-100	80-100	75-95	45-70	25-40	5-12
	24-60	Gravelly sand, gravelly loamy sand, loamy sand.	SP, SP-SM, GP, GP-GM	A-1, A-3, A-2	0-5	45-100	40-95	10-80	2-10	---	NP
135 Coland	0-36	Silty clay loam, clay loam.	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	36-60	Loam, sandy loam, sandy clay loam.	CL, SC, CL-ML, SM-SC	A-4, A-6	0	100	90-100	60-70	40-60	20-40	5-15
138B, 138C, 138C2, 138D, 138D2 Clarion	0-15	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	95-100	95-100	75-90	50-75	25-40	5-15
	15-32	Loam, clay loam	CL, CL-ML	A-4, A-6	0-5	90-100	85-100	75-90	50-75	25-40	5-15
	32-60	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
201B*:											
Coland	0-36	Silty clay loam, clay loam.	CL, CH	A-7	0	100	100	95-100	65-80	45-55	20-30
	36-60	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	0-36	Loam	CL	A-6	0	100	95-100	85-95	60-80	25-40	10-20
	36-60	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
202 Cylinder	0-15	Loam	CL	A-6, A-7	0	100	90-100	80-100	50-75	30-50	10-25
	15-26	Loam, clay loam	CL, SC	A-6	0	95-100	80-100	80-95	45-70	30-40	10-20
	26-60	Gravelly coarse sand, loamy sand, gravelly loamy sand.	SP-SM, SM	A-1, A-2, A-3	0-10	75-95	40-95	20-55	5-25	---	NP
203 Cylinder	0-21	Loam	CL	A-6, A-7	0	100	90-100	80-100	50-75	30-50	10-25
	21-35	Loam, clay loam	CL, SC	A-6	0	95-100	80-100	80-95	45-70	30-40	10-20
	35-60	Gravelly sand, loamy sand, gravelly loamy sand.	SP-SM, SM	A-1, A-2, A-3	0-10	75-95	40-95	20-55	5-25	---	NP

