SOIL SURVEY
Lincoln County Minnesota

UNITED STATES DEPARTMENT OF AGRICULTURE
Soil Conservation Service
In cooperation with
MINNESOTA AGRICULTURAL EXPERIMENT STATION

Issued January 1970

Major fieldwork for this soil survey was done in the period 1950–62. Soil names and descriptions were approved in 1965. Unless otherwise indicated, statements in the publication refer to conditions in the county in 1965. This survey was made cooperatively by the Soil Conservation Service and the Minnesota Agricultural Experiment Station. It is part of the technical assistance furnished to the Lincoln Soil and Water Conservation District.

HOW TO USE THIS SOIL SURVEY

THIS SOIL SURVEY of Lincoln County contains information that can be applied in managing farms; in selecting sites for roads, ponds, buildings, or other structures; and in appraising the value of tracts of land for agriculture, industry, or recreation.

Locating Soils

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

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

Finding and Using Information

The "Guide to Mapping Units" can be used to find information in the survey. This guide lists all of the soils of the county in alphabetic order by map symbol. It shows the page where each kind of soil is described, and also the page for the capability unit and the windbreak suitability group in which the soil has been placed.

Interpretations not included in the text can be developed by using information in the text to group soils according to their suitability or limitations for a particular use. Translucent material can be used as an overlay over the soil map and colored to show soils that have the same limitation or suitability. For example, soils that have a slight limitation for a given use can be colored green, those with a moderate limitation can be colored yellow, and those with a severe limitation can be colored red.

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

Foresters and others can refer to the section "Field and Farmstead Windbreaks," where the soils of the county are grouped according to their suitability for trees and shrubs.

Engineers and builders will find under "Engineering Properties of Soils" tables that give engineering descriptions of the soils in the county and that name soil features that affect engineering practices and structures.

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

Students, teachers, and others will find information about soils and their management in various parts of the text, depending on their particular interests.

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

Cover picture: **Contour farming on soils of the Barnes-Flom association**

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SOIL SURVEY OF LINCOLN COUNTY, MINNESOTA

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UNITED STATES DEPARTMENT OF AGRICULTURE, SOIL CONSERVATION SERVICE, IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA AGRICULTURAL EXPERIMENT STATION

LINCOLN COUNTY is in the southwestern part of Minnesota on the South Dakota border (fig. 1). Ivanhoe, the county seat, is about 160 airline miles west-southwest of St. Paul, the State capital. The total land area of the county is 540 square miles, and water makes up about 10 square miles. The county is mainly agricultural. Growing of corn, oats, flax, soybeans, and hay, and dairying, cattle feeding, and stockraising produce most of the income.

Lincoln County has mostly dark-colored, nearly level to steep soils that developed in glacial materials. The original vegetation was tall and medium prairie grasses.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soils are in Lincoln County, where they are located, and how they can be used.

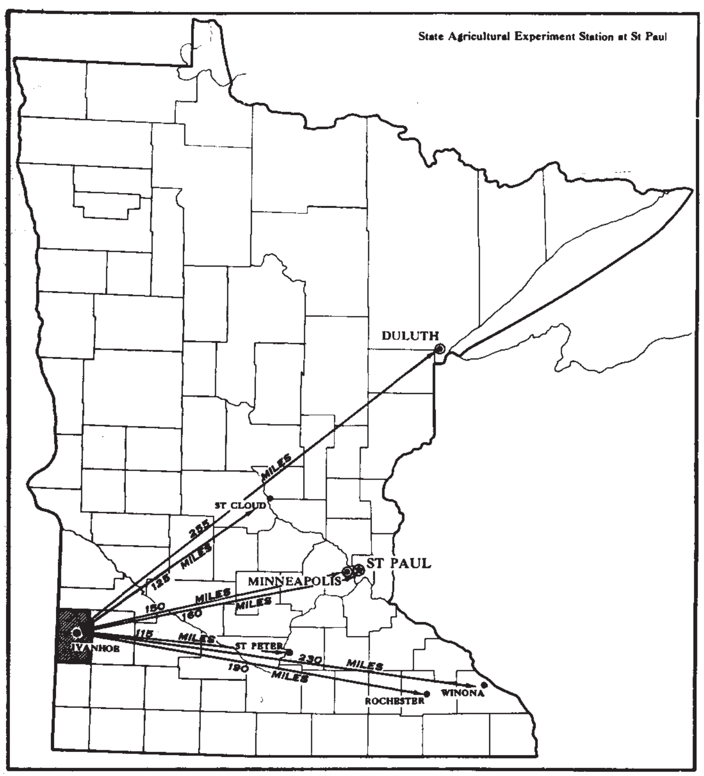

Figure 1.—Location of Lincoln County in Minnesota.

They went into the county knowing they likely would find many soils they had already seen, and perhaps some they had not. As they traveled over the county, they observed steepness, length, and shape of slopes; size and speed of streams; kinds of native plants or crops; kinds of rock; and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by roots of plants.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. To use this soil survey efficiently, it is necessary to know the kinds of groupings most used in a local soil classification.

Soils that have profiles almost alike make up a soil series. Except for different texture in the surface layer, all the soils of one series have major horizons that are similar in thickness, arrangement, and other important characteristics. Each soil series is named for a town or other geographic feature near the place where a soil of that series was first observed and mapped. Barnes and Kranzburg, for example, are the names of two soil series. All the soils in the United States having the same series name are essentially alike in those characteristics that go with their behavior in the natural, untouched landscape. Soils of one series can differ somewhat in texture of the surface soil and in slope, stoniness, or some other characteristic that affects use of the soils by man.

Many soil series contain soils that differ in texture of their surface layer. According to such differences in texture, separations called soil types are made. Within a series, all the soils having a surface layer of the same texture belong to one soil type. Barnes loam and Kranzburg silt loam are two soil types in this county. The difference in texture of their surface layers is apparent from their names.

Some types vary so much in slope, degree of erosion, number and size of stones, or some other feature affecting their use, that practical suggestions about their management could not be made if they were shown on the soil map as one unit. Such soil types are divided into phases. The name of a soil phase indicates a feature that affects management. For example, Barnes loam, 2 to 6 percent slopes, is one of the phases of Barnes loam in Lincoln County.

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that greatly help in drawing boundaries accurately. The soil map in the back of this survey was prepared from the aerial photographs.

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

In preparing some detailed maps, the soil scientists have a problem of delineating areas where different kinds of soils are so intricately mixed, and so small in size, that it is not practical to show them separately on the map. Therefore, they show this mixture of soils as one mapping unit and call it a soil complex. Ordinarily, a soil complex is named for the major kinds of soils in it, for example, Buse-Arvilla complex, 18 to 40 percent slopes. Another kind of mapping unit is the undifferentiated soil group. The undifferentiated soil group consists of two or more soils not separated on the map, because differences among them are small, their practical value is limited, or they are too difficult to reach. An example is Forman and Barnes soils, 2 to 6 percent slopes. Also, on most soil maps, areas are shown that are so rocky, so shallow, or so frequently worked by wind and water that they cannot be classified by soil series. These areas are shown on a soil map like other mapping units, but they are given descriptive names, such as Gravel pit, and are called land types.

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

But only part of a soil survey is done when the soils have been named, described, and delineated on the map, and the laboratory data and yield data have been assembled. The mass of detailed information then needs to be organized in a way that it is readily useful to different groups of readers, farmers, persons who wish to establish windbreaks, engineers, and home owners. Grouping soils that are similar in suitability for each specified use is the method of organization commonly used in soil surveys. On the basis of yield and practice tables and other data, the soil scientists set up trial groups, and then test them by further study and by consultation with farmers, agronomists, engineers, and others. Then, the scientists adjust the groups according to the results of their studies and consultation. Thus, the groups that are finally evolved reflect up-to-date knowledge of the soils and their behavior under present methods of use and management.

General Soil Map

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

A map showing soil associations is useful to people who want a general idea of the soils in a county, who want to compare different parts of a county, or who want to know the location of large tracts that are suitable for a certain kind of farming or other land use. Such a map is not suitable for planning the management of a farm or field, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect management. The eight soil associations in Lincoln County are described in the following paragraphs.

1. Barnes-Flom Association

Deep, well-drained and poorly drained, undulating to hilly and moderately steep soils formed in loamy glacial till

This soil association is mainly undulating but is hilly and moderately steep in some places. Many shallow drainageways cross the area. This association covers about 125 square miles, or 23 percent of the county, and is mainly in the northeastern part.

The Barnes soils are undulating, deep, well drained, and productive. They have a dark-colored surface soil and a brownish subsoil. The Flom soils, in the drainageways, are deep and poorly drained, and drainage of them is needed for the best production of farm crops. They have a thick, black surface soil and a mottled, grayish subsoil.

The steeper slopes of the association are occupied by Barnes and Buse soils, so closely intermingled that it was not practical to differentiate them in mapping. They were mapped together in undifferentiated units and in complexes with the Arvilla soils.

In the association there are areas of Sverdrup and Arvilla soils, which are underlain by sand and gravel. On the narrow bottom lands along the rivers and creeks are Lamoure and Rauville soils. The small closed depressions and the drained lakebeds are occupied by Parnell and Blue Earth soils.

The major hazards in using the soils of this association are erosion of the undulating Barnes soils and wetness of the nearly level Flom soils. Stripcropping, terracing, and contour farming are the most effective means of controlling erosion. Where the slopes are too complex or irregular for these practices, the growing of grasses and legumes will lessen erosion. Tile and surface ditches are used to drain the Flom soils and other soils that are likely to be wet.

About half of the farms in this soil association have livestock. The rest are cash-grain farms. This association supports many kinds of wildlife. The population of pheasants and Hungarian partridges is fairly large. Waterfowl live in areas near lakes and streams. White-tailed deer, squirrels, and foxes live in the hilly and steep areas and in wetland areas.

2. Colvin-LaPrairie Association

Deep, poorly drained and moderately well drained, nearly level soils formed in silty lacustrine deposits and loamy alluvial sediments

This association is the smallest in the county and is in the extreme northeastern corner. It covers about 4 square miles, or 1 percent of the county. The soils are nearly level. They formed in a narrow glacial lake basin that extends from Lake Marshall in Lyon County generally northwestward across Lyon, Lincoln, Yellow Medicine, and Lac qui Parle Counties to the South Dakota border. The North Branch Yellow Medicine River dissects this area in Lincoln County. As a result, many of the glacial lake soil areas have been modified by alluvial sediments.

The Colvin soils developed in the silty lake-laid sediments. They are deep and poorly drained and have a limy surface layer. Their drainage needs to be improved before they can be successfully cropped every year. The LaPrairie soils are near the streams. They are moderately well drained. They developed in the loamy alluvial sediments and have a thick, limy, dark surface layer.

Minor areas of Fordville and Arvilla soils are in the small areas of gravelly terraces within this association. A few islands of glacial till outcrop in the lake basin. The well-drained Barnes soils developed in these places.

Wetness and flooding are the major soil hazards in this association. Open ditches are used to drain away the surface water and to help confine the floodwaters. Suitable outlets for tile drains are difficult to establish on the wet Colvin soils because of the low-lying topography. Most of the soils in this association need special fertilization because the lime content of their surface layer is extremely high.

Much of this association is in permanent grass, and livestock are raised on most of the farms. The association is of minor importance as a habitat for wildlife.

3. Forman-Barnes Association

Deep, well drained and moderately well drained, nearly level and very gently undulating soils formed in loamy glacial till

The soils of this association are mainly nearly level and very gently undulating, but along the outer edges of the association they are undulating. Deep, narrow drainageways that extend in a northeasterly direction dissect the area about every half mile. These drainageways have sloping to steep side slopes (fig. 2). This association occupies about 49 square miles, or 9 percent of the county.

The Forman soils developed on the higher parts of the slopes, and intermingled Barnes and Buse soils developed

Figure 2.—A typical scene in association 3.

on the side slopes of the drainageways. The Forman and Barnes soils are well drained. The Forman soils have a dark-colored surface layer and a brownish, compact subsoil.

Aastad soils, on the lower parts of the slopes; Flom soils, in shallow drainageways; and Parnell soils, in small, closed depressions make up minor acreages in this association. The Aastad soils are moderately well drained and have an olive, compact subsoil. Like the Forman soils, Aastad soils have a dark-colored surface layer, but they are slightly more productive than Forman soils.

In this association water erosion is not a hazard, except where the steeper side slopes of the deep drainageways are cultivated. Wind erosion is sometimes a problem, especially in spring. Good soil management is needed to control wind erosion and improve soil tilth. Included in such management are crop rotations that include grasses and legumes. Some drainage by surface ditches and tile is needed in areas of the Parnell and Flom soils.

Cash-grain farms are predominant in this association. A few farmers raise livestock. This association is less suitable for wildlife than most of the other associations. In the main, it lacks areas that provide cover for pheasants and Hungarian partridges. It also lacks extensive areas of wetland suitable for waterfowl and other kinds of wildlife.

4. Barnes-Buse-Flom Association

Deep, excessively drained to poorly drained, nearly level to gently undulating or moderately steep soils formed in loamy glacial till and clayey lacustrine deposits

This soil association extends from the northwestern corner diagonally southeastward across the county. It comprises the area occupied by the Altamont moraine. In most places the soils are nearly level to gently undulating or moderately steep, but in some places they are steep. The association covers about 149 square miles, or 27 percent of the county.

The Barnes, Buse, and Flom soils developed in the part of the county underlain by glacial till. In many places the Barnes and Buse soils are too closely intermingled to be mapped separately.

Fulda, Sinai, Poinsett, and Waubay soils occupy minor acreages in this association. The Fulda soils, which are poorly drained, developed in clayey lake-laid deposits on flat hilltops and in some of the drainageways. Clayey Sinai soils, which are moderately well drained, occur with the Fulda soils but at a slightly higher elevation. Well-drained Poinsett and moderately well drained Waubay soils occur where the lake-laid deposits are more silty than clayey, and they formed in those deposits.

Minor areas of Arvilla and Sverdrup soils that developed in gravelly or sandy glacial materials are also in this association. Other minor acreages are occupied by Blue Earth and Oldham soils, which developed in the numerous small lakes that formed in some of the depressions in the glacial till. Many of the areas of Blue Earth and Oldham soils have been drained and are cropped, but improved drainage is needed in most of the areas of these soils. Very poorly drained Parnell soils occupy the smaller closed depressions.

Erosion-control measures are needed on the Barnes and Buse soils used for crops. Supplementary drainage is needed on the Flom and other wet soils.

Livestock are raised on most of the farms in the northern half of the association. Cash-grain crops are grown on the farms in the southern half. This association provides good habitats for pheasants, Hungarian partridges, and waterfowl. White-tailed deer inhabit the steeper wooded slopes of Buse soils and the wooded shores of lakes. Squirrels live in farmstead windbreaks and some of the wooded areas along streams.

5. Singsaas-Oak Lake Association

Deep, well drained and moderately well drained, nearly level and gently undulating soils formed in silty glacial till

This soil association has more good farmland than any of the others. This association extends from Hendricks across the county in a southeasterly direction and into the southeastern corner. This area has low, nearly level and undulating slopes. It is somewhat like a trough, with hilly land on both sides. The soils developed in silty and nearly stone-free glacial till. The major lakes in the county (Hendricks, Shaokatan, and Benton) are in this association. This association occupies about 96 square miles or 17 percent of the county.

The Singsaas soils are gently undulating, and the Oak Lake soils are nearly level and very gently undulating. Both have a subsoil that has been mixed with surface soil and with the underlying glacial till by earthworm activity. The Singsaas soils are well drained, deep, and productive and have a dark-colored surface layer. The Oak Lake soils are moderately well drained, deep, and very productive. They have a thicker dark-colored surface layer than the Singsaas soils.

Poorly drained Flom soils occupy the drainageways. Parnell soils are in the closed depressions. A few small areas of the clayey Fulda and Sinai soils are also in this association.

Water erosion is not a serious hazard, as the slopes are mostly short and gentle. Wind erosion is likely to occur in spring, and also in winter if the soils are bare. Most of the wet soils need additional tile or open-ditch drainage. Suitable outlets for tile drains are generally difficult to find unless deep drainage ditches are excavated.

Most of the grain produced in this association is fed to livestock on the farms. About 25 percent of the farms chiefly grow cash-grain crops. Dairying is a major enterprise around Tyler. This association is especially well suited to pheasants because it has a fair distribution of wetland areas that provide winter cover and escape cover. Hungarian partridges, waterfowl, and squirrels also live in the area.

6. Buse-Barnes Association

Deep, excessively drained and well-drained, sloping to steep soils formed in loamy glacial till

This soil association is hilly. The soils are mainly sloping to steep, but there are a few gently undulating areas. The strongest slopes are southwest of Lake Shaokatan and Lake Benton, along two separate glacial valleys formed by melt waters during the last glaciation. This association includes the second-highest elevation in Minnesota. The association covers about 49 square miles, or 9 percent of the county. The land is hilly and the slopes are rolling to steep (fig. 3).

The soils of this association developed in loam or clay loam glacial till that in some places contains many pockets of sandy and gravelly material. The principal soils are the Buse and Barnes soils. The Buse soils are mostly steep and have a thin, dark-colored, loam surface layer that is underlain by glacial till that has been only slightly altered by soil-forming processes. The Barnes soils show more profile development than the Buse. Their surface layer is also dark colored but is thicker than that of the Buse soils. On the gentler slopes, Barnes and Buse soils are closely intermingled and are mapped together as a complex.

Minor areas of Flom soils occupy the drainageways. They are poorly drained and have a thick, black surface layer underlain by mottled, grayish soil material. Minor areas of Sverdrup and Arvilla soils, which are underlain by sand and gravel, are scattered throughout the association.

Most of the association consists of permanent grassland, which supplies forage for the livestock that are raised on most of the farms. Where the permanent grassland has been carefully managed, native grasses are the dominant vegetation. Where the grassland has been heavily grazed, the native grasses have nearly all disappeared and Kentucky bluegrass is dominant. The bluegrass produces less forage than the native grasses. Wherever the soils are under cultivation, erosion is a severe hazard. The steep soils are somewhat droughty.