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	
259-------------- Biscay	0-24	Clay loam--------	CL, ML	A-7, A-6	0	95-100	95-100	70-90	50-75	35-50	10-25
	24-34	Loam, clay loam, sandy loam.	CL, ML	A-6, A-7	0	95-100	90-100	70-90	50-75	30-50	10-20
	34-60	Stratified loamy sand to gravelly coarse sand.	SP, SP-SM, GP, GP-GM	A-1	0-5	45-95	35-95	20-45	2-10	---	NP
274-------------- Rolfe	0-17	Silty clay loam	OL, CL, ML	A-6, A-4	0	100	95-100	90-100	80-95	30-40	5-15
	17-46	Clay, silty clay, clay loam.	CH	A-7	0	100	95-100	90-100	75-95	50-65	25-35
	46-60	Clay loam, loam, sandy clay loam.	CL	A-7, A-6	0	95-100	90-100	80-90	55-75	30-45	10-20
282-------------- Ransom	0-20	Silty clay loam	OL, ML	A-7	0	100	100	95-100	80-95	40-50	10-20
	20-30	Silty clay loam, silt loam.	ML	A-6, A-7	0	95-100	90-100	85-100	75-95	35-50	10-20
	30-60	Silt loam, loam, clay loam.	ML, CL	A-4, A-6	0-5	95-100	85-100	75-95	55-80	30-40	5-15
308, 308B-------- Wadena	0-12	Loam-------------	ML, CL-ML	A-4	0	95-100	80-100	75-95	50-65	25-40	2-10
	12-39	Loam, sandy loam, clay loam.	SM-SC, ML, CL, SC	A-4, A-6	0	95-100	80-100	75-95	45-70	25-40	5-12
	39-60	Sand, gravelly loamy sand, gravelly sand.	SP, SP-SM, GP, GP-GM	A-1, A-3, A-2	0-5	45-100	40-95	10-80	2-10	---	NP
330-------------- Kingston	0-18	Silty clay loam	ML, OL, CL-ML, CL	A-4	0	100	100	95-100	85-100	30-40	10-25
	18-39	Silty clay loam, silt loam.	CL	A-6, A-7	0	100	100	95-100	85-100	35-45	10-20
	39-60	Silt loam, silty clay loam.	CL-ML, CL	A-4, A-6	0	100	100	95-100	85-100	25-35	5-15
331-------------- Madelia	0-17	Silty clay loam	ML	A-7	0	100	100	100	90-100	40-50	10-25
	17-32	Silty clay loam, silt loam.	CL	A-7, A-6	0	100	100	100	90-100	30-50	10-25
	32-60	Silt loam, silty clay loam.	ML, CL	A-6, A-4, A-7	0	100	100	100	90-100	30-50	5-25
384-------------- Collinwood	0-15	Silty clay loam	CL, CH, ML, MH	A-7	0	100	100	95-100	90-95	40-55	15-25
	15-40	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, silty clay loam, silt loam.	CH, CL	A-7, A-6	0	100	100	95-100	90-95	35-50	11-30
390-------------- Waldorf	0-10	Silty clay loam	ML, MH	A-7	0	100	100	95-100	90-100	45-65	14-30
	10-38	Silty clay, silty clay loam.	MH	A-7	0	100	100	95-100	95-100	50-70	20-35
	38-60	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
397-------------- Letri	0-20	Silty clay loam	CL	A-7	0	95-100	95-100	95-100	80-95	40-50	15-25
	20-32	Clay loam, silty clay loam.	CL	A-7	0	95-100	90-100	85-95	75-85	40-50	15-25
	32-60	Loam, clay loam	CL, ML	A-6, A-7, A-4	0-5	95-100	85-98	85-95	65-75	30-50	7-25
456-------------- Wilmonton	0-18	Silty clay loam	CL	A-6, A-7	0	100	92-100	85-97	60-90	30-50	12-25
	18-30	Clay loam, loam	CL	A-6, A-7	0-5	95-100	87-97	80-90	60-80	30-50	15-25
	30-60	Clay loam, loam	CL	A-6	0-5	95-100	87-97	75-85	55-75	25-40	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	
474B, 474C2------ Bolan	0-18	Loam-------------	CL, ML	A-4, A-6	0	100	100	85-95	50-70	30-40	5-15
	18-28	Loam-------------	CL, SC, CL-ML, SM-SC	A-4, A-6	0	100	100	80-90	40-55	25-35	5-15
	28-31	Fine sandy loam	SM, SM-SC, SC	A-4	0	100	100	80-90	35-50	15-25	2-8
	31-60	Loamy fine sand, fine sand.	SM, SP-SM	A-2	0	100	100	70-85	10-30	---	NP
485, 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	0-22	Silty clay loam	CL	A-7, A-6	0	100	100	90-100	85-100	35-50	15-25
	22-27	Clay loam, loam, silty clay loam.	CL	A-6, A-7	0	98-100	90-100	85-95	65-85	38-50	25-35
	27-38	Clay loam, loam, sandy loam.	CL, ML, SM, SC	A-6, A-4	0-5	90-100	80-95	60-90	40-80	30-40	5-15
	38-60	Clay loam, loam, silty clay loam.	CL	A-6	0-5	95-100	90-98	80-95	60-90	30-40	12-20
511-------------- Blue Earth	0-7	Mucky silt loam	OL, ML	A-5	0	95-100	95-100	85-95	80-95	41-50	2-8
	7-20	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
	20-60	Clay loam, loam, silty clay loam.	CL, ML	A-6, A-7	0	95-100	90-100	80-100	70-95	35-50	11-20
559-------------- Talcot	0-24	Silty clay loam, clay loam.	CL	A-7	0	100	100	80-90	60-85	40-50	15-25
	24-35	Clay loam, silty clay loam, loam.	CL	A-7	0-5	95-100	85-100	70-90	60-85	40-50	15-25
	35-60	Stratified loamy sand to gravelly coarse sand.	SP, SP-SM, SW	A-1	0	65-90	50-85	20-50	2-10	---	NP
577, 577B, 577C2- Everly	0-11	Clay loam--------	CL	A-6, A-7	0	100	95-100	85-95	65-80	30-45	10-20
	11-29	Clay loam, loam	CL	A-6, A-7	0	95-100	95-100	85-95	70-90	35-50	15-25
	29-60	Loam, clay loam	CL	A-6	0-5	90-100	85-95	75-85	60-80	30-40	10-20
655-------------- Crippin	0-16	Loam-------------	CL	A-6, A-7	0	95-100	95-100	80-90	60-80	30-45	10-20
	16-35	Loam, clay loam	CL	A-6	0-5	95-100	90-100	80-90	60-80	30-40	10-20
	35-60	Loam, clay loam	CL	A-6	0-5	90-100	85-100	75-90	55-80	30-40	10-20
733-------------- Calco	0-40	Silty clay loam	CH, CL	A-7	0	100	100	95-100	85-100	40-60	15-30
	40-60	Loam, clay loam, sandy loam.	CL	A-7, A-6	0	100	100	90-100	80-100	30-45	10-20
878, 878B-------- Ocheyedan	0-15	Loam-------------	CL	A-6	0	100	100	75-90	65-80	30-40	10-15
	15-37	Sandy clay loam, fine sandy loam, loam.	SC, CL, SM-SC, CL-ML	A-4, A-6	0	100	100	60-80	35-55	25-40	5-15
	37-60	Sandy loam, loam, silt loam.	CL-ML, CL	A-4, A-6	0	100	100	85-95	50-90	25-40	5-15
879-------------- Fostoria	0-17	Loam-------------	CL, CL-ML	A-4, A-6	0	100	100	95-100	80-95	25-40	5-15
	17-60	Silt loam, loam, clay loam.	CL	A-6	0-5	100	100	75-100	55-95	30-40	10-20
1202------------- Cylinder Variant	0-18	Loam-------------	CL	A-6	0	100	95-100	80-100	50-75	30-40	10-20
	18-27	Sandy clay loam, gravelly sandy loam.	CL, SC, SM-SC, CL-ML	A-6, A-4	0	95-100	80-100	80-95	45-70	25-40	5-15
	27-60	Gravelly loamy sand, gravelly sand.	SP-SM, SM	A-1, A-2, A-3	0-10	75-95	40-95	20-55	5-25	---	NP

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	
1384B, 1384C: Collinwood Variant	0-14	Silty clay loam	CL	A-7	0	100	100	95-100	90-95	40-50	15-25
	14-45	Silty clay loam, silty clay.	CH	A-7	0	100	100	95-100	90-95	50-65	20-35
	45-53	Silt loam, silty clay loam, loam.	CL, CH	A-5, A-6, A-7	0	100	100	95-100	90-100	35-60	11-30
	53-60	Loam, clay loam	CL, CL-ML	A-4, A-6	0	90-100	85-100	75-90	50-75	25-40	5-15
1458: Millington	0-34	Loam	ML, CL, OL	A-6, A-7, A-4	0	90-100	90-100	80-100	70-95	30-45	8-17
	34-60	Stratified loamy sand to silty clay loam.	CL, CL-ML	A-6, A-7, A-4	0	80-100	80-100	80-100	60-95	20-45	5-20
1511: Blue Earth	0-10	Muck	Pt	A-8	0	---	---	---	---	---	---
	10-24	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
	24-60	Clay loam, loam, silt loam.	CL, ML	A-6, A-7	0	95-100	90-100	80-100	70-95	35-50	11-20
5010*. Pits											
5040*. Orthents											

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 15.--PHYSICAL AND CHEMICAL PROPERTIES OF THE SOILS

[The symbol < means less than; > means more than. Entries under "Erosion factors--T" apply to the entire profile. Entries under "Wind erodibility group" and "Organic matter" apply only to the surface layer. Absence of an entry indicates that data were not available or were not estimated]