This association provides good habitats for pheasants, Hungarian partridges, and waterfowl. White-tailed deer, squirrel, and fox are plentiful.

7. Kranzburg-Vienna Association

Deep, well-drained, gently sloping soils formed in wind-blown silts and glacial till

This soil association is in the southwestern corner of the county. It occupies about 62 square miles, or 11 percent of the county. Most of the area is covered by a thin mantle of wind-deposited silt. The slopes are long, smooth, and gentle, having been filled in and leveled off by the wind-deposited silt. The Kranzburg soils are the dominant soils developed in the silt. These soils are deep, well drained, and productive when properly managed. The dark surface layer and the brownish subsoil developed in the wind-blown silty material. Below the subsoil is loamy glacial till.

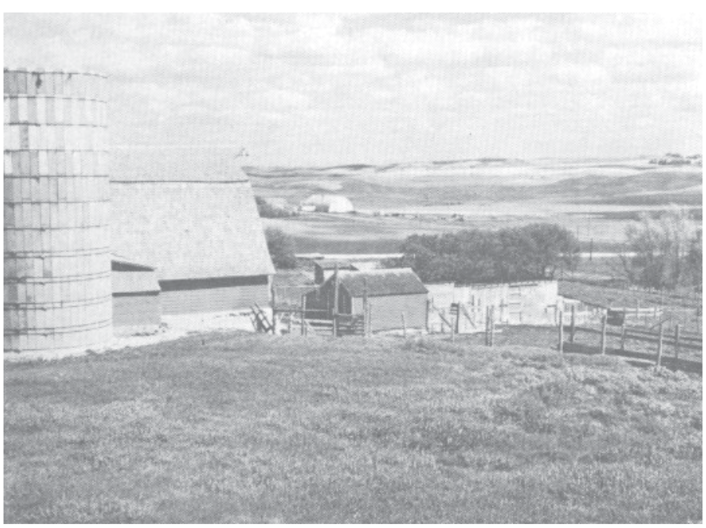

***Figure 3.*—A livestock farm in association 6. Hilly areas are in the background.**

Wherever the glacial till is exposed or the silt is very thin, the Vienna soils developed. These soils are also well drained. They differ from the Kranzburg soils by having stones and pebbles in the surface layer and subsoil.

Lying with the Kranzburg soils are the moderately well drained Brookings soils at lower elevations and the somewhat poorly drained Hidewood soils in the drainageways. Minor areas of moderately well drained Lismore soils occupy lower slopes in the Vienna soil areas.

In many places in this association, more than half of the surface layer of the soil has been lost through erosion. Further erosion can be controlled because the slopes are smooth and simple and are well adapted to terracing and contour farming. There are only a few upland depressions in this soil association, so drainage is only a minor problem. Drainage is needed in some of the drainageways.

Small grains and alfalfa grow well on the soils in this association. Yields of corn and soybeans are slightly lower than in other parts of the county. The cool nights and early frosts associated with the higher elevations in this association limit the growth of corn and soybeans. Periods of drought are somewhat more frequent in this part of the county than elsewhere. The farms in this association produce cash-grain crops or livestock. This association is less suitable for wildlife than most of the other associations. It lacks suitable cover for pheasants and Hungarian partridges. It lacks extensive areas suitable for waterfowl and other kinds of wildlife.

8. Beotia-Dickey, Silty Variants, Association

Deep, well-drained or somewhat excessively drained, nearly level and gently sloping soils formed in silty and sandy materials deposited by wind and water

This association is in the southwestern part of the county. It covers about 16 square miles or about 3 percent of the county. For the most part, the terrain is nearly level, but there are a few sloping and steeper areas along some of the drainageways and on some of the escarpments breaking into the bottom lands.

The Beotia soils are well drained and have 3 to 5 feet of silty material over sand and gravel (fig. 4). They are productive soils when rainfall is ample. Silty variants of the Dickey soils are mainly in the areas along the western boundary of the county. They have a sandy surface layer and subsoil over silty sediments. These soils are more droughty than the Beotia soils, but deep-rooted crops do fairly well on them.

A small area, a few miles southeast of the town of Lake Benton, consists mainly of Divide and Rauville soils. These wet soils are underlain by sand and gravel. Most of their area is in permanent grass. Further drainage is needed before these soils can be cropped.

Drought is the chief hazard on these soils. Wind erosion is likely to occur, especially if the soils are fall plowed or if little residue is left on the surface. Rotations that

Figure 4.—**Typical landscape in association 8, with nearly level Beotia soils in the foreground.**

include legumes and grasses will control erosion and increase the level of organic matter. These soils are suitable for irrigation. Most of the farms have livestock enterprises. This association is of minor importance as a habitat for wildlife.

Descriptions of the Soils

This section describes the single soils, or mapping units; that is, the areas on the detailed soil map that are bounded by a line and are identified by a symbol. For more general information about the soils, the reader can refer to the section "General Soil Map" in which the broad patterns of soils in the county are described.

In the descriptions that follow, the soils in a series are first discussed as a group by describing important features that apply to all the soils in the series. The position of the soils in the landscape is given. Some of the nearby or similar soils are named and compared with the soils in the series being described. A representative profile is described. The general description of the series contains a broad statement that tells how the soils are used.

Following the description of each series are descriptions of each soil in the series. Generally, these descriptions tell how the profile of the soil described differs from the one described as representative of the series. They also tell about the use and suitability of the soil described and something about its management needs.

Some of the terms used in the soil descriptions are defined in the section "How This Survey Was Made." Other terms are defined in the Glossary at the back of this survey. Unless otherwise indicated, the colors given are those of a moist soil. Table 1 lists the acreage and proportionate extent of each soil mapped. The location and extent of the soils in the county are shown on the soil map.

Aastad Series

The Aastad soils are deep, moderately well drained, nearly level soils that developed under prairie grasses in clay loam glacial till. These soils have a firm or compact subsoil. Pockets of sand and gravel, which are common in glacial till in most places, are absent from most areas of these soils.

A typical profile of an Aastad soil has a black clay loam surface layer about 13 inches thick. A very dark gray clay loam transitional layer, about 6 inches thick, grades to a firm, olive-brown and very dark grayish-brown clay loam subsoil about 13 inches thick, that is mottled in the lower part. The underlying material is limy, light brownish-gray clay loam that is more mottled than the olive-colored layer. Its upper part contains soft, white lime concretions.

Permeability is moderate, and moisture-holding capacity is very high. Reaction is neutral in the surface layer. Surface cracks develop after these soils dry out.

The Aastad soils are good farm soils, but the compact subsoil somewhat restricts percolation of water. They are suited to all the crops commonly grown in the county.

Representative profile of Aastad clay loam in a cultivated field where the slope is nearly level (75 feet southwest of the northeast corner of sec. 34, T. 113 N., R. 44 W.) :

Ap—0 to 6 inches, black (10YR 2/1) clay loam; very dark brown (10YR 2/2) when dry; cloddy; friable when moist; abrupt, smooth boundary.

A12—6 to 13 inches, black (10YR 2/1) clay loam; weak, fine and medium, subangular blocky structure, friable when moist; neutral; clear, smooth boundary.

AB—13 to 19 inches, very dark gray (10YR 3/1) clay loam having a few spots of very dark grayish brown (10YR 3/2) in the lower part; moderate, coarse, prismatic structure that breaks to weak to moderate, very fine, subangular blocky structure; friable to firm when moist; neutral; clear, smooth boundary.

B2—19 to 29 inches, olive-brown (2.5Y 4/4) and very dark grayish-brown (10YR 3/2) clay loam; few, fine, distinct, strong-brown (7.5YR 5/8) iron stains; moderate, fine and medium, subangular blocky structure that breaks to weak, fine and medium, subangular blocky structure; firm when moist; a few very dark gray (10YR 3/1) root channels; neutral; clear, smooth boundary.

B3—29 to 32 inches, olive-brown (2.5Y 4/4) and light olive-brown (2.5Y 5/4) clay loam; few, fine, distinct, strong-brown (7.5YR 5/8) mottles; weak to moderate, medium, prismatic structure breaking to weak, very fine and fine, subangular blocky structure; friable to firm when moist; mildly alkaline; clear, wavy boundary.

C1ca—32 to 46 inches, grayish-brown (2.5Y 5/2) and light yellowish-brown (2.5Y 6/4) clay loam; many, coarse, distinct, light olive-brown (2.5Y 5/4) mottles and few, fine, distinct, strong-brown (7.5YR 5/8) iron stains; weak, medium, prismatic structure; friable when moist; hard and soft, white calcium carbonate concretions, less than 10 millimeters in diameter, are common; strongly calcareous; gradual boundary.

C2—46 inches +, light brownish-gray (2.5Y 6/2) clay loam; many, coarse, distinct, light olive-brown (2.5Y 5/4) mottles and few, fine, distinct, strong-brown (7.5YR 5/8) iron stains; massive; friable when moist; calcareous.

The thickness of the A horizon ranges from 10 to 20 inches. The depth to free lime ranges from 20 to 36 inches; in most places it is about 28 inches. Free lime is present in either the lower B horizon or the upper C horizon.

The Aastad soils have a thicker A horizon and are more olive colored in the B horizons than the Forman soils, which are well drained and which developed on the same ground moraine. They have firmer B horizons than the Svea or Oak Lake soils. They also differ from the Oak Lake soils by having fewer wormcasts in the B horizons.

Aastad clay loam, 0 to 2 percent slopes (AaA).—This soil occupies slightly depressed places and occurs in irregular patterns on the till plain. Most of the areas of this soil are surrounded by slightly higher, well-drained, nearly

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

Soil	Area	Extent
	Acres	*Percent*
Aastad clay loam, 0 to 2 percent slopes	1, 598	0. 5
Arvilla sandy loam, 0 to 2 percent slopes	338	. 1
Arvilla sandy loam, 2 to 6 percent slopes	2, 312	. 7
Arvilla sandy loam, 6 to 12 percent slopes, eroded	1, 122	. 3
Arvilla sandy loam, 12 to 18 percent slopes, eroded	427	. 1
Barnes loam, 0 to 2 percent slopes	508	. 1
Barnes loam, 2 to 6 percent slopes	19, 734	5. 7
Barnes loam, 2 to 6 percent slopes, eroded	44, 784	13. 0
Barnes and Buse loams, 2 to 6 percent slopes, eroded	1, 181	. 3
Barnes and Buse loams, 6 to 12 percent slopes	3, 290	1. 0
Barnes and Buse loams, 6 to 12 percent slopes, eroded	29, 200	8. 4
Barnes-Buse-Arvilla complex, 2 to 6 percent slopes	327	. 1
Barnes-Buse-Arvilla complex, 2 to 6 percent slopes, eroded	836	. 2
Barnes-Buse-Arvilla complex, 6 to 12 percent slopes, eroded	1, 052	. 3
Beotia silt loam, 0 to 2 percent slopes	2, 601	. 8
Beotia silt loam, 2 to 4 percent slopes	353	. 1
Blue Earth silt loam	6, 392	1. 8
Brookings silty clay loam, 0 to 2 percent slopes	4, 374	1. 3
Brookings silty clay loam, 2 to 4 percent slopes	2, 405	. 7
Buse loam, 18 to 25 percent slopes	2, 481	. 7
Buse loam, 25 to 40 percent slopes	6, 663	1. 9
Buse stony loam, 5 to 40 percent slopes	520	. 1
Buse-Arvilla complex, 12 to 18 percent slopes, eroded	548	. 2
Buse-Arvilla complex, 18 to 40 percent slopes	260	. 1
Buse-Barnes loams, 12 to 18 percent slopes	2, 533	. 7
Buse-Barnes loams, 12 to 18 percent slopes, eroded	4, 995	1. 4
Colvin silty clay loam	627	. 2
Crofton silty clay loam, 4 to 12 percent slopes	599	. 2
Dickey sandy loam, silty variant, 0 to 2 percent slopes	163	(1)
Dickey sandy loam, silty variant, 2 to 6 percent slopes	547	. 2
Divide silt loam	422	. 1
Estelline silt loam, 0 to 2 percent slopes	378	. 1
Flandreau loam, 0 to 2 percent slopes	426	. 1
Flandreau loam, 2 to 6 percent slopes	567	. 2
Flom clay loam	41, 535	12. 1
Fordville loam, 0 to 2 percent slopes	868	. 2
Fordville loam, 2 to 6 percent slopes	934	. 3
Fordville loam, 2 to 6 percent slopes, eroded	945	. 3
Forman clay loam, 0 to 2 percent slopes	3, 095	. 9
Forman and Barnes soils, 2 to 6 percent slopes	3, 885	1. 1
Forman and Barnes soils, 2 to 6 percent slopes, eroded	11, 253	3. 3
Fulda silty clay loam	2, 535	. 7
Gravel pit	275	. 1
Hamerly loam, 0 to 3 percent slopes	2, 152	. 6
Hidewood silty clay loam	3, 413	1. 0
Kranzburg silt loam, 0 to 2 percent slopes	2, 712	. 8
Kranzburg silt loam, 2 to 6 percent slopes	6, 481	1. 9
Kranzburg silt loam, 2 to 6 percent slopes, eroded	9, 152	2. 7
Lake beaches	1, 235	. 4
Lamoure silty clay loam	5, 001	1. 4
Lamoure and LaPrairie soils, frequently flooded	6, 045	1. 8
LaPrairie loam	1, 033	. 3
Lismore silty clay loam, 0 to 3 percent slopes	749	. 2
Marsh	3, 803	1. 1
Muck	288	. 1
Oak Lake silty clay loam, 0 to 2 percent slopes	8, 199	2. 4
Oak Lake silty clay loam, 2 to 4 percent slopes	4, 483	1. 3
Oldham silty clay loam	700	. 2
Parnell silty clay loam	10, 641	3. 0
Poinsett silty clay loam, 2 to 6 percent slopes	1, 692	. 5
Poinsett silty clay loam, 2 to 6 percent slopes, eroded	1, 693	. 5
Rauville silty clay loam	1, 528	. 4
Sinai silty clay loam, 0 to 2 percent slopes	753	. 2
Sinai silty clay loam, 2 to 4 percent slopes	794	. 2
Singsaas silty clay loam, 2 to 6 percent slopes	11, 566	3. 3
Singsaas silty clay loam, 2 to 6 percent slopes, eroded	5, 842	1. 7
Sioux gravelly sandy loam, 5 to 40 percent slopes	536	. 2
Svea clay loam, 0 to 2 percent slopes	6, 385	1. 8
Svea clay loam, 2 to 4 percent slopes	6, 924	2. 0
Sverdrup sandy loam, 2 to 6 percent slopes	672	. 2
Sverdrup sandy loam, 6 to 12 percent slopes	193	(1)
Terril silt loam, 2 to 6 percent slopes	5, 205	1. 5
Vallers silty clay loam	14, 497	4. 2
Vienna silt loam, 2 to 6 percent slopes	1, 290	. 4
Vienna silt loam, 2 to 6 percent slopes, eroded	3, 478	1. 0
Vienna silt loam, 6 to 12 percent slopes, eroded	1, 294	. 4
Waubay silty clay loam, 0 to 2 percent slopes	2, 907	. 9
Waubay silty clay loam, 2 to 4 percent slopes	2, 376	. 7
Total	345, 600	100. 0

[1] Less than 0.05 percent.

level Forman soils. Runoff water flows slowly across areas of this soil, allowing ample time for the soil to absorb and store water for crop needs. Thus, this soil has higher reserves of moisture than the slightly elevated Forman soils.

Included with this soil in mapping were a few areas of Svea soils, which are moderately well drained. These areas are along the northern edge of the Forman-Barnes association.

This soil has no outstanding limitations. It is suitable for intensive row cropping if soil management is good. (Capability unit I-1; windbreak suitability group 1)

Arvilla Series

This series consists of somewhat excessively drained, nearly level to moderately steep soils that are shallow over gravel. These soils developed in gravelly glacial drift on uplands and in gravelly outwash on stream terraces and outwash plains.

A typical profile of a nearly level, cultivated Arvilla soil (fig. 5) has about 9 inches of surface soil, a friable, black sandy loam. The subsoil is friable, very dark brown and dark-brown sandy loam about 7 inches thick. A 5-inch, brown layer of loamy coarse sand separates the subsoil from limy, dark yellowish-brown gravel.

Permeability above the gravelly underlying material is moderately rapid. Moisture-holding capacity is low. The reaction of the surface soil ranges from neutral to slightly acid.

Gravel pits have been opened on these soils; they are a good source of road gravel. Growth of corn is restricted by drought in most years, and yields are poor. In some

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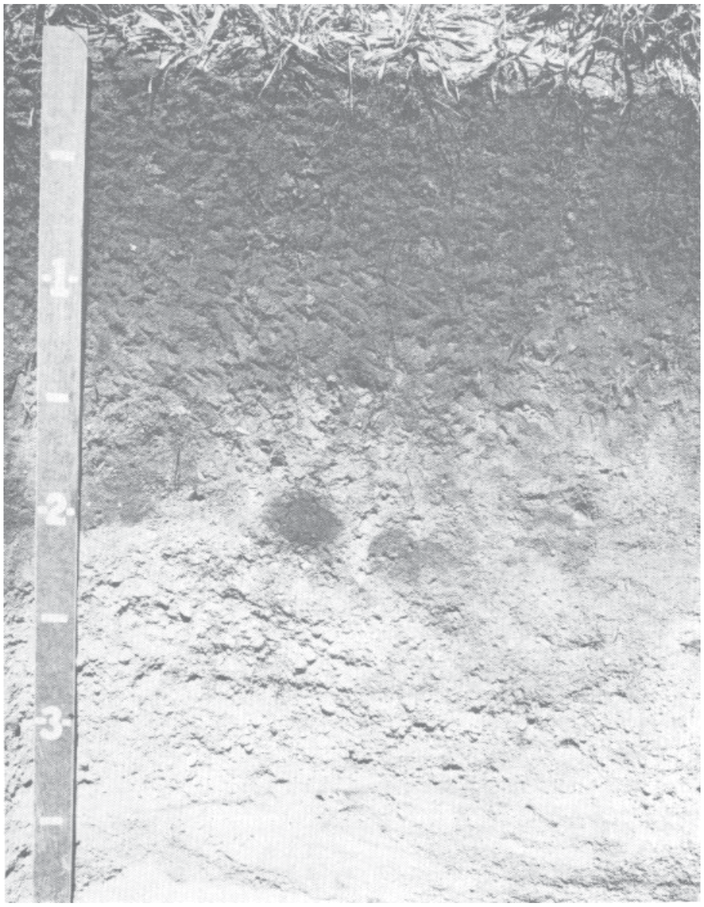

Figure 5.—**Profile of Arvilla sandy loam showing stratification in the underlying gravel. The dark spots are rodent burrows.**

seasons, however, when the rainfall is adequate and timely, yields are fair.