Soil name and map symbol	Depth	Clay	Moist bulk density	Permeability	Available water capacity	Soil reaction	Shrink-swell potential	Erosion factors K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	G/cm^3	In/hr	In/in	pH					Pct
6----------------- Okoboji	0-7	35-42	1.25-1.30	0.2-0.6	0.21-0.23	6.6-7.8	High----------	0.37	5	4	9-11
	7-32	35-42	1.30-1.35	0.2-0.6	0.18-0.20	6.6-7.8	High----------	0.37			
	32-56	35-45	1.35-1.40	0.2-0.6	0.18-0.20	7.4-8.4	High----------	0.37			
	56-60	20-30	1.40-1.50	0.6-2.0	0.18-0.20	7.4-8.4	Moderate------	0.28			
27B, 27C---------- Terril	0-24	18-26	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low-----------	0.24	5	6	4-5
	24-60	22-30	1.45-1.70	0.6-2.0	0.16-0.18	6.1-7.8	Low-----------	0.32			
28B--------------- Dickman	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	1-2
	12-29	6-18	1.35-1.50	2.0-6.0	0.12-0.14	5.6-7.3	Low-----------	0.20			
	29-60	1-10	1.50-1.60	6.0-20	0.02-0.07	5.6-7.8	Low-----------	0.15			
32---------------- Spicer	0-15	18-35	1.20-1.30	0.6-2.0	0.18-0.24	7.4-8.4	Moderate------	0.28	5	4L	6-7
	15-30	18-35	1.25-1.35	0.6-2.0	0.16-0.22	7.4-8.4	Moderate------	0.28			
	30-60	18-35	1.25-1.35	0.6-2.0	0.16-0.22	7.4-8.4	Low-----------	0.28			
55---------------- Nicollet	0-18	24-35	1.15-1.25	0.6-2.0	0.17-0.22	5.6-7.3	Moderate------	0.24	5	6	4-6
	18-30	24-35	1.25-1.35	0.6-2.0	0.15-0.19	5.6-7.8	Moderate------	0.32			
	30-60	22-28	1.35-1.45	0.6-2.0	0.14-0.19	7.4-7.8	Low-----------	0.32			
62C2, 62D, 62D2, 62E, 62G--------- Storden	0-6	18-27	1.35-1.45	0.6-2.0	0.20-0.22	7.4-8.4	Low-----------	0.28	5	4L	1-2
	6-60	18-27	1.35-1.65	0.6-2.0	0.17-0.19	7.4-8.4	Low-----------	0.37			
72, 72B, 72C2----- Estherville	0-10	10-18	1.35-1.45	2.0-6.0	0.19-0.22	5.6-7.3	Low-----------	0.20	3	5	1-4
	10-18	10-18	1.35-1.60	2.0-6.0	0.09-0.14	5.6-7.3	Low-----------	0.20			
	18-60	0-8	1.50-1.65	6.0-20	0.02-0.04	6.6-8.4	Low-----------	0.10			
73D, 73E, 73G----- Salida	0-7	5-15	1.35-1.45	2.0-6.0	0.10-0.12	6.1-8.4	Low-----------	0.10	3	3	.5-1
	7-15	2-8	1.50-1.65	>20	0.02-0.04	7.4-8.4	Low-----------	0.10			
	15-60	0-5	1.50-1.65	>20	0.02-0.04	7.4-8.4	Low-----------	0.10			
77B--------------- Sac	0-13	30-35	1.25-1.30	0.6-2.0	0.21-0.23	5.6-7.3	Moderate------	0.32	5	7	3-4
	13-30	30-39	1.30-1.35	0.6-2.0	0.18-0.20	6.1-7.3	Moderate------	0.43			
	30-60	22-30	1.60-1.80	0.6-2.0	0.14-0.16	6.6-8.4	Moderate------	0.43			
91, 91B----------- Primghar	0-20	35-39	1.25-1.30	0.6-2.0	0.21-0.23	5.6-7.3	High----------	0.28	5	4	5-6
	20-34	30-35	1.30-1.35	0.6-2.0	0.18-0.20	6.1-8.4	High----------	0.43			
	34-48	25-30	1.35-1.40	0.6-2.0	0.20-0.22	7.9-8.4	Moderate------	0.43			
	48-60	22-30	1.60-1.80	0.6-2.0	0.14-0.19	7.9-8.4	Low-----------	0.43			
92---------------- Marcus	0-16	36-42	1.30-1.35	0.2-0.6	0.21-0.23	6.1-7.8	High----------	0.28	5	4	6-7
	16-32	30-40	1.35-1.40	0.2-0.6	0.18-0.20	6.1-8.4	High----------	0.43			
	32-46	22-26	1.35-1.45	0.6-2.0	0.20-0.22	7.9-8.4	Moderate------	0.43			
	46-60	22-30	1.60-1.80	0.6-2.0	0.17-0.19	7.9-8.4	Moderate------	0.43			
95---------------- Harps	0-20	25-35	1.35-1.40	0.6-2.0	0.19-0.21	7.9-8.4	Moderate------	0.24	5	4L	4-5
	20-38	18-32	1.40-1.50	0.6-2.0	0.17-0.19	7.9-8.4	Moderate------	0.32			
	38-60	20-26	1.50-1.70	0.6-2.0	0.17-0.19	7.9-8.4	Moderate------	0.32			
107--------------- Webster	0-17	26-36	1.35-1.40	0.6-2.0	0.19-0.21	6.6-7.3	Moderate------	0.24	5	6	6-7
	17-35	25-35	1.40-1.50	0.6-2.0	0.16-0.18	6.6-7.8	Moderate------	0.32			
	35-60	18-29	1.50-1.70	0.6-2.0	0.17-0.19	7.4-8.4	Moderate------	0.32			
108, 108B, 108C--- Wadena	0-15	18-30	1.30-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Low-----------	0.24	4	6	3-4
	15-24	18-30	1.35-1.50	0.6-2.0	0.14-0.19	5.6-7.3	Low-----------	0.32			
	24-60	1-5	1.55-1.65	>6.0	0.02-0.04	6.6-8.4	Low-----------	0.10			