Representative profile of Arvilla sandy loam in a cultivated field where the slope is 2 percent, about 35 feet south of fence line directly south of west edge of farmstead (NW¼NW¼ sec. 22, T. 111 N., R. 44 W.):

Ap—0 to 6 inches, black (10YR 2/1) sandy loam; cloddy; friable when moist, nonsticky when wet; neutral; abrupt, smooth boundary.

A12—6 to 9 inches, black (10YR 2/1) sandy loam; weak, coarse, subangular blocky structure; friable when moist; neutral; clear, smooth boundary.

B21—9 to 12 inches, very dark brown (10YR 2/2) sandy loam; weak, medium, prismatic structure breaking to weak, coarse, subangular blocky structure; friable when moist; neutral; gradual, smooth boundary.

B22—12 to 16 inches, dark-brown (7.5YR 3/2) sandy loam; weak, medium, prismatic structure breaking to weak, coarse, subangular blocky structure; friable when moist; neutral; gradual, smooth boundary.

C1—16 to 21 inches, brown (7.5YR 4/4) loamy coarse sand; single grain; loose when moist; neutral; clear, wavy boundary.

IIC2ca—21 to 48 inches +, dark yellowish-brown (10YR 4/4) gravel; mildly alkaline; calcareous.

The A1 horizon ranges from black in most places to very dark gray or very dark brown in eroded places. The solum ranges from 12 to 24 inches in thickness. Most commonly observed colors of the B horizon are dark yellowish brown, dark brown, very dark grayish brown, and very dark brown. The proportions of sand and gravel in the underlying material are extremely variable. Free lime has accumulated on top of the gravel or has been dispersed throughout the gravel.

The Arvilla soils differ from the Sverdrup soils principally by being underlain by gravelly instead of sandy materials. They have a coarser textured and thinner solum than the Fordville soils.

Arvilla sandy loam, 0 to 2 percent slopes (ArA).—This shallow, somewhat excessively drained soil is shallow over gravel. It is in the uplands and on stream terraces and outwash plains. Free lime has accumulated just above, or slightly within, the gravel substratum.

Included with this soil in mapping were (1) a few places where erosion has exposed the dark-brown subsoil; (2) places where cobblestones and other stones are on the surface and in the soil and there are some small outcrops of gravel; (3) areas where the gravelly underlying material is only a few feet thick and is underlain by glacial till or silty alluvium; (4) some moderately well drained or somewhat poorly drained areas in drainageways and other low places; and (5) a few areas where the surface layer and subsoil are loam and are similar to the surface layer and subsoil of the Fordville soils, but where the depth to gravel is less than 2 feet.

Drought is the main hazard in the use of this Arvilla soil, but soil blowing can be serious, especially in spring. Small grains and alfalfa are the most dependable crops. Corn usually does not grow well during normal midsummer dry periods. (Capability unit IIIs–1; windbreak suitability group 4)

Arvilla sandy loam, 2 to 6 percent slopes (ArB).—This soil is gently sloping or undulating and is on stream terraces and uplands. In cultivated areas the surface layer is about 6 inches thick and is somewhat light in color as a result of erosion and loss of organic matter. In pastures and other uncultivated areas, the surface layer in most places is darker and a few inches thicker. Free lime is in the upper part of the gravel.

Included with this soil in mapping were (1) some spots where the brownish subsoil is exposed and some spots where gravelly underlying material is exposed; (2) some places where cobblestones and other stones are on the surface and in the soil; (3) some places where the gravel deposits are only a few feet thick and are underlain by glacial till or silty alluvium; and (4) areas where the surface layer and subsoil are loam and are similar to those of the Fordville soils, but where the depth to gravel is less than 24 inches.

Erosion and drought are hazards. Contouring is beneficial. Besides controlling erosion, it helps catch and hold needed rainfall for crop use. Fair yields are obtained on this soil when rainfall is timely during the growing season. Small grain and hay are the most reliable crops. Pastures are fairly productive until July. Then they dry up, unless rains are frequent. (Capability unit IIIe–2; windbreak suitability group 4)

Arvilla sandy loam, 6 to 12 percent slopes, eroded (ArC2).—This soil is on irregular, rolling upland areas and on sloping terrace escarpments. In cultivated areas the plow or surface layer, about 5 inches thick, is light in color as a result of erosion and the loss of organic matter. In pastures and other uncultivated places, the surface layer is slightly thicker and darker.

Included with this soil in cultivated areas are numerous places where brown subsoil and gravel are exposed, and many uncultivated areas where cobblestones and other stones are on the surface and in the soil. Also included in mapping were some places where the gravel substratum is only a few feet thick and is underlain by glacial till.

Drought and erosion are severe hazards. Pastures usually dry up after early summer. Most areas are or have been cultivated, but this soil is too droughty for corn; it is more suitable for small grain and hay crops. (Capability unit IVe–2; windbreak suitability group 4)

Arvilla sandy loam, 12 to 18 percent slopes, eroded (ArD2).—This soil is moderately steep and occurs along some streams and drainageways and on terrace escarpments.

The surface layer, about 5 inches thick, is light colored in many places as a result of mixing with subsoil by tillage and the loss of organic matter by tillage and cropping. Brown subsoil and gravel are exposed in spots. Cobblestones and other stones are on the surface and in the soil. In some places the gravel substratum is only a few feet thick and is underlain by glacial till. A small acreage of steeper Arvilla soils has been included with this soil in mapping.

Erosion and drought are very severe hazards. About three-fourths of the acreage of this soil is or has been used for crops. The individual areas in crops are small, usually only a few acres. These are now cropped because this is often the most practical use for them where they occur within a field of less sloping and less droughty soils. This soil is best suited to permanent pasture. (Capability unit VIe–2; windbreak suitability group 8)

Barnes Series

The Barnes soils are deep and well drained. They occupy glacial uplands and are nearly level and undulating. Barnes soils developed under prairie grasses in loam or clay loam glacial till. The Barnes soils are the most extensive in the county.

A typical profile of a slightly eroded, undulating Barnes soil has a black loam surface layer about 9 inches thick. The subsoil is friable loam about 15 inches thick. The upper part of the subsoil is dark yellowish brown and is somewhat mixed with dark surface soil. The mixing has resulted from earthworm activity and from the filling of root channels by soil material from the surface layer. The lower part of the subsoil is light olive brown and is limy. The underlying material is glacial till, a friable, limy, light olive-brown loam or clay loam. Stones and pebbles are common throughout the profile.

Permeability is moderately rapid in the subsoil and moderate in the underlying till. Moisture-holding capacity is high. The content of potassium is high, that of organic matter is high, and that of phosphorus is low.

The Barnes soils are well suited to crops commonly grown in the county if adequate amounts of fertilizer are used, and if erosion control measures are applied.

Representative profile of Barnes loam in a schoolyard where the slope is 3 percent, 65 feet east of fence west of school and 35 feet south of road ditch (NW¼NE¼NE¼ sec. 29, T. 112 N., R. 44 W.):

A1—0 to 9 inches, black (10YR 2/1) loam, very dark gray (10YR 3/1) when dry; moderate, very fine, subangular blocky structure; slightly hard when dry, friable when moist; neutral; gradual, smooth boundary.

AB—9 to 12 inches, very dark brown (10YR 2/2) loam; about 50 percent wormcasts of very dark grayish brown (10YR 3/2); weak to moderate, fine and medium, prismatic structure breaking to weak to moderate, fine and medium, subangular blocky structure; friable when moist; neutral; clear, smooth boundary.

B2—12 to 18 inches, dark yellowish-brown (10YR 4/4) loam; wormcasts are few, very dark gray (10YR 3/1) and dark gray (10YR 4/1) and, in the lower part of horizon, are few, dark grayish brown (10YR 4/2) and calcareous; moderate, coarse, prismatic structure that breaks to weak, medium, subangular blocky structure; friable when moist, slightly sticky when wet; neutral to mildly alkaline; clear, smooth boundary.

B3ca—18 to 24 inches, light olive-brown (2.5Y 5/4) loam; weak, medium and coarse, prismatic structure breaking to weak, medium, subangular blocky structure; friable when moist, slightly sticky when wet; few calcium carbonate concretions; strongly calcareous; gradual, smooth boundary.

C1ca—24 to 41 inches, olive-brown (2.5Y 4/4) and light olive-brown (2.5Y 5/4) loam; very weak, medium and fine, subangular blocky structure; friable when moist; numerous, white, hard and soft concretions of calcium carbonate, 5 to 10 millimeters in diameter; strongly calcareous; gradual, smooth boundary.

C2—41 to 54 inches +, light olive-brown (2.5Y 5/4) and grayish-brown (2.5Y 5/2) loam; friable when moist; few calcium carbonate concretions; calcareous.

In areas that have not been disturbed and that are not eroded, the A1 horizon is 8 to 13 inches thick. In areas that have been cultivated and that are eroded, the plow layer is very dark gray or very dark brown and is less than 8 inches thick. Some mixing by earthworms has occurred in the upper part of the B horizon. Depth to free lime is around 18 inches but is variable in the Barnes soils in this county. The B2 horizon colors range from dark grayish brown to dark yellowish brown or yellowish brown. The B3ca horizon is olive brown or light olive brown in most places.

In most places Barnes soils have a thinner solum and are less deeply leached of free lime than Vienna soils. Barnes soils occupy complex slopes and developed in loam or clay loam glacial till, whereas Vienna soils occupy simple slopes and, in most places, the upper part of their solum developed in a mixture of glacial till and loess. In the B horizon of the Barnes soils, worm working has been less extensive than in the B horizon of the Singsaas soils.

Some of the Barnes soils are mapped in complexes and undifferentiated soil units with Buse soils, with Forman soils, and with Buse and Arvilla soils.

Barnes loam, 0 to 2 percent slopes (BaA).—This soil is nearly level and is in areas between drainageways occupied by poorly drained Flom soils and on hilltops above steeper Barnes and Buse soils.

Included with this soil in mapping were a few areas where the surface layer is clay loam or silt loam. In some places part of the surface layer and underlying material has been mixed with the subsoil, and the subsoil now resembles that of the Singsaas soils. In some nearly level places, free lime has been leached to a depth of 36 inches. Small areas of moderately well drained Svea soils were included in mapping. Also included were sandy, gravelly, stony, or eroded spots too small to be mapped separately.

Water erosion normally is not a hazard. There is, however, a danger of soil blowing in spring if this soil has been improperly managed. If this soil is well managed, it can be farmed intensively. (Capability unit I–1; windbreak suitability group 1)

Barnes loam, 2 to 6 percent slopes (BaB).—The slopes of this soil are short and irregular, and in most places are in the lower part of the slope range of 2 to 6 percent.

Included with this soil in mapping were a few areas of a clay loam or silt loam. Sandy, gravelly, stony, and eroded spots too small to map separately were also included. Many of these spots are shown on the soil map by a special symbol. Also included with this soil in mapping were some places where thin layers of sandy, gravelly, or cobbly material occur in the subsoil or in the substratum.

There is a slight erosion hazard. Most of the slopes are too short and irregular for contouring or terracing. Inclusion of grasses and legumes in the crop rotation about once every 5 years will control erosion and maintain a satisfactory content of organic matter. Many farmsteads are located on this soil. (Capability unit IIe–2; windbreak suitability group 1)

Barnes loam, 2 to 6 percent slopes, eroded (BaB2).—This soil is undulating. It is the most extensive of the Barnes soils. From 3 to 5 inches of the original surface layer have been lost. The surface layer has a grayish-brown cast because the original surface layer has been mixed with subsoil by tillage, and because organic matter has been lost through erosion and excessive row cropping.

Included with this soil in mapping were some places where the brown subsoil is exposed. Also included were a few areas of a Barnes soil that has slopes of 2 to 6 percent and from which almost all of the original surface layer has eroded away. The plow layer is limy in some places in these areas. Also included with this soil in mapping were a few areas where the texture is clay loam or silt loam. Sandy, gravelly, and stony spots too small to map separately were included in the mapping unit. Also included were some places where thin layers of sandy, gravelly, or cobbly material occur in the subsoil or in the substratum.

This soil is subject to water erosion. Soil blowing occurs on the bare knobs. If the slopes are suitable, terracing or contouring are effective in controlling erosion and holding water on this soil. (Capability unit IIe–2; windbreak suitability group 1)

Barnes and Buse loams, 2 to 6 percent slopes, eroded (BbB2).—Most areas of this mapping unit consist of intermingled Buse and Barnes soils. Some of the areas consist only of Buse soils. The slopes are short and undulating.

Included in this mapping unit were some places where the yellowish underlying material of the Buse soils and the brownish subsoil of the Barnes soils are exposed. The surface layer or plow layer of these inclusions is about 6 inches thick and is very dark gray, eroded, and limy.

Erosion is the main hazard in the use of these soils. Erosion and excessive row cropping have reduced the fertility and the supply of organic matter. Yields are generally fairly good, however, if the soils are terraced or stripcropped and adequately fertilized, and if crop residues are returned to the soil. A small acreage of these soils is in pasture, and other areas are uncultivated. (Capability unit IIe–2; Barnes soil, windbreak suitability group 1; Buse soil, windbreak suitability group 5)

Barnes and Buse loams, 6 to 12 percent slopes (BbC).—These soils are rolling. The Buse soils developed on the steepest parts of slopes. There is a gradual transition from them to the Barnes soils, which developed on the more gentle parts of the slopes. In some places, especially those having slopes of 6 to 8 percent, Barnes soils are predominant.

Included in this mapping unit were some areas where stones and boulders are on the surface. Also included were small areas of sand, small areas of gravel, small eroded spots, and a few areas of Singsaas and Kranzburg soils having slopes of 6 to 12 percent.

If these Barnes and Buse soils are plowed, erosion becomes a severe hazard.

Most areas of these soils are uncultivated; some are in pasture. The use of fertilizers, especially nitrogen, would improve the pastures. If these soils are used for cultivated crops, they ought to be fertilized and terraced or stripcropped. All crop residues should be returned to the soil. (Capability unit IIIe–1; Barnes soil, windbreak suitability group 1; Buse soil, windbreak suitability group 5)

Barnes and Buse loams, 6 to 12 percent slopes, eroded (BbC2).—These are rolling soils along the sides and around the heads of drainageways and around depressions. The Buse soil developed on the steeper, more exposed slopes. The Barnes soil developed on the gentler, less exposed parts of the slopes (fig. 6). The plow layer in this mapping unit is light colored as a result of erosion and mixing of the original surface layer with subsoil and underlying material by tillage.

Included in this mapping unit were numerous spots where erosion and plowing have exposed yellowish, eroded Buse soils. These spots are fringed with brownish subsoil of the Barnes soils. Also included in mapping were small spots of sandy or gravelly material and some places where there are numerous surface stones.

Erosion is a severe hazard in the use of these soils.

In most places these soils are cropped. Terracing and use of a rotation that includes a sod crop about every 4 years would control erosion and help make these soils more productive. So would stripcropping that keeps alternate strips in grass. All crop residues should be returned if the soils are cultivated. Applying barnyard manure to the eroded Buse soils would help to control erosion and improve yields. (Capability unit IIIe–1; Barnes soil, windbreak suitability group 1; Buse soil, windbreak suitability group 5)

Figure 6.—**Flom soils are in the foreground. Beyond them are eroded Barnes and Buse soils that have slopes of about 10 percent. The light-colored areas are Buse soils, and the darker areas on the slope are Barnes soils.**

Barnes-Buse-Arvilla complex, 2 to 6 percent slopes (BcB).—In this complex the texture of the surface layer is loam and sandy loam. The soils occur in specific areas, each of which is only a few acres in size. They are undulating and have short, irregular slopes. About 25 to 50 percent of the complex is Barnes soils, 15 to 25 percent is Buse soils, and 25 to as much as 50 percent is Arvilla soils. Small areas of Sverdrup, Terril, and other soils were included in mapping.

The soils of this complex are subject to erosion if they are cultivated. The Arvilla soils are droughty.

The soils of this complex are mostly in pasture. During dry spells, the areas of Arvilla soils are especially apparent because crops grown on them "fire" and show the effects of drought first. Practices that control erosion and conserve moisture are needed on the soils of this complex. In some places gravel suitable for farm driveways can be obtained from pockets in the Arvilla soils. (Capability unit IIIe–2; Barnes soil, windbreak suitability group 1; Buse soil, windbreak suitability group 5; Arvilla soil, windbreak suitability group 4)

Barnes-Buse-Arvilla complex, 2 to 6 percent slopes, eroded (BcB2).—The soils of this complex have lost several inches of surface soil. Otherwise, this mapping unit is similar to Barnes-Buse-Arvilla complex, 2 to 6 percent slopes. The plow layer has a very dark gray color as a result of erosion and of mixing of the original surface layer with subsoil by tillage. It has a texture of loam and sandy loam. About 25 to 50 percent of the complex is Barnes soils, a similar percentage is Arvilla soils, and about 15 to 25 percent is Buse soils.

Included in this mapping unit are some places where spots of yellow underlying material and brown subsoil have been exposed. Small areas of Sverdrup soils, Terril soils, and other soils were also included in the mapping unit.

Erosion and drought are moderate hazards.