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 K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	G/cm3	In/hr	In/in	pH					Pct
135: Coland	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	5-7
	36-60	12-26	1.50-1.65	2.0-6.0	0.13-0.17	6.1-7.3	Low	0.28			
138B, 138C, 138C2, 138D, 138D2: Clarion	0-15	20-28	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low	0.28	5	6	2-4
	15-32	24-30	1.50-1.70	0.6-2.0	0.17-0.19	5.6-7.8	Low	0.37			
	32-60	12-22	1.70-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Low	0.37			
201B*:											
Coland	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	5-7
	36-60	12-26	1.50-1.65	2.0-6.0	0.13-0.17	6.1-7.3	Low	0.28			
Spillville	0-36	18-26	1.45-1.55	0.6-2.0	0.19-0.21	5.6-7.3	Moderate	0.28	5	6	4-6
	36-60	14-24	1.55-1.70	0.6-6.0	0.15-0.18	5.6-7.3	Low	0.28			
202: Cylinder	0-15	22-32	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Moderate	0.24	4	6	4-5
	15-26	22-30	1.45-1.60	0.6-2.0	0.17-0.19	6.1-7.3	Moderate	0.32			
	26-60	2-12	1.60-1.70	>20	0.02-0.04	7.4-8.4	Low	0.10			
203: Cylinder	0-21	22-32	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Moderate	0.24	4	6	4-5
	21-35	22-30	1.45-1.60	0.6-2.0	0.17-0.19	6.1-7.3	Moderate	0.32			
	35-60	2-12	1.60-1.70	>20	0.02-0.04	7.4-8.4	Low	0.10			
259: Biscay	0-24	18-30	1.20-1.30	0.6-2.0	0.20-0.22	6.1-7.8	Moderate	0.28	4	6	5-7
	24-34	18-30	1.25-1.35	0.6-2.0	0.17-0.19	6.6-7.8	Moderate	0.28			
	34-60	1-6	1.55-1.65	6.0-20	0.02-0.04	6.6-8.4	Low	0.10			
274: Rolfe	0-17	22-28	1.35-1.40	0.6-2.0	0.22-0.24	5.1-7.3	Moderate	0.28	5	6	4-5
	17-46	38-45	1.40-1.50	0.06-0.2	0.11-0.13	6.1-7.3	High	0.28			
	46-60	24-35	1.50-1.60	0.2-2.0	0.14-0.16	6.1-8.4	Moderate	0.28			
282: Ransom	0-20	24-38	1.20-1.30	0.6-2.0	0.18-0.22	6.6-7.3	Moderate	0.32	5	7	4-5
	20-30	24-38	1.25-1.35	0.6-2.0	0.16-0.19	6.6-7.8	Moderate	0.43			
	30-60	18-30	1.40-1.70	0.2-0.6	0.20-0.22	7.4-8.4	Low	0.43			
308, 308B: Wadena	0-12	18-30	1.30-1.50	0.6-2.0	0.20-0.22	6.1-7.3	Low	0.24	4	6	3-4
	12-39	18-30	1.35-1.50	0.6-2.0	0.14-0.19	5.6-7.3	Low	0.32			
	39-60	1-5	1.55-1.65	>6.0	0.02-0.04	6.6-8.4	Low	0.10			
330: Kingston	0-18	18-32	1.20-1.30	0.6-2.0	0.18-0.24	5.6-7.3	Low	0.28	5	7	5-6
	18-39	18-32	1.25-1.35	0.6-2.0	0.16-0.20	5.6-7.8	Moderate	0.37			
	39-60	18-32	1.25-1.35	0.6-2.0	0.16-0.20	7.4-8.4	Low	0.37			
331: Madelia	0-17	18-35	1.20-1.30	0.6-2.0	0.18-0.24	6.1-7.3	Moderate	0.28	5	6	6-7
	17-32	18-35	1.25-1.35	0.6-2.0	0.16-0.22	6.6-7.8	Moderate	0.28			
	32-60	18-32	1.30-1.40	0.6-2.0	0.16-0.22	7.4-8.4	Low	0.37			
384: Collinwood	0-15	35-45	1.20-1.30	0.2-0.6	0.14-0.17	5.6-7.3	Moderate	0.28	5	4	5-6
	15-40	40-45	1.25-1.35	0.06-0.6	0.13-0.16	5.6-7.3	High	0.28			
	40-60	24-45	1.25-1.35	0.06-0.6	0.11-0.15	7.4-8.4	High	0.28			
390: Waldorf	0-10	35-45	1.20-1.30	0.2-2.0	0.18-0.25	6.1-7.3	Moderate	0.28	5	4	6-7
	10-38	40-55	1.25-1.35	0.2-0.6	0.13-0.16	6.6-7.8	High	0.28			
	38-60	24-45	1.25-1.35	0.2-2.0	0.20-0.22	7.4-8.4	Moderate	0.28			
397: Letri	0-20	27-35	1.20-1.30	0.6-2.0	0.18-0.22	6.1-7.8	Moderate	0.28	5	7	6-8
	20-32	27-35	1.25-1.35	0.6-2.0	0.15-0.19	6.1-7.8	Moderate	0.28			
	32-60	22-32	1.40-1.70	0.2-0.6	0.17-0.19	6.6-8.4	Moderate	0.28			
456: Wilmonton	0-18	25-35	1.25-1.35	0.6-2.0	0.20-0.26	6.1-7.3	Moderate	0.28	5	6	5-6
	18-30	25-32	1.30-1.45	0.2-0.6	0.15-0.19	6.1-7.8	Moderate	0.28			
	30-60	22-32	1.45-1.70	0.2-0.6	0.14-0.19	7.4-8.4	Moderate	0.37			