The soils of this complex are cultivated in most places. If the slopes are suitable, contouring generally controls erosion and helps to conserve moisture. The moisture-holding capacity of these soils is increased by practices that increase the content of organic matter and improve soil tilth. (Capability unit IIIe–2; Barnes soil, windbreak suitability group 1; Buse soil, windbreak suitability group 5; Arvilla soil, windbreak suitability group 4)

Barnes-Buse-Arvilla complex, 6 to 12 percent slopes, eroded (BcC2).—The soils of this complex are rolling and eroded, and they occupy upland areas. The percentage of Barnes soils, of Buse soils, and of Arvilla soils in the complex ranges from 25 to 50 percent. The soils have a surface layer of loam or sandy loam.

Included in this mapping unit were (1) spots where brown and yellow subsoil and gravelly underlying material are exposed; (2) small areas of Sverdrup, Terril, and other soils; (3) small areas of noneroded soils that are in pasture; and (4) a few areas of eroded Fordville soils that have slopes of 6 to 12 percent.

Erosion and drought are severe hazards. The slopes are very irregular in many places, but where they are suitable for it, stripcropping helps to control erosion, to increase the organic-matter supply, and thus to improve the infiltration rate and moisture-holding capacity of these soils. (Capability unit IVe–2; Barnes soil, windbreak suitability group 1; Buse soil, windbreak suitability group 5; Arvilla soil, windbreak suitability group 4)

Beotia Series

The Beotia series consists of deep, well-drained, nearly level and gently sloping soils on river terraces and outwash plains. These soils developed in silty water-laid or windblown materials overlying limy sand and gravel.

A typical profile of a nearly level Beotia soil has a friable, dark-colored silt loam surface layer about 12 inches thick. The subsoil, about 28 inches thick, is very friable silt loam that is dark brown to dark yellowish brown in the upper part and grades to olive brown in the lower part. A 5-inch, slightly limy, transitional layer of olive-brown loam lies between the subsoil and limy gravel. The depth to sand and gravel is 3 to 5 feet in most places. Free lime is in the lower part of the subsoil in most places. In some places where the profile is thinner, free lime has leached into the gravelly underlying material.

Permeability above the gravel is moderately rapid. Moisture-holding capacity is high. Reaction is neutral or slightly acid in the surface layer and in the subsoil. In most places the upper part of the subsoil is the most acid part.

The Beotia soils are suitable for the crops commonly grown in the county. In seasons when the rainfall is spotty, however, corn yields are decreased. The underlying material is suitable for use as gravel for roads and other purposes.

Representative profile of Beotia silt loam in a cultivated field where the slope is 1 percent, 50 feet south of fence line from center of approach to field (NW¼NE¼NE¼ sec. 36, T. 109 N., R. 46 W.):

Ap—0 to 6 inches, black (10YR 2/1) silt loam; cloddy; soft when dry, friable when moist, sticky when wet; neutral; abrupt, smooth boundary.

A12—6 to 9 inches, black (10YR 2/1) silt loam; moderate, very fine and fine, angular blocky structure; slightly hard when dry, very friable when moist; horizon has been compacted as a result of tillage; neutral; abrupt, smooth boundary.

A3—9 to 12 inches, very dark gray (10YR 3/1) silt loam; weak, coarse, prismatic structure breaking to weak, fine and medium, subangular blocky structure; very friable when moist; neutral; gradual, wavy boundary.

B1—12 to 19 inches, silt loam that is very dark grayish brown (10YR 3/2) grading to dark brown (10YR 3/3); dark brown (10YR 3/3) when crushed; weak, medium, prismatic structure breaking to weak, medium, subangular blocky structure; friable when moist; neutral; clear, wavy boundary.

B21—19 to 32 inches, silt loam that is dark brown (10YR 3/3) grading to dark yellowish brown (10YR 3/4); moderate, coarse, prismatic structure breaking to weak, medium and coarse, subangular blocky structure; very friable when moist; neutral; diffuse, smooth boundary.

B22—32 to 40 inches, olive-brown (2.5Y 4/4) silt loam; yellowish brown (10YR 5/4) when dry; moderate, coarse, prismatic structure breaking to weak, medium and coarse, subangular blocky structure; very friable when moist; neutral; clear, smooth boundary.

C1ca—40 to 45 inches, olive-brown (2.5Y 4/4) loam; structureless; loose when dry; a few white calcium carbonate concretions 5 to 15 millimeters in diameter; mildly alkaline; calcareous; clear, smooth boundary.

IIC2—45 to 54 inches +, olive-brown (2.5Y 4/4) gravel; single grain; loose when moist; mildly alkaline; calcareous.

The A1 horizon ranges from black in some places to very dark grayish brown in eroded places. The B horizons range from silt loam to light silty clay loam. Typical colors in the subsoil are dark brown, brown, dark yellowish brown, and dark grayish brown.

The Beotia soils are better drained than the Divide soils. Their solum is neutral or slightly acid, whereas the solum of the Divide soils is alkaline. The Beotia soils differ from the Estelline soils, which are also on terraces and outwash plains, in being deeper to sand and gravel.

Beotia silt loam, 0 to 2 percent slopes (BeA).This soil is on broad river terraces and outwash plains. Gravelly material is 3 feet or more below the surface. In most places free lime is just above the gravelly material.

Included with this soil in mapping were some low swales that are moderately well drained, and in these places the lower part of the subsoil is mottled. In some places the gravelly underlying material is only a few feet thick and is underlain by glacial till or silty alluvium. Also included was a small acreage that has been eroded.

Drought may be a hazard in years of low rainfall. It is advisable to plow in spring to control wind erosion and to allow stubble and cornstalks to catch snow. If a high level of fertility and good tilth are maintained, this soil can be farmed intensively. (Capability unit I-1; windbreak suitability group 1)

Beotia silt loam, 2 to 4 percent slopes (BeB).—This soil is on parts of stream terraces and outwash plains. The underlying gravelly material is 3 feet or more below the surface. In some spots this material is only a few feet thick and is underlain by glacial till or silty alluvium.

About one-third of the acreage has been eroded, several inches of the orginal surface layer having been lost through wind and water erosion. In the eroded areas brown subsoil is exposed in numerous places.

Drought and erosion hazards are moderate. It is advisable to plow in spring to help control wind erosion. Terracing and contouring retard runoff and help to control water erosion. (Capability unit IIe-2; windbreak suitability group 1)

Blue Earth Series

The Blue Earth series consists of deep, very poorly drained soils that occupy drained lakes and ponds. They developed in lake-laid, highly organic, limy silt loam. The amount of lime in them depends on the abundance of snail shells.

In a typical profile, the surface layer is highly organic, limy, very dark gray silt loam about 42 inches thick. This layer is underlain by lake-laid deposits of sticky, mottled, dark-gray and olive-gray silty clay loam. These deposits, in turn, are underlain by clay loam glacial till. In most places the lake basins where the Blue Earth soils occur have a sandy rim of beach material and have steep escarpment slopes (fig. 7) around the edges. The highly organic material of these soils is thickest near the middle of the lakebed. It gradually becomes thinner toward the beach. In most places the larger marsh areas in the county are underlain by Blue Earth soils.

Permeability is moderate, and moisture-holding capacity is very high. The reaction is alkaline.

After they are partly drained, the Blue Earth soils are used for pasture. After they are adequately drained, they are farmed intensively.

Figure 7.—**A drained lake basin used for pasture. Buse soils are in the foreground. Blue Earth silt loam is on the floor of the basin.**

Representative profile of Blue Earth silt loam, in a cultivated field in a drained lake basin along U.S. Highway 75 (NW¼NW¼SW¼ sec. 22, T. 112 N., R. 45 W.):

A11ca—0 to 9 inches, very dark gray (10YR 3/1), highly organic silt loam; weak, very fine, subangular blocky structure; very friable when moist, slightly sticky when wet; fragments of snail shells are abundant; mildly alkaline; strongly calcareous; clear, smooth boundary.

A12gca—9 to 19 inches, silt loam having a dark-gray (5Y 4/1) color that grades to very dark gray (5Y 3/1); common, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, very thin, platy structure; friable when moist; fragments of snail shells are abundant; mildly alkaline; strongly calcareous; diffuse, clear boundary.

A13gca—19 to 31 inches, very dark gray (N 3/0) silt loam, common, medium, distinct, dark-brown (10YR 4/3) mottles; weak, very thin, platy structure; friable when moist; fragments of snail shells are abundant; mildly alkaline; strongly calcareous; diffuse, smooth boundary.

A14gca—31 to 42 inches, silt loam having a very dark gray (N 3/0) color that grades to dark gray (N 4/0); very weak, fine and medium, subangular blocky structure; friable when moist, slightly sticky when wet; fragments of snail shells are common; mildly alkaline; strongly calcareous; gradual, smooth boundary.

IIC1g—42 to 48 inches, dark-gray (5Y 4/1) silty clay loam; few, fine, distinct, dark yellowish-brown (10YR 3/4) mottles; sticky and plastic when wet; calcareous.

IIC2g—48 to 54 inches +, olive-gray (5Y 4/2) silty clay loam; common, medium, faint, dark olive-gray (5Y 3/2) mottles; sticky and plastic when wet; calcareous.

The A horizon ranges from black to dark gray in color. Typically, fragments of snail shells are abundant in the A horizon; however, they range to few in some places. The surface layer of highly organic silt loam ranges from 24 to 48 inches in thickness.

The Blue Earth soils differ from the Parnell soils in having a higher content of organic matter, a limy A horizon, and numerous fragments of snail shells throughout the solum. They are coarser textured and have a higher content of organic matter than the Oldham soils, which also occupy drained lake basins.

Blue Earth silt loam (Bh) (0 to 2 percent slopes).—This is the only Blue Earth soil in the county. It is in lakebeds. From 10 to 20 percent of the surface layer is organic matter. In some places the surface layer is light silty clay loam.

Wetness is the main limitation of this soil. Wind erosion is a hazard in large, open areas because of the silty, fluffy nature of the soil. The high content of lime makes some plant nutrients unavailable to plants. More drainage, especially tile drainage, is needed in most areas before the soils can be cropped intensively. This soil is productive when properly drained, fertilized, and managed. (Capability unit IIIw-2; windbreak suitability group 3)

Brookings Series

The Brookings soils are deep and moderately well drained. They are nearly level and gently sloping and occupy loessal uplands. They are commonly on side slopes of gently sloping upland drainageways. They developed in a moderately thick mantle of silt that is underlain by limy glacial till. These soils are in the southwestern part of the county.

In a typical profile (fig. 8), the surface layer consists of about 12 inches of black silty clay loam. The next layer, about 5 inches thick, consists of a mixture of surface soil and subsoil. The mixing was done by earthworms. The subsoil is friable, very dark grayish-brown silty clay loam about 16 inches thick. The lower part is limy and mottled.

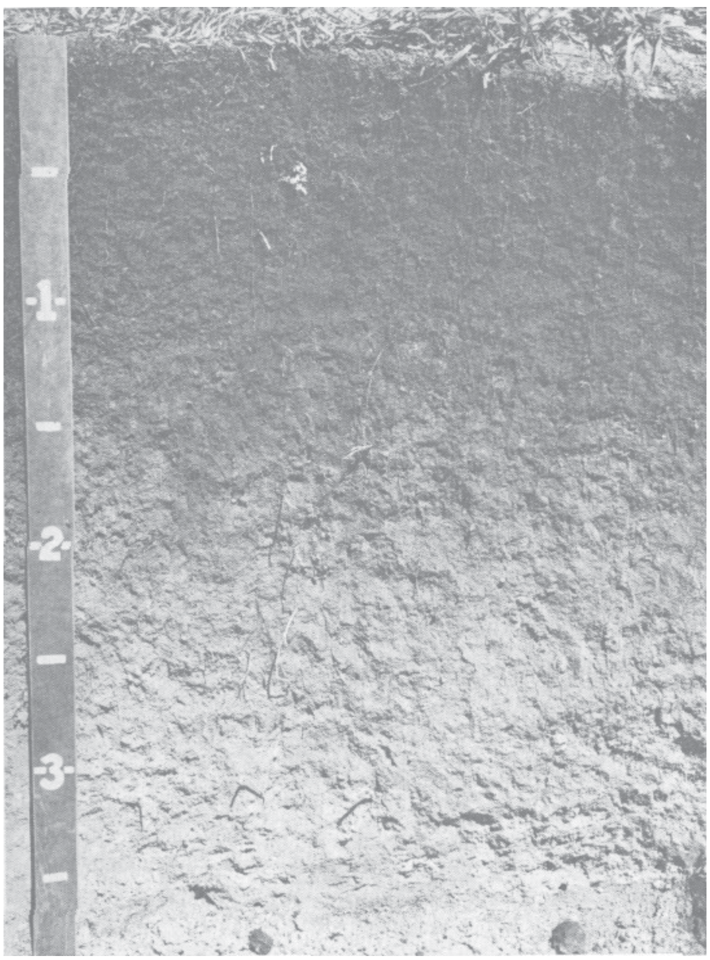

Figure 8.—**Profile of Brookings silty clay loam showing thick, dark surface layer. Visible at the bottom is the underlying clay loam glacial till.**

Beneath the subsoil is glacial till of limy, mottled yellowish-brown and grayish-brown clay loam. In places where the loess is very thick, the upper part of the underlying material is loess rather than glacial till.

Permeability is moderate, and moisture-holding capacity is high or very high. The surface layer has a neutral reaction.

The Brookings soils are almost entirely used for corn, small grains, and alfalfa.

Representative profile of Brookings silty clay loam in a grassy border of a field, under the guy wires of second electric pole from north one-quarter line (NW¼NE¼SW¼ sec. 18, T. 109 N., R. 45 W.):

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam; moderate, very fine, granular structure; friable when moist; neutral; clear, smooth boundary.

A12—7 to 12 inches, black (10YR 2/1) silty clay loam; moderate, very thin, platy structure breaking to weak, very fine, subangular blocky structure; friable when moist; neutral; clear, smooth boundary.

A3—12 to 17 inches, very dark gray (10YR 3/1) and very dark grayish-brown (10YR 3/2) silty clay loam; moderate, very fine, subangular blocky structure; very friable when moist; neutral; gradual, irregular boundary.

B2—17 to 28 inches, very dark grayish-brown (2.5Y 3/2) silty clay loam; few very dark gray (10YR 3/1) wormcasts; weak, coarse, prismatic structure breaking to moderate, fine, subangular blocky structure; friable when moist; old root channels, 1 millimeter in diameter, are common; calcareous, light olive-brown (2.5Y 5/4) spots in lower part; clear, irregular boundary.

B3—28 to 33 inches, light olive-brown (2.5Y 5/4) silty clay loam that is a mixture of loess and glacial till; few, fine, faint, light olive-brown (2.5Y 5/6) mottles; weak, fine and medium, subangular blocky structure; friable when moist; root channels are common; calcareous; clear, smooth boundary.

IICca—33 to 54 inches +, glacial till of yellowish-brown (10YR 5/4) and grayish-brown (2.5Y 5/2) clay loam; common, medium, distinct, strong-brown (7.5YR 5/8) mottles; fractures readily; friable when moist; soft, white calcium carbonate concretions, 5 to 25 millimeters in diameter, are common; strongly calcareous.

The A1 horizon ranges from black to very dark gray. It ranges from 8 to 15 inches in thickness but is about 12 inches thick in most places. In most places the B2 horizon is dark grayish brown or very dark grayish brown. The upper part of this horizon contains a variable amount of very dark gray wormcasts. In places the lower part is light olive brown, slightly mottled, and limy. Typically, free lime has been leached into the B3 horizon, which is 24 to 33 inches below the surface. The loess mantle ranges from 27 to 36 inches thick. Common colors of the IICca horizon are yellowish brown, light olive brown, grayish brown, and light brownish gray.

The sloping Brookings soils are on the lower part of slopes occupied by the Kranzburg soils, which are well drained. The nearly level Brookings soils are located among areas of the Kranzburg soils. Brookings soils are similar to the Lismore soils in the same region, but contain less grit and fewer pebbles.

Brookings silty clay loam, 0 to 2 percent slopes (BkA).—This soil occurs among areas of gently sloping Kranzburg soils, which are well drained. It also occurs on gentle side slopes adjacent to drainageways of the Hidewood soils, which are somewhat poorly drained. The surface layer (A1 horizon) of this soil is 10 to 15 inches thick. The silt layer over the glacial till is more than 30 inches thick in most places. In most areas free lime has been leached into the part of the soil that is 27 to 33 inches below the surface.

Included with this soil in mapping were a few places where the surface layer is silt loam. Also included were many places where a thin layer of sandy, gravelly, or cobbly material is present between the silt and the glacial till. Some small areas of Kranzburg soils and Hidewood soils were also included with this soil in mapping.

Normally, this soil has no serious limitations for intensive row cropping. (Capability unit I–1; windbreak suitability group 1)

Brookings silty clay loam, 2 to 4 percent slopes (BkB).—This soil is on the lower part of slopes below areas of the Kranzburg soils, which are well drained. Also, very gently sloping areas of this soil are on sides of drainageways occupied by the Hidewood soils, which are somewhat poorly drained. The surface layer of this Brookings soil is 8 to 10 inches thick in most places, and the silt mantle is less than 30 inches thick. Free lime has been leached out of the silty material and has accumulated in the upper part of the glacial till.

Included with this soil in mapping were a few areas where the surface layer is silt loam. A thin layer of sandy, gravelly, or cobbly material is present above the till in some places that were also included, as were some areas where Terril soils are intermingled with Brookings soils.

Since this soil slopes so little, erosion is only a slight hazard. This soil can be row cropped intensively, but a crop of legumes and grasses is needed periodically to maintain the level of organic matter and the capacity of the surface layer to absorb moisture. (Capability unit IIe–1; windbreak suitability group 1)

Buse Series

The Buse series consists of deep, excessively drained, steep and very steep soils in the uplands. These soils developed in loam or clay loam glacial till. They occur throughout the county.

In a typical profile, the surface layer is limy, very dark gray loam about 6 inches thick (fig. 9). This grades to a layer, about 11 inches thick, that is is composed of surface soil and underlying material that have been mixed by earthworms. The underlying material is glacial till of limy, dark yellowish-brown and yellowish-brown loam or clay loam.

Permeability and moisture-holding capacity are moderate. The surface layer is mildly or moderately alkaline.

Because their steepness results in excessive runoff of surface water, Buse soils are droughty. There is a very severe hazard of erosion when they are cultivated.

Representative profile of Buse loam in a pasture where the slope is steep, on a southwest-facing slope about 125 feet east of old U.S. Highway No. 75 (NE¼SW¼ sec. 17, T. 109 N., R. 45 W.):

A1—0 to 6 inches, very dark gray (10YR 3/1) loam; moderate, very fine and fine, subangular blocky structure; slightly hard when dry, friable when moist, sticky when wet; mildly alkaline; calcareous; gradual, wavy boundary.

A1&Cca—6 to 9 inches, very dark gray (10YR 3/1) loam; dark grayish-brown (10YR 4/2) wormcasts make up 50 percent of layer; moderate, very fine and fine, subangular blocky structure; friable when moist; mildly alkaline; strongly calcareous; gradual, wavy boundary.

Cca&A1—9 to 17 inches, dark grayish-brown (10YR 4/2) clay loam; very dark gray (10YR 3/1) wormcasts make up 25 percent of layer; moderate, very fine and fine, subangular blocky structure; friable when wet; mildly alkaline; strongly calcareous; clear, irregular boundary.

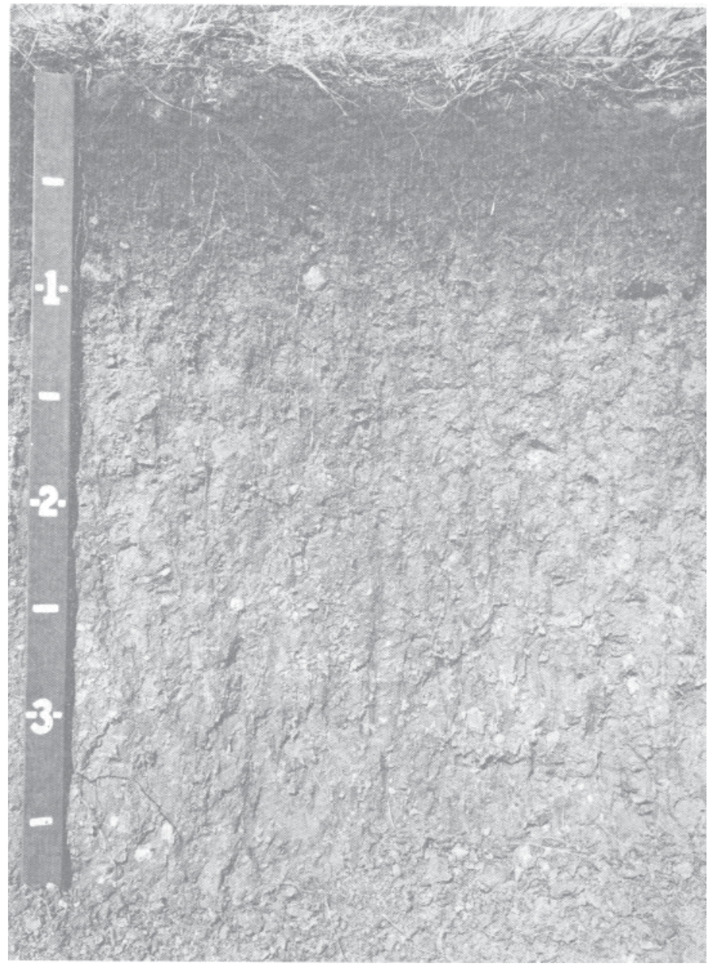

Figure 9.—**Profile of Buse loam showing thin surface layer and, near the bottom, glacial till containing pebbles and stones.**

C1ca—17 to 25 inches, dark yellowish-brown (10YR 4/4) clay loam; weak, very fine and fine, subangular blocky structure; friable when moist; mildly alkaline; strongly calcareous; gradual, smooth boundary.

C2—25 to 45 inches +, yellowish-brown (10YR 5/4) clay loam; massive to very weak, medium, subangular blocky structure; friable when moist; moderately alkaline; calcareous.

The A horizon in uneroded areas ranges from black to very dark gray. In eroded areas the A horizon ranges from very dark gray to very dark brown and to dark grayish brown. A transitional horizon that was formed by earthworms is prominent in most undisturbed places. In most cropped areas this horizon is less evident because it has been disturbed by tillage and erosion.

The Buse soils differ from the Barnes and Vienna soils, which are well drained, by having a thin, limy A horizon and by lacking a B horizon. They are similar to the Hamerly soils, which are moderately well drained, in their limy nature and in the sequence of their horizons.

Some of the Buse soils are mapped in complexes or undifferentiated units with less sloping Barnes or Arvilla soils, or both, where they are too intermingled to be mapped separately.

Buse loam, 18 to 25 percent slopes (BlE).—This soil is steep. It lies along streams and drainageways and around borders of ponds and lakes. The surface layer is about 6 inches thick. Stones and boulders are on the surface and in the soil in most of the areas. In some places there are small sandy or gravelly spots. The shallow, narrow drainageways that dissect this soil at irregular intervals are occupied by Terril soils.

The erosion hazard is very severe in areas of this soil that are used for row crops. This soil is best suited to pasture. If it is necessary to grow row crops, a rotation consisting mostly of legumes and grasses would help to control erosion. Because of very rapid surface runoff on the steep slopes, this soil is droughty. (Capability unit VIe–1; windbreak suitability group 6)

Buse loam, 25 to 40 percent slopes (BlF).—This soil is too steep to be farmed safely. Most areas are along rivers, creeks, and deep drainageways. The surface layer is less than 6 inches thick. There are sandy and gravelly spots in some places. This soil is droughty because of excessive runoff.

The hazard of erosion is very severe on this soil whenever the native sod is broken. Deep gullies develop if too much runoff water flows into a single drainageway. Most areas are used for pasture. Wherever overgrazing has been permitted, the native grasses have all but disappeared, and the less desirable Kentucky bluegrass has replaced them. Some of the north-facing slopes are wooded and have on them bur oak, green ash, cottonwood, ironwood, wild plum, sumac, or chokecherry. (Capability unit VIIe–1; windbreak suitability group 6)

Buse stony loam, 5 to 40 percent slopes (BnF).—This soil consists of stony glacial till. It ranges from undulating to very steep, and the slopes are complex and irregular. The largest acreage is in the rough, hilly parts of the county. Numerous stones and large granite boulders are on the surface. Most of the areas of this soil are only a few acres in size. Many small areas of this soil are shown on the soil map by symbols.

In most areas the profile of this soil resembles that of the Buse soils. In some gently sloping areas, however, the soil profile resembles that of the Barnes or the Vienna soils. Because of the difficulty of examining all the areas, some sandy and gravelly areas of undetermined extent have been included with this soil in mapping.

This soil is too stony to be used as cropland. The areas are normally used for pasture. These stony pastures produce only small amounts of forage because it is not practical to fertilize and manage them. (Capability unit VIIs–1; windbreak suitability group 8)

Buse-Arvilla complex, 12 to 18 percent slopes, eroded (BrD2).—This is a complex of moderately steep soils that have a surface layer of loam and sandy loam. It consists of about 40 to 60 percent Buse soils and about 40 to 60 percent Arvilla soils. In some places up to 15 percent of this mapping unit consists of Barnes soils. Spots of yellow underlying material are exposed in the areas of Buse soils. Spots of gravelly underlying material are exposed in the areas of Arvilla soils.

Most of the acreage in this complex is used for pasture and hay. Small gravel pits have been opened up in some of the Arvilla areas. Drought is a very severe hazard, and the acreage used for crops is subject to a very severe erosion hazard. If it is necessary to crop areas of this soil complex, a system of stripcropping, or a rotation consisting mostly of sod crops, would help to control erosion. Corn and other clean-tilled crops are not suited to these soils. (Capability unit VIe–2; Buse soil, windbreak suitability group 6; Arvilla soil, windbreak suitability group 8)

Buse-Arvilla complex, 18 to 40 percent slopes (BrF).—This complex consists mostly of steep and very steep Buse and Arvilla soils. The percentage of each of the main soils in areas of the complex ranges from 40 to 60 percent. The complex lies on slopes bordering streams or on side slopes along deep drainageways. The Buse and the Arvilla soils in this complex have thin, immature profiles because little soil development has occurred on the steep slopes. Their surface layer is loam and sandy loam.

This complex provides some grazing during spring and early summer. A few small areas have been used for crops. The hazards of erosion and drought are severe. Some gravel pits in the areas of Arvilla soils provide a source of gravel for use on farms. (Capability unit VIIe–1; Buse soil, windbreak suitability group 6; Arvilla soil, windbreak suitability group 8)

Buse-Barnes loams, 12 to 18 percent slopes (BoD).—This complex of moderately steep soils lies along the sides and around the heads of drainageways. It consists of 60 to 80 percent Buse soils and 20 to 40 percent Barnes soils. In some places the surface is stony. The Buse soil has a profile similar to the one described for the Buse series. The Barnes soil in most places has a profile thinner than the one described for the Barnes series. The texture of the surface layer is loam and sandy loam.

Some small grains and alfalfa are grown on the soils of this complex, but most of the acreage is in pasture. The hazard of erosion is very severe when the sod is plowed. Because of very rapid runoff, these soils are droughty. Good management, especially fertilization of the existing pastures, would help increase production of forage on these soils. (Capability unit IVe–1; windbreak suitability group 6)

Buse-Barnes loams, 12 to 18 percent slopes, eroded (BoD2).—This is a complex of moderately steep Buse and Barnes loams and sandy loams. About 60 to 80 percent of the acreage consists of Buse soils. The rest is mainly Barnes soils that are on the upper and lower parts of the slopes. On many eroded hillsides there are large yellowish spots where the material that normally underlies the soils has been exposed. The fringes of these spots are brown because the subsoil of the Barnes soils has been exposed. Small spots of sand and gravel are present in some places.

Small grains and alfalfa are grown to some extent on areas of this complex, but a considerable acreage is in pasture. The hazard of erosion is very severe. Because runoff is very rapid, the soils of this complex are droughty. To control erosion and minimize the effects of drought, a rotation that consists mainly of grasses and legumes is the most suitable. (Capability unit IVe–1; windbreak suitability group 6)

Colvin Series

The Colvin series consists of deep, poorly drained, nearly level soils that occupy parts of the lake plain in the northeastern part of the county. These soils developed in silty lake-laid sediments mixed with alluvium from the North Branch Yellow Medicine River, which flows through this area.

In a typical profile, the surface layer is limy, black silty clay loam 11 inches thick. Beneath this is the underlying material of limy, very dark gray silty clay loam consisting of water-laid sediments, about 12 inches thick, and this grades to limy, mottled, dark-gray and gray silty clay loam.

Permeability is moderate, and the moisture-holding capacity is high. Reaction is mildly to moderately alkaline.

A large acreage of these soils is used for pasture or wild hay. After they are drained and properly fertilized, Colvin soils are suited to crops commonly grown in the county.

Representative profile of Colvin silty clay loam in a cropped area on a lake plain, 120 feet south of gatepost (NE¼SE¼SE¼ sec.12, T. 113 N., R. 44 W.):

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam; cloddy; friable when moist, slightly sticky when wet: calcareous; abrupt, smooth boundary.

A12—7 to 11 inches, black (10YR 2/1) silty clay loam; weak, very fine, subangular blocky structure; friable when moist, slightly sticky when wet; calcareous; clear, smooth boundary.

C1gca—11 to 16 inches, very dark gray (N 3/0) silty clay loam, gray (N 6/0) when dry; weak, fine, subangular blocky structure; friable when moist, slightly sticky when wet; small pockets of light brownish-gray (2.5Y 6/2) calcium sulfate crystals; strongly calcareous; clear, smooth boundary.

C2gca—16 to 23 inches, very dark gray (5Y 3/1) silty clay loam, gray (N 6/0) when dry; very weak, fine and medium, subangular blocky structure; friable when moist, slightly sticky when wet; small pockets of calcium sulfate crystals; strongly calcareous; clear, smooth boundary.

C3gca—23 to 33 inches, dark-gray (5Y 4/1) silty clay loam; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; very weak, fine, subangular blocky structure; friable when moist, slightly sticky when wet; strongly calcareous; gradual, smooth boundary.

C4gca—33 to 44 inches, gray (5Y 5/1) silty clay loam; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; fractures readily; friable when moist, slightly sticky when wet; few, soft, white calcium carbonate concretions that are less than 5 millimeters in diameter; strongly calcareous; gradual, smooth boundary.

C5g—44 to 60 inches +, gray (5Y 5/1) silty clay loam; few, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; fractures readily; friable when moist, slightly sticky when wet; thin strata of sandy material; calcareous.

The A1 horizon ranges from 8 to 16 inches in thickness and from black to very dark gray in color. The zone of lime accumulation ranges from light gray to very dark gray. The presence of calcium carbonate, calcium sulfate, and manganese concretions in the Cca and C horizons is variable.

The Colvin soils differ from the Flom soils in the uplands by having developed in lacustrine sediments, by having a high content of lime in the A horizon, and by having a zone of lime accumulation directly below the A1 horizon. They have a profile somewhat similar to that of the Vallers soils, which developed in glacial till, but they developed in lacustrine sediments instead of in glacial till.

Colvin silty clay loam (Co) (0 to 2 percent slopes).—This is the only soil of the Colvin series mapped in the county. It is on a low-lying lake plain. Included with this soil in mapping were a few spots where the surface layer is silt loam. Thin strata of sandy material occur in places in the C horizon.

Wetness and flooding are the dominant hazards. The water table is near the surface in spring and during other periods of wetness. Tile drainage is needed, but outlets for tile systems are hard to locate. The excessive lime in the soil makes some plant nutrients unavailable to plants. (Capability unit IIw-2; windbreak suitability group 3)

Crofton Series

The Crofton series consists of deep, excessively drained, gently sloping and sloping soils on the side slopes around former glacial lakes. They developed in silty materials that were deposited by water. The slopes are long and smooth, because the silty sediments that were deposited by water over the glacial till have filled in the irregular places.

In a typical profile, the surface layer is friable, limy, very dark gray silty clay loam about 7 inches thick. The next layer, about 9 inches thick, is a mixture of dark grayish-brown and very dark gray silty clay loam. Earthworms have mixed in this layer material similar to that of the surface layer with material similar to that in the deeper layers. This mixed layer is absent in some areas where the soil has been cultivated and erosion has been active. The underlying material is stratified, friable, limy, grayish-brown silty clay loam.

Permeability of Crofton soils is moderately rapid, and moisture-holding capacity is moderate to high. The surface layer is mildly alkaline. The soils are free of stones and are easy to work. Most of the acreage is used for crops, but some of the steeper slopes are used for pasture.

Representative profile of Crofton silty clay loam in a cultivated field where the slope is 7 percent, about 75 feet north of the edge of a field and about 125 feet west of the farmstead windbreak on south side of road (SE¼SE¼SW¼ sec. 23, T. 113 N., R. 46 W.):

Ap—0 to 7 inches, very dark gray (10YR 3/1) silty clay loam mixed with dark grayish-brown (10YR 4/2) silty clay loam similar to that in the underlying horizons; cloddy; friable when moist; calcareous; abrupt, smooth boundary.

C1ca—7 to 16 inches, mainly dark grayish-brown (10YR 4/2) and very dark gray (10YR 3/1) silty clay loam wormcasts; moderate, very fine and fine, subangular blocky structure; friable when moist; strongly calcareous; clear, irregular boundary.

C2ca—16 to 31 inches, grayish-brown (2.5Y 5/2) silty clay loam; common, medium, distinct, dark yellowish-brown (10YR 3/4) iron accumulations or mottles; stratified; friable when moist; a few calcium carbonate concretions in upper part; strongly calcareous; gradual, smooth boundary.

C3—31 to 54 inches +, grayish-brown (2.5Y 5/2) silty clay loam; many, coarse, prominent, strong-brown (7.5YR 5/8) iron accumulations or mottles; stratified; friable when moist; calcareous.

The texture of the horizons in most profiles ranges from light silty clay loam to silt loam. The color of the A horizon in uneroded areas ranges from black to very dark gray. The thickness of the A1 horizon in uncultivated areas ranges from 5 to 9 inches. The color of the C horizons is commonly grayish brown, light olive brown, or light brownish gray. Stratification is not readily apparent in all profiles.

Crofton soils developed in material similar to that of the well drained Poinsett soils and the moderately well drained Waubay soils. The Crofton soils do not have a B horizon. They have an A horizon that is thinner than that of the Poinsett and the Waubay soils, and their A horizon contains lime. The horizons in Crofton soils are similar to those in the Buse soils, which developed in glacial till.

Crofton silty clay loam, 4 to 12 percent slopes (CrC).—This soil is on side slopes around former glacial lakes in the uplands of glacial till and on slopes around closed depressions within areas of Poinsett and Waubay soils. The surface layer is 6 to 9 inches thick. It is grayish because the original surface soil has been mixed with the underlying material as a result of erosion and tillage. On some slopes the texture is silt loam. In places where severe erosion has occurred, the grayish-brown underlying material is exposed at the surface. On some gentle slopes there are small areas of Poinsett soil next to areas of Crofton soil.

Much of the acreage of this soil has been slightly or moderately eroded, but a small acreage is uneroded. Included in mapping of this soil was a small acreage of a Crofton soil that has slopes of 12 to 18 percent. Also included were a few areas of a Sinai soil that has slopes of 6 to 12 percent.

The hazard of erosion is severe on this Crofton soil. The slopes are long and smooth, and therefore the soil is well suited to terracing and stripcropping. These practices are effective in reducing losses of soil and water that are caused by the rapid runoff. (Capability unit IIIe–1; windbreak suitability group 5)

Dickey Series, Silty Variants

The Dickey soils mapped in the county are silty variants of the Dickey series. These variants consist of deep, somewhat excessively drained, sandy soils that have in them horizons of silt loam or silty clay loam.