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 K	Erosion factors T	Wind erodibility group	Organic matter
	In	Pct	G/cm^3	In/hr	In/in	pH					Pct
474B, 474C2------ Bolan	0-18	20-26	1.40-1.45	0.6-2.0	0.20-0.22	5.6-7.3	Low-----------	0.28	4	6	1-4
	18-28	14-20	1.45-1.50	0.6-2.0	0.17-0.19	5.6-6.5	Low-----------	0.28			
	28-31	10-15	1.50-1.60	2.0-6.0	0.11-0.13	6.1-7.3	Low-----------	0.28			
	31-60	2-8	1.60-1.70	6.0-20	0.08-0.10	6.1-7.3	Low-----------	0.17			
485, 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	4-5
	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	0-22	18-35	1.20-1.30	0.6-2.0	0.20-0.22	7.4-8.4	Moderate------	0.32	5	4L	6-7
	22-27	20-35	1.35-1.50	0.6-2.0	0.15-0.19	7.4-8.4	Moderate------	0.32			
	27-38	10-35	1.30-1.50	0.6-6.0	0.12-0.18	7.4-8.4	Low-----------	0.32			
	38-60	22-32	1.45-1.60	0.6-2.0	0.14-0.16	7.4-8.4	Low-----------	0.32			
511--------------- Blue Earth	0-7	18-32	0.20-0.80	0.6-6.0	0.18-0.24	7.4-8.4	Moderate------	0.28	5	4L	>15
	7-20	18-32	0.20-0.80	0.6-2.0	0.18-0.24	7.4-8.4	Low-----------	0.28			
	20-60	18-32	1.30-1.60	0.2-2.0	0.14-0.16	7.4-8.4	Moderate------	0.28			
559--------------- Talcot	0-24	27-35	1.20-1.30	0.6-2.0	0.18-0.22	7.4-8.4	Moderate------	0.28	4	4L	5-7
	24-35	25-35	1.25-1.35	0.6-2.0	0.17-0.20	7.4-8.4	Moderate------	0.28			
	35-60	1-6	1.55-1.65	6.0-20	0.02-0.04	7.4-8.4	Low-----------	0.15			
577, 577B, 577C2- Everly	0-11	25-30	1.40-1.45	0.6-2.0	0.17-0.19	5.6-7.3	Moderate------	0.24	5	6	2-4
	11-29	25-35	1.45-1.55	0.6-2.0	0.15-0.17	6.1-7.3	Moderate------	0.32			
	29-60	22-32	1.55-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Moderate------	0.32			
655--------------- Crippin	0-16	22-28	1.35-1.40	0.6-2.0	0.20-0.22	6.6-8.4	Low-----------	0.28	5	4L	4-6
	16-35	24-30	1.40-1.55	0.6-2.0	0.17-0.19	7.4-8.4	Low-----------	0.28			
	35-60	22-28	1.55-1.75	0.6-2.0	0.17-0.19	7.9-8.4	Low-----------	0.37			
733--------------- Calco	0-40	28-33	1.25-1.30	0.6-2.0	0.21-0.23	7.4-8.4	High----------	0.28	5	4L	5-7
	40-60	22-32	1.30-1.45	0.6-2.0	0.18-0.20	7.4-8.4	Moderate------	0.28			
878, 878B--------- Ocheyedan	0-15	24-27	1.40-1.45	0.6-2.0	0.20-0.22	5.1-7.3	Low-----------	0.24	5	6	3-4
	15-37	14-24	1.45-1.60	0.6-2.0	0.16-0.18	6.1-7.3	Low-----------	0.32			
	37-60	12-24	1.45-1.70	0.6-2.0	0.19-0.21	6.6-8.4	Low-----------	0.32			
879--------------- Fostoria	0-17	25-30	1.35-1.40	0.6-2.0	0.20-0.22	6.1-7.3	Low-----------	0.24	5	6	5-6
	17-60	16-26	1.40-1.75	0.6-2.0	0.20-0.22	7.4-8.4	Low-----------	0.43			
1202-------------- Cylinder Variant	0-18	22-27	1.40-1.60	0.6-2.0	0.20-0.22	7.4-8.4	Moderate------	0.28	4	4L	4-5
	18-27	15-25	1.45-1.60	2.0-6.0	0.13-0.16	7.4-8.4	Moderate------	0.28			
	27-60	2-12	1.60-1.70	>20	0.02-0.04	7.4-8.4	Low-----------	0.10			
1384B, 1384C------ Collinwood Variant	0-14	32-38	1.30-1.35	0.6-2.0	0.21-0.23	5.6-7.3	High----------	0.28	5	7	3-4
	14-45	35-42	1.35-1.40	0.2-0.6	0.18-0.20	5.6-7.3	High----------	0.43			
	45-53	24-34	1.35-1.45	0.6-2.0	0.20-0.22	7.4-8.4	Moderate------	0.43			
	53-60	22-30	1.60-1.80	0.6-2.0	0.17-0.19	7.4-8.4	Moderate------	0.43			
1458-------------- Millington	0-34	20-27	1.40-1.60	0.6-2.0	0.20-0.24	7.4-8.4	Low-----------	0.28	5	8	4-6
	34-60	18-35	1.50-1.70	0.6-2.0	0.14-0.20	7.4-8.4	Moderate------	0.28			
1511-------------- Blue Earth	0-10	---	0.20-0.50	2.0-6.0	0.35-0.48	7.4-8.4	Moderate------	0.28	5	3	>20
	10-24	18-32	0.20-0.80	0.6-2.0	0.18-0.24	7.4-8.4	Low-----------	0.28			
	24-60	18-32	1.30-1.60	0.2-2.0	0.14-0.16	7.4-8.4	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 "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]