In a typical profile, the surface layer, about 7 inches thick, is friable, very dark brown sandy loam. The next layer, about 20 inches thick, is dark-brown and dark yellowish-brown, loose loamy sand. Below the loamy sand is friable, limy, olive-brown silty clay loam and silt loam about 22 inches thick. A thin, sandy transitional layer lies below the silty layer and grades to limy, olive-brown glacial till of clay loam texture.

Permeability of the Dickey soils is moderately rapid, and the moisture-holding capacity is moderate. The reaction of the surface layer is neutral or slightly acid.

These soils are free of stones and are easy to work. They are fair soils for farming, in spite of the sandy texture, because the silty horizons hold moisture. Deep-rooted crops are affected less by drought on these soils than on sandy soils that do not have the silty horizons.

Representative profile of Dickey sandy loam, silty variant, in a cultivated field where the slope is 1 percent, 75 feet south and 75 feet west of third electric pole from section corner (NE¼NE¼ sec. 24, T. 109 N., R. 47 W.):

Ap—0 to 7 inches, very dark brown (10YR 2/2) sandy loam; very dark gray (10YR 3/1) when dry; cloddy; friable when moist; neutral; clear, smooth boundary.

A3—7 to 12 inches, very dark brown (10YR 2/2) to dark-brown (7.5YR 3/2) sandy loam; very dark grayish brown (10YR 3/2) when dry; weak, coarse, subangular blocky structure; very friable when moist; neutral; clear, smooth boundary.

B21—12 to 16 inches, dark-brown (7.5YR 3/2) loamy sand; weak, medium, subangular blocky structure; loose when moist; neutral; clear, smooth boundary.

B22—16 to 32 inches, dark yellowish-brown (10YR 4/4) loamy sand; massive to weak, coarse, subangular blocky structure; loose when moist; neutral; clear, smooth boundary.

IIB23—32 to 42 inches, olive-brown (2.5Y 4/4) grading to dark yellowish-brown (10YR 4/4) light silty clay loam; moderate, coarse and medium, subangular blocky structure; friable when moist, slightly sticky when wet; mildly alkaline; calcareous; clear, smooth boundary.

IIB3—42 to 46 inches, light olive-brown (2.5Y 5/4), grading to olive-brown (2.5Y 4/4), light silty clay loam; weak, coarse, subangular blocky structure; friable when moist, slightly sticky when wet; mildly alkaline; calcareous; abrupt, smooth boundary.

IIC1ca—46 to 54 inches, light olive-brown (2.5Y 5/4) silt loam; friable when moist, slightly sticky when wet; moderately alkaline; strongly calcareous; clear, smooth boundary.

IIC2—54 to 60 inches, light olive-brown (2.5Y 5/4) sandy clay loam; friable when moist; moderately alkaline; calcareous; clear, smooth boundary.

IIC3—60 to 64 inches, light yellowish-brown (2.5Y 6/4) loamy fine sand; single grain; loose when moist; moderately alkaline; calcareous; clear, smooth boundary.

IIIC4—64 to 68 inches +, light olive-brown (2.5Y 5/4) clay loam glacial till; iron stains; a few, hard and soft, white calcium carbonate concretions less than 10 millimeters in diameter; moderately alkaline; calcareous.

Thickness of the loamy sand or sand beneath the A horizons and above the silty material ranges from 12 to 36 inches. The depth from the surface to the glacial till under the silty material is in most places more than 60 inches.

Dickey soils on the uplands are near areas of Kranzburg and Vienna soils. On outwash plains adjacent to the uplands, they grade to Beotia soils. Dickey soils have a sequence of horizons similar to that of the Flandreau soils, but they have a coarser textured profile. They have a sandy solum somewhat similar to that of the Sverdrup soils, but Sverdrup soils do not have the silty layer and are not underlain by glacial till.

Dickey sandy loam, silty variant, 0 to 2 percent slopes (DcA).—This soil is on outwash plains and uplands in the southwestern part of the county. It is nearly level. On outwash plains it lies between the Beotia soils and the soils on uplands. On the uplands it lies on flat areas among more strongly sloping Dickey soils.

A few eroded areas were included in mapping this soil. Although the surface layer is normally sandy loam, in some places it is light loam, and in a few spots it is loamy sand. The thickness of the loamy sand layer in the subsoil, which ranges from 12 to 36 inches, influences the degree of droughtiness. Free lime has been leached from the A horizons and deposited in the silty material.

Drought is the main hazard when these soils are used. If these soils are plowed in fall, serious wind erosion is likely to occur in spring. (Capaiblity unit IIIs–1; windbreak suitability group 4)

Dickey sandy loam, silty variant, 2 to 6 percent slopes (DcB).—The areas of this soil lie among areas of the silty Kranzburg soils and the loamy Flaudreau soils. Slopes of this soil are smooth and gentle.

A few inches of the original surface layer have been lost through erosion in most areas. The color of the surface layer has been made lighter by the loss of organic matter through erosion and excessive row cropping. Some sandy, dark-brown, severely eroded spots on knolls, and some slightly eroded, dark-colored areas in saddles of the slopes, have been included in mapping this soil. In some places the surface layer is light loam or loamy sand. The loamy sand in the subsoil ranges from 12 to 36 inches thick. The thickness of the loamy sand directly affects the degree of droughtiness. Free lime has been leached from the upper layers and deposited in the silty material.

Drought and erosion, especially wind erosion, are hazards when this soil is used. Contouring, spring plowing, and a rotation that includes a sod crop every 4 to 5 years would help increase the productivity. (Capability unit IIIe–2; windbreak suitability group 4)

Divide Series

The Divide series consists of limy, somewhat poorly drained and poorly drained soils that are moderately deep and deep over sand and gravel. They are nearly level soils in low places on river terraces and in broad glacial outwash valleys in the southwestern part of the county. They developed in limy, water-laid or windblown materials that are underlain by limy sand and gravel.

In a typical profile, the surface layer is friable, limy, black silt loam about 14 inches thick. The next layer, to a depth of about 32 inches, is friable and limy. It is dark-colored loam in the upper part and is mottled, light brownish-gray and light-gray gravelly sandy clay loam and sandy loam in the lower part. It is underlain by limy sand and gravel.

Permeability of Divide soils above the sand and gravel is moderate. Moisture-holding capacity is moderate in most places but is high in places where the depth to sand and gravel is more than 36 inches. The reaction of the surface layer is mildly alkaline or moderately alkaline.

Much of the acreage of Divide soils is used for pasture. These soils produce corn, small grains, alfalfa, and other crops if they are adequately drained and fertilized.

Representative profile of Divide silt loam under native prairie grasses in an outwash valley where the slope is 1 percent, 25 feet south and 65 feet east of road approach (SW¼NW¼NW¼ sec. 34, T. 109 N., R. 45 W.):

A1—0 to 9 inches, black (N 2/0) highly organic silt loam; weak, very fine, subangular blocky structure; friable when moist; mildly alkaline; abrupt, smooth boundary.

A3—9 to 14 inches, black (10YR 2/1) silt loam; weak, very fine, subangular blocky structure; friable when moist; moderately alkaline; calcareous; clear, wavy boundary.

ACgca—14 to 23 inches, black (10YR 2/1) and very dark gray (2.5Y 3/1) loam; about 10 percent dark-gray (2.5Y 4/1) wormcasts; weak, fine and medium, subangular blocky structure; friable when moist; moderately alkaline; strongly calcareous; abrupt, smooth boundary.

IIC1ca—23 to 27 inches, light brownish-gray (2.5Y 6/2) gravelly sandy clay loam; common, medium, distinct, olive-yellow (2.5Y 6/6) mottles; structureless; friable when moist, sticky when wet; moderately alkaline; strongly calcareous; abrupt, smooth boundary.

IIC2ca—27 to 32 inches, light-gray (2.5Y 7/2) gravelly sandy loam; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; structureless; friable when moist; moderately alkaline; strongly calcareous; abrupt, smooth boundary.

IIC3—32 to 54 inches +, stratified sand and gravel; single grain; loose when moist; calcareous.

Combined thickness of the A horizons ranges from 8 to 20 inches. In some places the A horizons are silty clay loam. The depth to sand and gravel typically is 30 to 36 inches but ranges from 24 to 48 inches.

The Divide soils occupy swales, drainageways, and other low places in the landscape. They are lower than the better drained Estelline and Fordville soils. They are on slightly higher places in the landscape than the very poorly drained Rauville soils. They differ from Lamoure soils by having a thinner A horizon and by having gravelly instead of silty underlying material.

Divide silt loam (Dv) (0 to 2 percent slopes).—This is the only soil of the Divide series mapped in the county. It is nearly level, and the areas in most places surround areas of the very poorly drained Rauville soils.

Thickness of the surface layer is 8 to 20 inches. In a few areas the surface layer is silty clay loam. Included in mapping this soil were a few small, somewhat poorly drained areas that are underlain by gravel and have a surface layer that is not limy.

Wetness is the major hazard when this soil is used. The excessive lime content makes special fertilization necessary. (Capability unit IIw-6; windbreak suitability group 3)

Estelline Series

The Estelline series consists of moderately deep, well-drained, nearly level soils that are moderately deep over sand and gravel. These soils occur on river terraces and outwash plains. They developed in silty, medium-textured, water-laid or windblown material that is underlain by limy sand and gravel.

In a typical profile, the surface layer, about 6 inches thick, is friable, black silt loam. The subsoil, about 19 inches thick, is friable, brownish silt loam. A 4-inch transitional layer of sandy loam separates the subsoil from the underlying material, which is limy sand and gravel. The depth to the sand and gravel ranges from 2 to 3 feet.

Permeability of these soils is moderately rapid, and moisture-holding capacity is moderate. The reaction is neutral to slightly acid in both the surface layer and the subsoil.

All the crops common in the county can be grown on these soils. Crops grow well, except in years when the rainfall is less than normal.

Representative profile of Estelline silt loam in a cultivated field where the slope is 2 percent, about 60 feet from road (south center of SW¼ sec. 27, T. 109 N., R. 45 W.):

Ap—0 to 6 inches, black (10YR 2/1) silt loam; cloddy; friable when moist; neutral; abrupt, smooth boundary.

B1—6 to 12 inches, very dark brown (10YR 2/2) silt loam; very dark grayish brown (10YR 3/2) when crushed; a few black (10YR 2/1) wormcasts; weak, coarse and medium, prismatic structure breaking to weak, fine, subangular blocky structure; friable when moist; slightly acid; abrupt, smooth boundary.

B2—12 to 21 inches, dark yellowish-brown (10YR 3/4), grading to dark-brown (10YR 3/3), silt loam; weak, medium and coarse, prismatic structure breaking to weak, coarse and medium, subangular blocky structure; friable when moist; neutral; gradual, smooth boundary.

B3—21 to 25 inches, brown (10YR 4/3) silt loam; very weak, fine and medium, subangular blocky structure; friable when moist; neutral; clear, smooth boundary.

IIC1—25 to 29 inches, dark grayish-brown (10YR 4/2) sandy loam; structureless; friable when moist; calcareous; clear, smooth boundary.

IIC2—29 to 42 inches +, dark yellowish-brown (10YR 4/4), yellowish-brown (10YR 5/4), and dark grayish-brown (10YR 4/2) sand and gravel; single grain; loose when moist; neutral to mildly alkaline; calcareous; amount of lime increases with depth.

The thickness of the surface layer ranges from 6 to 12 inches, and its color ranges from black to very dark grayish brown. The latter color is present in some eroded sites. The color of the B horizon typically is very dark grayish brown, dark brown, brown, or dark yellowish brown. Thickness of the B horizon ranges from 15 to 30 inches, and its texture ranges from silt loam to light silty clay loam. Free lime has been leached from the A horizon and the upper B horizons and has accumulated in the upper part of the gravel or in the transitional layer just above it.

The Estelline soils are better drained than the Divide soils, and they have a solum that is neutral or slightly acid instead of alkaline. They resemble the Fordville soils in some ways, but they developed in silty, medium-textured alluvium or loess, and the Fordville soils developed in gritty, medium-textured alluvium or glacial drift. Estelline soils are shallower to sand and gravel than Beotia soils.

Estelline silt loam, 0 to 2 percent slopes (EsA).—This soil is nearly level and is on broad stream terraces and outwash plains.

In some areas the gravelly material is only a few feet thick and is underlain by glacial till or silty alluvium. Included in mapping of this soil are small areas that have a gritty, medium-textured surface layer and some spots that have a surface layer or subsoil of silty clay loam. Also included in some of the drainageways are areas of a moderately well drained soil that is mottled in the lower part of the subsoil.

The hazard of drought is slight on this soil. There is a hazard of wind erosion, and a small acreage has been eroded. Spring plowing is advisable to reduce the risk of further wind erosion. This soil can be farmed intensively if measures are applied to control wind erosion and minimize the effects of drought. (Capability unit IIs-1; windbreak suitability group 7)

Flandreau Series

The Flandreau series consists of well-drained, nearly level, gently sloping and undulating soils. They developed in loamy materials of glacial origin that were deposited by wind or water, and they are underlain by sandy loam at a depth of 24 to 36 inches.

A typical nearly level Flandreau soil in the southwestern part of the county has a surface layer, about 11 inches thick, that is friable, dark-colored loam. The upper part of the subsoil, about 15 inches thick, consists of friable, very dark brown to dark yellowish-brown loam. The lower part of the subsoil, about 14 inches thick, consists of friable, dark yellowish-brown sandy loam that grades to loose, yellowish-brown loamy sand. In many places there is below the loamy sand a layer of grayish-brown and light olive-brown silt loam that is mottled and calcareous in the lower part. In other places the Flandreau soils do not have the layer of silt loam but are underlain by deep sand. In some places glacial till is present beneath several feet of sand.

Permeability of the Flandreau soils is moderately rapid, and moisture-holding capacity is moderate. The reaction in the surface layer is neutral or slightly acid.

These soils are easy to work, and in most places they are free of stones. They tend to be droughty, especially in years when the amount of rainfall is less than normal.

Representative profile of Flandreau loam in a cropped area where the slope is 1 percent, 50 feet east and 20 feet north of farm drive (SW¼SW¼NW¼ sec. 19, T. 109 N., R. 46 W.):

Ap—0 to 6 inches, very dark gray (10YR 3/1) loam; cloddy; friable when moist; neutral; abrupt, smooth boundary.

A1—6 to 11 inches, black (10YR 2/1) loam; weak, medium, subangular blocky structure; friable when moist; neutral; clear, wavy boundary.

B21—11 to 16 inches, very dark brown (10YR 2/2), grading to very dark grayish-brown (10YR 3/2), loam; few very dark gray (10YR 3/1) old root channels; weak, medium, prismatic structure breaking to weak, medium, subangular blocky structure; friable when moist; slightly acid; clear, smooth boundary.

B22—16 to 26 inches, dark yellowish-brown (10YR 4/4) light loam; weak, medium, prismatic structure breaking to weak, medium, subangular blocky structure; friable when moist; slightly acid; clear, smooth boundary.

IIB23—26 to 40 inches, dark yellowish-brown (10YR 4/4) sandy loam; weak, medium, prismatic structure breaking to weak, medium, subangular blocky structure; friable when moist; neutral; gradual, smooth boundary.

IIC1—40 to 46 inches, yellowish-brown (10YR 5/4) loamy sand; loose when moist; neutral; abrupt, smooth boundary.

IIIC2—46 to 52 inches, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) silt loam; friable when moist; neutral.

IIIC3ca—52 to 60 inches, grayish-brown (2.5Y 5/2) silt loam; many, coarse, distinct, yellowish-brown (10YR 5/4) mottles; friable when moist; many, hard, irregular calcium carbonate concretions, 5 to 25 millimeters in diameter; strongly calcareous.

The color of the A horizon ranges from black to very dark gray in uneroded places, and to very dark brown in eroded places where the plow layer contains material from the B horizons as a result of mixing by tillage. Depth to the IIB23 horizon (sandy loam material) ranges from 24 to 36 inches. The texture of the IIC horizons is typically medium sand, but it ranges to light sandy loam. The depth to lime is variable, especially in the Flandreau soils that are in areas of Cary and Mankato glacial till. In some of those areas lime is at or near the surface, but in most places the depth to lime is 3 to 5 feet.

The Flandreau soils are finer textured and are deeper over sand than the Sverdrup soils. They differ from the Fordville soils, principally because they have a sandy rather than a gravelly substratum.

Flandreau loam, 0 to 2 percent slopes (FaA).—This soil is moderately deep, well drained, and nearly level. It is in nearly level places and in drainageways among areas of Sverdrup, Barnes, Dickey, Arvilla, and other soils of the uplands. In the extreme southwestern corner of the county, this soil occurs with Beotia soils on a nearly level outwash plain.

In a few spots the subsoil has been exposed by wind erosion. The surface layer in a few places is lighter colored than the one described as typical of the series, because some subsoil has been mixed into it by tillage. The lower part of the subsoil in some of the drainageways is olive brown and mottled. In some places thin layers of silty material are present in the underlying sand. The sand in some places is only a few feet thick and is underlain by silty material or by glacial till. In a small acreage the surface layer and subsoil are silt loam.

The hazard of drought is slight on this soil. There is also a hazard of wind erosion, especially if plowing is done in fall. This soil is easy to work and is moderately productive, except when a long drought occurs. (Capability unit IIs-1; windbreak suitability group 7)

Flandreau loam, 2 to 6 percent slopes (FaB).—Areas of this soil that lie among areas of the silty Kranzburg and Poinsett soils and the sandy Dickey soils have smooth slopes. Those that lie among the Barnes and Sverdrup soils are gently undulating.

The surface layer in most places is a few inches thinner than the one in the profile described as typical of the series. In some areas the surface layer is light colored because the brownish subsoil has been exposed by erosion. In some places this soil has a surface layer and subsoil of silt loam. The depth to free lime is variable. In some places lime has been leached from the solum, but in others free lime is present in the subsoil. In some places thin layers of silty material are present in the loose, sandy substratum. This soil in some places is underlain at a depth of 3 to 4 feet by silty material or by glacial till.