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.
27B, 27C---------- Terril	B	None--------	---	---	>6.0	---	---	Moderate	Moderate	Low.
28B--------------- Dickman	A	None--------	---	---	>6.0	---	---	Low------	Low------	Moderate.
32---------------- Spicer	B/D	None--------	---	---	1.0-3.0	Apparent	Nov-Jun	High-----	High-----	Low.
55---------------- Nicollet	B	None--------	---	---	2.5-5.0	Apparent	Nov-Jun	High-----	High-----	Low.
62C2, 62D, 62D2, 62E, 62G--------- Storden	B	None--------	---	---	>6.0	---	---	Moderate	Low------	Low.
72, 72B, 72C2----- Estherville	B	None--------	---	---	>6.0	---	---	Low------	Low------	Low.
73D, 73E, 73G----- Salida	A	None--------	---	---	>6.0	---	---	Low------	Low------	Low.
77B--------------- Sac	B	None--------	---	---	>6.0	---	---	High-----	Moderate	Low.
91, 91B----------- Primghar	B	None--------	---	---	3.0-5.0	Apparent	Nov-Jul	High-----	Moderate	Moderate.
92---------------- Marcus	B/D	None--------	---	---	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
95---------------- Harps	B/D	None--------	---	---	1.0-3.0	Apparent	Nov-Jun	High-----	High-----	Low.
107--------------- Webster	B/D	None--------	---	---	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
108, 108B, 108C--- Wadena	B	None--------	---	---	>6.0	---	---	Low------	Low------	Low.
135--------------- Coland	B/D	Occasional	Brief-----	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
138B, 138C, 138C2, 138D, 138D2------ Clarion	B	None--------	---	---	>6.0	---	---	Moderate	Low------	Low.
201B*: Coland-----------	B/D	Occasional	Brief-----	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High-----	High-----	Low.
Spillville-------	B	Occasional	Very brief	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	Moderate	High-----	Moderate.
202, 203---------- Cylinder	B	None--------	---	---	2.0-4.0	Apparent	Nov-Jul	High-----	Moderate	Low.
259--------------- Biscay	B/D	None--------	---	---	1.0-3.0	Apparent	Nov-Jun	High-----	Moderate	Low.
274--------------- Rolfe	C	None--------	---	---	+1-1.0	Apparent	Nov-Jul	High-----	High-----	Moderate.

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					
282 Ransom	B	None	---	---	2.5-5.0	Apparent	Nov-Jun	High	High	Low.
308, 308B Wadena	B	None	---	---	>6.0	---	---	Low	Low	Low.
330 Kingston	B	None	---	---	2.5-5.0	Apparent	Nov-Jun	High	High	Low.
331 Madelia	B/D	None	---	---	1.0-2.5	Apparent	Nov-May	High	High	Low.
384 Collinwood	C	None	---	---	2.0-5.0	Apparent	Nov-May	High	High	Low.
390 Waldorf	C/D	None	---	---	0-3.0	Apparent	Nov-Jun	High	High	Low.
397 Letri	B/D	None	---	---	0.5-2.0	Perched	Apr-Jun	High	High	Low.
456 Wilmonton	B	None	---	---	2.5-5.0	Apparent	Nov-Jun	High	Moderate	Low.
474B, 474C2 Bolan	B	None	---	---	>6.0	---	---	Moderate	Moderate	Moderate.
485 Spillville	B	Occasional	Very brief	Feb-Nov	3.0-5.0	Apparent	Nov-Jul	Moderate	High	Moderate.
485B Spillville	B	None	---	---	3.0-5.0	Apparent	Nov-Jul	Moderate	High	Moderate.
507 Canisteo	C/D	None	---	---	1.0-3.0	Apparent	Oct-Jul	High	High	Low.
511 Blue Earth	B/D	None	---	---	+2-1.0	Apparent	Jan-Dec	High	High	Low.
559 Talcot	B/D	None	---	---	1.0-2.5	Apparent	Nov-Jun	High	High	Low.
577, 577B, 577C2 Everly	B	None	---	---	>6.0	---	---	Moderate	Moderate	Moderate.
655 Crippin	B	None	---	---	2.0-4.0	Apparent	Nov-Jun	High	High	Low.
733 Calco	B/D	Occasional	Brief	Feb-Nov	1.0-3.0	Apparent	Nov-Jul	High	High	Low.
878, 878B Ocheyedan	B	None	---	---	>6.0	---	---	Moderate	Low	Low.
879 Fostoria	B	None	---	---	2.0-4.0	Apparent	Nov-Jul	High	High	Low.
1202 Cylinder Variant	B	None	---	---	2.0-4.0	Apparent	Nov-Jul	High	High	Low.
1384B, 1384C Collinwood Variant	B	None	---	---	>6.0	---	---	Moderate	Moderate	Moderate.
1458 Millington	B/D	Frequent	Brief	Apr-Jun	0-2.0	Apparent	Nov-Jun	High	High	Low.
1511 Blue Earth	B/D	None	---	---	+2-1.0	Apparent	Jan-Dec	High	High	Low.

See footnote at end of table.

TABLE 16.--SOIL AND WATER FEATURES--Continued

Soil name and map symbol	Hydrologic group	Flooding: Frequency	Flooding: Duration	Flooding: Months	High water table: Depth	High water table: Kind	High water table: Months	Potential frost action	Risk of corrosion: Uncoated steel	Risk of corrosion: Concrete
					Ft					
5010*. Pits										
5040*. Orthents										

* See description of the map unit for composition and behavior characteristics of the map unit.

TABLE 17.--CLASSIFICATION OF THE SOILS

Soil name	Family or higher taxonomic class
Biscay	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Haplaquolls
Blue Earth	Fine-silty, mixed (calcareous), mesic Mollic Fluvaquents
Bolan	Coarse-loamy, mixed, mesic Typic Hapludolls
Calco	Fine-silty, mixed (calcareous), mesic Cumulic Haplaquolls
Canisteo	Fine-loamy, mixed (calcareous), mesic Typic Haplaquolls
Clarion	Fine-loamy, mixed, mesic Typic Hapludolls
Coland	Fine-loamy, mixed, mesic Cumulic Haplaquolls
Collinwood	Fine, montmorillonitic, mesic Aquic Hapludolls
Collinwood Variant	Fine, montmorillonitic, mesic Typic Hapludolls
Crippin	Fine-loamy, mixed, mesic Aquic Hapludolls
Cylinder	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Aquic Hapludolls
Cylinder Variant	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Aquic Hapludolls
Dickman	Sandy, mixed, mesic Typic Hapludolls
Estherville	Sandy, mixed, mesic Typic Hapludolls
Everly	Fine-loamy, mixed, mesic Typic Hapludolls
Fostoria	Fine-loamy, mixed, mesic Aquic Hapludolls
Harps	Fine-loamy, mesic Typic Calciaquolls
Kingston	Fine-silty, mixed, mesic Aquic Hapludolls
Letri	Fine-loamy, mixed, mesic Typic Haplaquolls
Madelia	Fine-silty, mixed, mesic Typic Haplaquolls
Marcus	Fine-silty, mixed, mesic Typic Haplaquolls
Millington	Fine-loamy, mixed (calcareous), mesic Cumulic Haplaquolls
Nicollet	Fine-loamy, mixed, mesic Aquic Hapludolls
Ocheyedan	Fine-loamy, mixed, mesic Typic Hapludolls
Okoboji	Fine, montmorillonitic, mesic Cumulic Haplaquolls
Orthents	Loamy, mixed, mesic Typic Udorthents
Primghar	Fine-silty, mixed, mesic Aquic Hapludolls
Ransom	Fine-silty, mixed, mesic Aquic Hapludolls
Rolfe	Fine, montmorillonitic, mesic Typic Argialbolls
Sac	Fine-silty, mixed, mesic Typic Hapludolls
Salida	Sandy-skeletal, mixed, mesic Entic Hapludolls
Spicer	Fine-silty, mixed (calcareous), mesic Typic Haplaquolls
Spillville	Fine-loamy, mixed, mesic Cumulic Hapludolls
Storden	Fine-loamy, mixed (calcareous), mesic Typic Udorthents
Talcot	Fine-loamy over sandy or sandy-skeletal, mixed (calcareous), mesic Typic Haplaquolls
Terril	Fine-loamy, mixed, mesic Cumulic Hapludolls
Wadena	Fine-loamy over sandy or sandy-skeletal, mixed, mesic Typic Hapludolls
Waldorf	Fine, montmorillonitic, mesic Typic Haplaquolls
Webster	Fine-loamy, mixed, mesic Typic Haplaquolls
Wilmonton	Fine-loamy, mixed, mesic Aquic Hapludolls

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