This soil is somewhat droughty because it has a sandy substratum. There is a hazard of wind erosion when it is cultivated or disturbed. This soil can be improved by soil management that includes fertilization, control of erosion, management of crop residues, and use of a rotation in which grasses and legumes are grown. (Capability unit IIe-3; windbreak suitability group 7)

Flom Series

The Flom series consists of deep, poorly drained, nearly level soils. They developed in glacial till in drainageways, at the base of steeper slopes, around the rims of depressions, and in low-lying, somewhat wet, flat areas. They are the most extensive wet soils in the glaciated uplands.

In a typical profile, the surface layer consists of about 17 inches of dark-colored clay loam. The upper part of this surface layer is black, and the lower part is very dark gray. The next layer, the subsoil, is friable, mottled, very dark grayish-brown clay loam about 4 inches thick. The underlying material is limy, mottled, gray clay loam.

Permeability of these soils is moderate, and the moisture-holding capacity is high or very high. The content of organic matter is high. The reaction in the surface layer in most places is neutral.

When they are adequately drained (fig. 10), fertilized, and managed, the Flom soils are well suited to the common crops. Most of the areas are too small and irregular to be farmed separately, and they are farmed along with the soils that adjoin them.

Figure 10.—Profile of a Flom soil. Visible at the bottom is the water table, 38 inches below the surface.

Representative profile of Flom clay loam in a cropped area where the slope is 1 percent, 80 feet north of railroad tracks and 110 feet east of road edge:

Ap—0 to 6 inches, black (N 2/0 to 10YR 2/1) clay loam; cloddy, or weak, very fine, subangular blocky structure; friable when moist, slightly sticky when wet; noncalcareous; neutral; abrupt, smooth boundary.

A1—6 to 13 inches, black (N 2/0 to 10YR 2/1) clay loam; moderate, very fine and fine, subangular blocky structure; friable when moist; noncalcareous; neutral; clear, smooth boundary.

A3g—13 to 17 inches, very dark gray (N 3/0 to 10YR 3/1) clay loam; few olive-brown (2.5Y 4/4) wormcasts; few, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, very fine, subangular blocky structure; friable when moist; olive-brown casts are calcareous; mildly alkaline; clear, irregular boundary.

B2g—17 to 21 inches, very dark grayish-brown (2.5Y 3/2) clay loam; about 20 percent very dark gray (10YR 3/1) wormcasts; common, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, very fine, subangular blocky structure; friable when moist; mildly alkaline; calcareous; gradual, wavy boundary.

C1g—21 to 30 inches, grayish-brown (2.5Y 5/2) clay loam; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, very fine, subangular blocky structure; friable when moist; moderately alkaline; calcareous; gradual, smooth boundary.

C2gca—30 to 54 inches +, gray (5Y 6/1) clay loam; many, coarse, distinct, yellowish-brown (10YR 5/6) mottles; very weak, very fine, subangular blocky structure; friable when moist; few, round, black, manganese oxide concretions 1 to 3 millimeters in diameter; few, soft, white calcium carbonate concretions in lower part; moderately alkaline; strongly calcareous.

The upper part of the profile in many places is free of stones and pebbles because the till has been reworked by water. All of the horizons in the profile range from clay loam to silty clay loam. The number, color, size, and distinctness of the mottles are variable and depend on the depth to the water table, texture of the parent material, and location of the soil in the landscape. The principal color of the B horizon ranges from very dark grayish brown to grayish brown. In some profiles a B horizon cannot be identified. The principal colors in the underlying material are grayish brown, olive gray, light olive gray, and gray. The depth to free lime is variable. In some places the soil is slightly limy at the surface and in others there is no free lime above a depth of 3 feet or more.

Flom soils are in lower areas than the Barnes, Buse, and Svea soils and in slightly higher areas than the Parnell soils, which are in depressions. They differ from the Vallers soils because their A horizon is generally not limy. In most places there is some evidence that a B horizon has developed in these soils, and they do not have a high-lime zone directly below the A horizon. They are coarser textured and have weaker structure than the Fulda soils.

Flom clay loam (Fc) (0 to 2 percent slopes).—This soil is in irregular areas around depressions that have in them the poorly drained Parnell soils and in low places and drainageways among areas of well drained Barnes soils and moderately well drained Svea soils. Most areas are nearly level, but in some of the drainageways there are small areas having slopes steeper than 2 percent.

The surface layer in most areas is 14 to 18 inches thick, and in some of the drainageways it is thicker. The surface layer generally is not limy, but it is slightly limy in some places and very limy in some small spots. These high-lime spots are indicated on the map by a special symbol. In a few places the surface soil and subsoil are silt loam or silty clay loam. In many places the glacial till in the upper part of this soil has been sorted and redeposited by the action of water. The reworked material is less stony and more silty than the underlying glacial till. In the Cary till plain a few areas of this soil are underlain by clayey, water-deposited sediments at a depth of 2 to 4 feet. Included in mapping this soil were some small areas of a fine-textured Fulda soil.

Wetness is the major hazard when this Flom soil is used, but there is a risk of gullying if the drainageways are not grassed. Most crops, especially corn and alfalfa, do not grow well in wet years unless tile drainage has been installed. Wind erosion is a problem in some large open areas. After adequate drainage, this soil is suited to intensive use for row crops. (Capability unit IIw–1; windbreak suitability group 2)

Fordville Series

The Fordville series consists of well-drained, nearly level to gently sloping soils on river terraces, outwash plains, and gravelly uplands. They developed in loamy outwash or in glacial till and are underlain at a depth of 24 to 36 inches by sand and gravel.

A typical profile of a nearly level Fordville soil has a surface layer, about 11 inches thick, of friable, black loam. The subsoil, about 15 inches thick, is friable, very dark brown and dark yellowish-brown loam. A 3-inch, slightly limy layer of gravelly sandy loam separates the subsoil from the underlying limy, yellowish-brown and light yellowish-brown sand and gravel.

Permeability of the Fordville soils is moderately rapid above the sand and gravel. The moisture-holding capacity is moderate. The reaction in the surface layer is neutral or slightly acid.

Corn, small grains, and alfalfa grow well in years when the rainfall is timely. Corn and small grains "fire" and do not make good growth, however, if the summer is hot and dry. Gravel pits are located on these soils, and most of them provide a good source of road gravel.

Representative profile of Fordville loam in a cropped field where the slope is nearly level, 100 feet south into field from fence line (north center of NE¼NW¼ sec. 18, T. 109 N., R. 46 W.):

Ap—0 to 6 inches, black (10YR 2/1) loam; cloddy; friable when moist; neutral; abrupt, smooth boundary.

A1—6 to 11 inches, black (10YR 2/1) loam; weak, coarse, prismatic structure breaking to weak, coarse, subangular blocky structure; friable when moist; neutral; clear, smooth boundary.

B21—11 to 16 inches, very dark brown (10YR 2/2) loam; weak, medium and coarse, prismatic structure breaking to weak, medium, subangular blocky structure; friable when moist; some cobblestones; slightly acid; clear, smooth boundary.

B22—16 to 26 inches, dark yellowish-brown (10YR 4/4) loam; moderate, medium and coarse, prismatic structure breaking to weak, fine and medium, subangular blocky structure; slightly hard when dry, friable when moist; neutral; clear, smooth boundary.

C1—26 to 29 inches, dark yellowish-brown (10YR 4/4) gravelly sandy loam; single grain; loose when dry; calcareous; clear, wavy boundary.

IIC2—29 to 42 inches +, yellowish-brown (10YR 5/4) and light yellowish-brown (10YR 6/4) stratified sand and gravel; single grain; loose when dry; calcareous.

Depending on the degree of mixing with subsoil, the color of the A horizon ranges from black to very dark brown. The thickness of the B horizon varies with the depth to the gravelly material. The most common colors in the B horizon are dark yellowish brown, brown, dark brown, and dark grayish brown. Free lime is present in the gravel and in some places is slightly above it.

The Fordville soils are deeper over sand and gravel and have a finer textured solum than the associated Arvilla soils. They differ from the Estelline soils by having a solum of loam rather than silt loam.

Fordville loam, 0 to 2 percent slopes (FdA).—Areas of this soil lie among areas of the Arvilla soils on river terraces and outwash plains and among areas of the Barnes soils in the uplands. Some of the areas of this soil are in drainageways. The surface layer and subsoil of this soil resemble those of the Barnes soils.

The gravelly substratum is 24 to 36 inches below the surface. Generally, free lime is present in the zone where the subsoil rests on the gravel. In a few places the subsoil is limy as a result of the activity of earthworms. In some areas the gravelly substratum is only a few feet thick and is underlain by glacial till. A small acreage of this soil has been eroded by wind, and there, the brown subsoil is exposed in some spots. In small areas that lie among silty soils on the uplands, the surface layer and subsoil are silt loam.

Drought is the major hazard when this soil is used. There is also a hazard of wind erosion, especially if fields are plowed in fall. Corn grows fairly well on this soil, except in years when there is a long drought. (Capability unit IIs–1; windbreak suitability group 7)

Fordville loam, 2 to 6 percent slopes (FdB).—This soil lies on stream terraces and on uplands. Most of the areas on uplands are among areas of Barnes soils and have short, undulating slopes.

The surface layer is about 8 inches thick, and the most common depth to the gravelly substratum is about 28 inches. In some areas the gravelly substratum is only a few feet thick and is underlain by glacial till or by silty alluvium. Free lime has been leached from most of the layers above the gravel, but in many places it is slightly above the gravel. In some areas that lie among the silty soils of the uplands, the surface layer and the subsoil are silt loam.

This soil is subject to erosion by water and wind. It is slightly more droughty than the nearly level Fordville soil, because runoff is greater and the soil above the gravel is thinner. Returning crop residues improves the organic-matter content and helps water to be absorbed and held in the soil. (Capability unit IIe–3; windbreak suitability group 7)

Fordville loam, 2 to 6 percent slopes, eroded (FdB2).—This soil is on stream terraces, generally next to the bottom lands, and on short, undulating slopes in the uplands. Most areas of this soil on the uplands are among areas of Barnes soils.

The surface layer, about 6 inches thick, contains some subsoil that has been mixed into it by tillage after erosion. A few stones are on the surface in some areas. The depth to the gravelly underlying material ranges from 24 to 36 inches, but in most places it is only 24 to 26 inches. In some areas the gravelly substratum is only a few feet thick and is underlain by glacial till or silty alluvium. In some areas that lie among silty soils of the uplands, this soil has a surface layer and a subsoil of silt loam.

Erosion and drought are moderate hazards when this soil is used. A rotation that includes grasses and legumes helps to maintain the supply of organic matter. A good supply of organic matter, in turn, helps to maintain a favorable infiltration rate in the surface layer. (Capability unit IIe-3; windbreak suitability group 7)

Forman Series

The Forman series consists of deep, well-drained soils that have a compact subsoil. They developed under prairie grasses in glacial till of clay loam. They are nearly level to undulating and occur on a glacial till plain where the topography is typical of that in the Forman-Barnes soil association. Where the slopes are undulating, Forman soils are intermingled with the Barnes soils. The glacial till in which the Forman soils developed is nearly uniform clay loam. It contains few pockets of sand or gravel, although such pockets are common in glacial till in most other places. Stones and boulders on the surface and in the soil range from few to many.

In a typical profile, the surface layer is black clay loam about 8 inches thick. Below the surface layer is a compact, somewhat firm, brownish subsoil of clay loam, about 19 inches thick. Free lime has accumulated in the lower subsoil. Limy, mottled, grayish-brown and light olive-brown glacial till of clay loam texture lies below the subsoil.

Permeability of the Forman soils is moderate. These soils have a compact subsoil, and they are less permeable than the Barnes soils. Moisture-holding capacity is high. The shrink-swell potential is moderate, and the soils crack as they dry. The reaction of the surface layer is neutral.

The Forman soils are well suited to corn, oats, flax, and alfalfa if a good level of organic matter is maintained. A good supply of organic matter helps the free infiltration of water and also helps prevent soil blowing.

Representative profile of Forman clay loam in a cultivated field, 50 feet east of the second electric pole from the southeastern corner (SE¼SE¼SE¼ sec. 6, T. 113 N., R. 44 W.):

Ap—0 to 8 inches, black (10YR 2/1) clay loam; few streaks of dark grayish brown (10YR 4/2); cloddy; firm when moist; neutral; abrupt, smooth boundary.

B21—8 to 15 inches, dark yellowish-brown (10YR 3/4) clay loam; moderate, medium, prismatic structure that breaks to weak, very fine and fine, subangular blocky structure; firm to friable when moist; few patchy clay films on horizontal and vertical surfaces of peds; more compact than the C horizon; neutral; clear, wavy boundary.

B22—15 to 22 inches, dark grayish-brown (2.5Y 4/2) and olive-brown (2.5Y 4/4) clay loam; weak to moderate, medium, prismatic structure that breaks to weak, fine, subangular blocky structure; friable when moist; continuous clay films on vertical surfaces of peds; patchy clay films on horizontal surfaces; more compact than the C horizon; neutral; clear, wavy boundary.

B3ca—22 to 27 inches, light olive-brown (2.5Y 5/4) and olive-brown (2.5Y 4/4) clay loam; few strong-brown (7.5YR 5/8) iron stains; weak to moderate, medium and coarse, prismatic structure; friable when moist; common, soft, white calcium carbonate concretions, 5 to 15 millimeters in diameter; moderately alkaline; strongly calcareous; gradual, smooth boundary.

C1ca—27 to 36 inches, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) clay loam; common, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, medium, prismatic structure; friable when moist; common, soft, white calcium carbonate concretions 5 to 15 millimeters in diameter; moderately alkaline; strongly calcareous; gradual, smooth boundary.

C2—36 to 54 inches +, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) clay loam; many, coarse, distinct, dark yellowish-brown (10YR 4/4) mottles; friable when moist; calcareous.

The texture of the A horizon ranges from clay loam to loam. The color of the A horizon ranges from black to very dark gray or very dark brown, and the thickness, from 6 to 10 inches. The color of the B horizon is typically dark yellowish brown, dark brown, or dark grayish brown. The depth to free lime in the profile ranges from 20 to 28 inches.

The Forman soils have a B horizon that is more firm and compact and has more pronounced structure than the B horizon in the Barnes or the Singsaas soils. The Forman soils developed in clay loam till, but most of the Barnes and Singsaas soils developed in till that is less fine in texture. Earthworms have not been active in the B horizon of the Forman soils, but they have affected prominently the B horizon of the Singsaas soils.

Forman clay loam, 0 to 2 percent slopes (FmA).—This soil is well drained and nearly level. It occupies broad areas of the till plain and lies slightly above areas of the moderately well drained Aastad soils. Shallow drainageways that are occupied by Flom soils dissect the areas of this soil. Included in mapping this soil were small areas of nearly level Barnes soils.

This soil has a browner subsoil than would normally be expected in a nearly level soil developed in clay loam glacial till. The deep drainageways that dissect the areas at intervals of ¼ to ½ mile have helped to improve natural soil drainage and to develop a brown subsoil.

Wind erosion is sometimes a problem on this soil, especially in spring, if good soil management practices have been neglected. Water erosion seldom occurs. In a few places the brown subsoil has been exposed, either because the original surface layer was thin or because soil was removed by wind erosion. When this soil is in good tilth, it can be farmed intensively if the level of soil management practices is high. (Capability unit I-1; windbreak suitability group 1)

Forman and Barnes soils, 2 to 6 percent slopes (FrB).—This mapping unit consists of two undifferentiated soils. Some of the areas mapped consist of the Forman soil; others consist of the Barnes soil; and a few have in them both of the soils. Most slopes of this mapping unit are in the lower part of the range from 2 to 6 percent.

The surface layer of each of the soils consists of loam or clay loam and is 6 to 8 inches thick. It is slightly thicker on the lower parts of some slopes. On the lower parts of slopes, also, the subsoil is more olive than on the upper parts. Extensive areas of this mapping unit are along the outer edges of the Forman-Barnes soil association. Included in mapping this unit were a few spots of moderately eroded soils that are too small to be mapped independently.

The hazard of erosion is slight on these soils. Most of the areas have slopes too short and too irregular to permit practical contour farming or terracing. A crop of grasses or legumes about once every 5 years keeps these soils in good tilth and largely prevents damage by erosion. (Capability unit IIe-2; windbreak suitability group 1)

Forman and Barnes soils, 2 to 6 percent slopes, eroded (FrB2).—This mapping unit of undifferentiated soils consists of gently undulating Forman and Barnes loams or clay loams.

The surface layer in plowed fields is about 6 inches thick. The plowed layer is grayish in most places because organic matter has been lost, but it is brownish in places where the brown subsoil has been mixed into it by tillage.

Erosion is the major hazard when these soils are used. Some of the surface layer has been lost through water erosion, and in some places strong winds have removed soil from exposed parts of the slopes. Many of the areas have slopes too irregular for contour farming or terracing. Erosion can be controlled on these soils by including enough legumes and grasses in the crop rotation or by keeping crop residues on the surface. Organic matter in the plowed layer needs to be replenished frequently to promote infiltration of water into the soil, especially in places where the compact subsoil has been exposed. (Capability unit IIe–2; windbreak suitability group 1)

Fulda Series

The Fulda series consists of deep, poorly drained, nearly level soils that are on upland flats and in drainageways. Some of them occupy parts of flat hilltops that were lakebeds in the glacial ice. These soils developed in water-laid sediments of silty clay and silty clay loam that were deposited in the glacial lakes or were deposited by silt-laden glacial waters that flowed over, filled in, and leveled out the undulating glacial till plain.

In a typical profile, the surface layer, about 13 inches thick, is black silty clay loam and silty clay. The subsoil, about 27 inches thick, is plastic, mottled dark-gray and olive-gray silty clay. The lower part of the subsoil is limy. The underlying material consists of water-laid sediments that are limy, mottled light olive-gray silty clay loam or silty clay.

Permeability is moderately slow, and moisture-holding capacity is very high. The very high moisture-holding capacity makes these soils drought resistant. Surface runoff and internal drainage are slow. The surface layer is neutral in most places, but in some spots it is mildly alkaline.

The Fulda soils have a high content of clay, and proper management is needed to keep them productive and easy to work.

Representative profile of Fulda silty clay loam in a cultivated field where the slope is 1 percent, 90 feet west of first fencepost south of electric pole adjacent to farm drive (NE¼NE¼SE¼ sec. 12, T. 110 N., R. 44 W.):

Ap—0 to 8 inches, black (N 2/0) silty clay loam; weak, very fine, angular blocky structure; slightly hard when dry, sticky when wet; neutral; abrupt, smooth boundary.

A12—8 to 13 inches, black (N 2/0) silty clay; moderate to strong, very fine, angular blocky structure; sticky and plastic when wet; neutral; gradual, smooth boundary.

B21g—13 to 28 inches, mostly dark-gray (5Y 4/1) silty clay; few, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; the upper part is very dark gray (N 3/0); moderate, very fine, angular blocky structure; sticky and plastic when wet; mildly alkaline; noncalcareous; gradual, smooth boundary.

B22g—28 to 33 inches, dark-gray (5Y 4/1) and olive-gray (5Y 5/2) silty clay; common, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; moderate, very fine, angular blocky structure; sticky and plastic when wet; mildly alkaline; olive-gray part is weakly calcareous; clear, smooth boundary.

B3gca—33 to 40 inches, olive-gray (5Y 5/2) silty clay; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; moderate, very fine, angular blocky structure; slightly sticky and slightly plastic when wet; moderately alkaline; strongly calcareous; clear, smooth boundary.

Cgca—40 to 54 inches +, light olive-gray (5Y 6/2) silty clay loam; massive to weak, very fine, subangular blocky structure; slightly sticky when wet; pockets of calcium sulfate crystals; a few, soft, white concretions of calcium carbonate that are less than 5 millimeters in diameter; moderately alkaline; strongly calcareous.

The combined thickness of the Ap horizon and the remaining A1 horizon ranges from 10 to 24 inches. The texture of the A horizon is heavy silt loam to silty clay. Tonguing of the A horizon into the B horizon is present in some profiles. Typical colors in the B horizon are dark gray, grayish brown, dark grayish brown, and olive gray. The texture of the B horizon is predominantly silty clay but ranges to silty clay loam. Clay films are on some of the ped surfaces in the B horizon. Common colors in the C horizon are olive gray, light olive gray, and gray. Texture of the C horizon ranges from light silty clay loam to silty clay. Concretions of manganese oxide, calcium carbonate, and calcium sulfate are present in the C horizon of some profiles, but the amounts are variable. The depth to free lime ranges from 20 to 36 inches.

These soils developed in slightly lower positions than the associated Sinai soils, and they have more strongly gleyed B and C horizons. The Fulda soils have a sequence of horizons similar to that of the Flom soils, which developed in glacial till. The Fulda soils, however, are finer textured and have a more strongly developed structural B horizon than the Flom soils.

Fulda silty clay loam (Fu) (0 to 2 percent slopes).—This is the only Fulda soil mapped in the county. It is on flats of the uplands and in drainageways.

The surface layer is 10 to 24 inches thick. The depth to free lime is normally 20 to 36 inches, but in a few spots the soil is limy at the surface. In a few places the subsoil is underlain by glacial till that is clay loam. Included in mapping this soil in Marble Township were a few areas of a poorly drained soil that developed a fine-textured glacial till.

Wetness is the dominant hazard when this soil is used. Tile drainage is necessary for the best growth of crops. Because the soil is fine textured, good soil management is needed to maintain desirable tilth. The fine particles are likely to blow if the soil is left unprotected. Almost all the acreage is used for corn, soybeans, small grains, and alfalfa. (Capability unit IIw–3; windbreak suitability group 2)

Gravel Pit

Gravel pit (Gp) consists of open excavations from which gravel has been removed. This miscellaneous land type occupies only a small acreage in Lincoln County.

Hamerly Series

The Hamerly series consists of deep, limy, moderately well drained, nearly level and gently undulating soils. They occupy short, irregular slopes on knolls amid wet areas in the uplands. Hamerly soils developed in glacial till under prairie grasses.

A typical profile has a 13-inch surface layer that is friable, limy, black loam and clay loam. The lower part of this layer contains numerous dark yellowish-brown wormcasts. The next layer, about 6 inches thick, is friable, limy, light olive-brown clay loam that also contains numerous dark-colored wormcasts. The underlying material consists of limy, mottled, grayish glacial till that is clay loam.

The permeability is moderate, and the moisture-holding capacity is high. The reaction from the surface downward is mildly alkaline to strongly alkaline. To obtain the best growth of crops, the imbalance of fertility that is caused by the high lime content must be corrected, and usually the supply of organic matter must be increased.

Most areas of Hamerly soils are cultivated, except for a few tracts that lie within larger undrained areas. The principal crops are corn and small grains.

Representative profile of Hamerly loam in a cultivated field where the slope is 2 to 3 percent, 110 feet east of second electric pole from corner, 65 feet into field (SE¼SE¼SE¼ sec. 6, T. 110 N., R. 45 W.):

Apca—0 to 8 inches, black (10YR 2/1) loam; very dark gray (N 3/0) when dry; cloddy to weak, very fine, subangular blocky structure; friable when moist; strongly calcareous; clear, smooth boundary.

A12ca&Cca—8 to 13 inches, dominantly black (10YR 2/1) clay loam; about 30 percent dark yellowish-brown (10YR 4/4) wormcasts; moderate, very fine, subangular blocky structure; friable when moist; strongly calcareous; clear, irregular boundary.

Cca&A1ca—13 to 19 inches, partly light olive-brown (2.5Y 5/4) clay loam; about 50 percent black (10YR 2/1) wormcasts; weak, very fine and fine, subangular blocky structure; friable when moist; strongly calcareous; clear, wavy boundary.

C1ca—19 to 27 inches, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) clay loam; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; very weak, very fine and fine, subangular blocky structure; friable when moist; a few crystals of calcium sulfate; strongly calcareous; gradual, smooth boundary.

C2—27 to 54 inches +, gray (5Y 5/1) clay loam; massive; friable when moist; a few calcium sulfate crystals; calcareous.

Thickness of the A horizon ranges from 6 to 16 inches. Color of the A horizon ranges from black to very dark gray when the soil is moist, and from very dark gray to dark gray when the soil is dry. The Hamerly soils in Lincoln County have a thicker A horizon and a darker colored high-lime zone than typical Hamerly soils elsewhere.

Most areas of Hamerly soils are on low swells among areas of the poorly drained Vallers soils. Hamerly soils are similar to the Svea and the Oak Lake soils in being moderately well drained. They have a solum that is highly calcareous, however, and their B horizon is less developed than the one in either of those soils.

Hamerly loam, 0 to 3 percent slopes (HaA).—This soil is nearly level and very gently undulating. Most of the areas lie within areas of Vallers soils. Few, if any, of the areas of this soil amount to more than 2 acres.

The surface layer of this soil in most places is loam, but in some places it is silty clay loam or clay loam. Thickness of the surface layer ranges from 6 to 16 inches. The surface layer is less limy in most of the uncultivated places than it is in cultivated fields. Pockets of gypsum crystals are present in some places in the underlying material.

Some light-colored spots, where underlying material has been mixed into the surface layer, can be seen in bare fields. The hazard of wind erosion is slight. The high lime content causes a fertility problem. (Capability unit IIs–3; windbreak suitability group 5)

Hidewood Series

The Hidewood series consists of deep, somewhat poorly drained, nearly level soils that occupy flats and drainageways in the uplands. They developed in moderately thick loess or in local alluvium that was derived from the nearby slopes of loess. These soils are underlain by calcareous glacial till. They are in the southwestern part of this county.

In a typical profile, the surface layer, about 19 inches thick, is friable, black silty clay loam. The lower part is slightly grayer than the upper part. The subsoil is friable, mottled, grayish-brown silty clay loam about 19 inches thick. The underlying material consists of limy, mottled, grayish-brown or olive-gray glacial till that is clay loam or loam. In some places the mantle of loess is more than 40 inches thick, and loess makes up the upper part of the material underlying the developed soil.

Permeability of these soils is moderate, and the water-holding capacity is high or very high. The reaction of the surface layer is neutral or alkaline. The soils are well supplied with organic matter.

Most areas of Hidewood soils are cultivated, except a few small tracts along the drainageways. The common crops grow well if the wetness has been corrected, and if the soil is managed well and fertilized properly.

Representative profile of Hidewood silty clay loam in a cropped area in a drainageway, 120 feet south of west center of section, 40 feet east of fence line (NW¼NW¼SW¼ sec. 17, T. 110 N., R. 46 W.):

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam; very weak, very fine, subangular blocky structure; friable when moist, slightly sticky when wet; neutral; abrupt, smooth boundary.

A12—7 to 14 inches, black (N 2/0 grading to 10YR 2/1) silty clay loam; moderate, very fine, subangular blocky structure; friable when moist, slightly sticky when wet; neutral; gradual, smooth boundary.

A3g—14 to 19 inches, black (N 2/0 grading to 10YR 2/1) and very dark gray (N 3/0) silty clay loam; about 10 percent is grayish-brown (2.5Y 5/2) wormcasts that have a few, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, coarse, prismatic structure breaking readily to weak to moderate, very fine, subangular blocky structure; very friable when moist; neutral; gradual, smooth boundary.

B2g—19 to 31 inches, grayish-brown (2.5Y 5/2), grading to olive-gray (5Y 5/2), silty clay loam; common, medium, faint, light olive-brown (2.5Y 5/4) mottles; few, fine, distinct, dark yellowish-brown (10YR 4/4) mottles of iron oxides; weak to moderate, coarse, prismatic structure breaking readily to weak, very fine, subangular blocky structure; very friable when moist; a few very dark gray (N 3/0) old root channels; noncalcareous; mildly alkaline; clear, smooth boundary.

B3g—31 to 38 inches, grayish-brown (2.5Y 5/2), grading to light brownish-gray (2.5Y 6/2), silty clay loam; common, medium, distinct, yellowish-brown (10YR 5/4) iron mottles; weak, fine, subangular blocky structure; friable when moist; a few pebbles and a few black manganese oxide concretions, 1 to 3 millimeters in diameter; a few isolated pockets are calcareous; mildly alkaline; clear, wavy boundary.

IICca—38 to 52 inches +, grayish-brown (2.5Y 5/2), grading to olive-gray (5Y 5/2), clay loam glacial till; many, coarse, distinct, yellowish-brown (10YR 5/8) mottles; friable when moist; segregated calcium carbonate; moderately alkaline; strongly calcareous.

In some areas drainage is poor. The mantle of loess ranges from 15 to 42 inches in thickness, but the most common thickness is about 32 to 38 inches. Structure in the B horizon is weak to moderate. Typical colors in the B horizon are grayish brown, olive, and olive gray.

The Hidewood soils make up the somewhat poorly drained member of the Kranzburg-Brookings-Hidewood drainage sequence. They differ from the Flom soils because they developed in loess rather than in glacial till.

Hidewood silty clay loam (Hd) (0 to 2 percent slopes).—This soil is nearly level and somewhat poorly drained. It is in somewhat wet, flat areas and in drainageways among areas of the gently sloping Brookings soils and the more strongly sloping Kranzburg soils.

The surface layer in most areas is about 16 to 19 inches thick. In some of the drainageways, however, it is more than 24 inches thick because soil has been washed in from the adjacent slopes. Near areas of the higher Vienna soils, the upper part of the washed-in surface layer in many places is gritty. The surface layer of this soil in some places is calcareous. Areas of this soil in some of the drainageways are poorly drained.

The thickness of the loess, in which this soil formed, is 32 to 38 inches in most places. It ranges to as much as 60 inches, however, in a few places. In many places a thin sandy, gravelly, or cobbly layer lies at the boundary between the loess and the underlying glacial till.

Wetness is the main hazard when this soil is used. During or just after heavy rains, the sediment-laden runoff can damage crops. The risk is especially great if the surrounding sloping soils are not protected by erosion-control practices. Gully erosion sometimes occurs in the drainageways, and grassed waterways are needed to hold the soil. If adequate drainage and protection are provided, this soil is nearly ideal for row crops. (Capability unit IIw–1; windbreak suitability group 2)

Kranzburg Series

The Kranzburg series consists of deep, well-drained, nearly level and gently sloping soils on uplands. They make up the most extensive series of soils in the loess-mantled part of the county. These soils developed in moderately thick deposits of windblown sediments (loess) that were deposited on glacial till. The irregularities in the landscape of glacial till were filled in by the windblown sediments to make slopes that are long, smooth, and convex.

A typical profile of a gently sloping Kranzburg soil has a friable, black surface layer of silt loam that is about 10 inches thick. Beneath it is a 4-inch transitional layer of very dark gray silt loam. The next layer is the subsoil, about 12 inches thick, of friable, dark-brown and dark grayish-brown silty clay loam and silt loam. The underlying material is limy, yellowish-brown and light olive-brown glacial till that is clay loam. Free lime is present in most areas just above the glacial till, but if the silt is very thin, lime has been leached from the upper part of the till.

The permeability of these soils is moderately rapid, and the moisture-holding capacity is high. The reaction in the surface layer is slightly acid or neutral.

Most of the acreage of these soils is cultivated. The principal crops are corn, small grains, and alfalfa.

Representative profile of Kranzburg silt loam in a field border where the slope is 2 percent, (100 feet north of east center of the SE¼ NE¼SE¼ sec. 31, T. 109 N., R. 45 W.):

Ap—0 to 6 inches, black (10YR 2/1), grading to very dark gray (10YR 3/1), silt loam; cloddy; friable when moist; neutral; abrupt, smooth boundary.

A12—6 to 10 inches, black (10YR 2/1) silt loam; weak, medium, subangular blocky structure breaking to weak, very fine, subangular blocky structure; friable when moist; neutral; clear, smooth boundary.

A3—10 to 14 inches, mostly very dark gray (10YR 3/1) silt loam; about 25 percent dark yellowish-brown (10YR 3/4) wormcasts; moderate, very fine and fine, subangular blocky structure; friable when moist; neutral; clear, irregular boundary.

B21—14 to 22 inches, dark-brown (10YR 4/3) silty clay loam; a few very dark gray (10YR 3/1) wormcasts; moderate, medium, prismatic structure breaking to weak, fine, subangular blocky structure; friable when moist; thin clay films on vertical cleavage surfaces; neutral; clear, smooth boundary.

B22—22 to 26 inches, dark grayish-brown (10YR 4/2) silt loam; weak, medium, prismatic structure; friable when moist; neutral; gradual, smooth boundary.

IIC1ca—26 to 40 inches, yellowish-brown (10YR 5/4) clay loam glacial till; very weak, medium, subangular blocky structure; friable when moist; a few cobblestones in the upper part; abundant, soft, white concretions of calcium carbonate; moderately alkaline; strongly calcareous; gradual, smooth boundary.

IIC2—40 to 54 inches +, light olive-brown (2.5Y 5/4) clay loam; friable when moist; moderately alkaline; strongly calcareous.

The thickness of the A1 horizon ranges from 6 to 12 inches, depending on the slope and the degree of erosion. The color of the A1 horizon commonly is black, very dark gray, or very dark brown. The color of the B horizon ranges from dark brown to dark yellowish brown and dark grayish brown in the upper part, and to olive brown in the lower part. The thickness of the loess mantle ranges from 15 to 42 inches, but is most commonly between 26 and 32 inches. In most places the B horizon developed in the loess. Free lime is present in the lower part of the loess or in the upper part of the underlying glacial till, depending on the thickness of the loess. The till is loam or clay loam, and its color ranges from yellowish brown to grayish brown.

The Kranzburg soils differ from the Vienna soils because their solum developed in loess instead of glacial till. Kranzburg soils are the well drained members of a drainage sequence that includes the moderately well drained Brookings soils and the somewhat poorly drained Hidewood soils.

Kranzburg silt loam, 0 to 2 percent slopes (KrA).—This is a nearly level soil on the silt-mantled plain. The surface layer and subsoil in most places are a few inches thicker than those in the profile that is described as representative of the series. The surface layer is thinner and the subsoil is browner than in the associated nearly level Brookings soils.

The surface layer in a few places is silty clay loam. Thickness of the silt mantle in most places ranges from 26 to 32 inches, but in a few spots it is more than 32 inches. Between the silt mantle and the glacial till in many places there is a thin layer that is sandy, gravelly, or cobbly. In a few areas the surface layer is thin and brown because the original surface layer has been partly removed by erosion. Included in mapping of this soil were small spots of sand and gravel that are too small to be mapped separately.

Plowing in spring reduces the risk of wind erosion. Corn, small grains, and alfalfa grow well on this soil, if they are managed well and fertilized properly. (Capability unit I–1; windbreak suitability group 1)

Kranzburg silt loam, 2 to 6 percent slopes (KrB).—This soil has long, smooth slopes. It occupies the upper parts of slopes above areas of Brookings soils. Its surface layer is thinner than that of the Brookings soils, and its subsoil is dark yellowish brown rather than olive brown.

In a few places the surface layer is silty clay loam. The silt mantle, in which most of the soil formed, is about 29 inches thick in most places. In a few areas it is thinner, and in a few spots glacial till crops out. A thin sandy, gravelly, or cobbly layer is present between the silt and the glacial till in many places. Included in mapping this soil were a few small sandy and gravelly spots.

Erosion is the major hazard when this soil is used. If terracing and contour farming are practiced, this soil can be farmed intensively in a rotation that consists mostly of row crops. (Capability unit IIe–2; windbreak suitability group 1)

Kranzburg silt loam, 2 to 6 percent slopes, eroded (KrB2).—This soil has long, smooth, gentle slopes. It is the most extensive Kranzburg soil. Its surface layer is 2 to 4 inches thinner than the one in the profile described for the series. The loess mantle in which most of the soil formed is normally about 26 inches thick, but in some places it is thinner, and glacial till crops out in a few places. Vienna soils developed in these spots where till is exposed. A few stones are on the surface of this Kranzburg soil in places where the loess is thin. The loess mantle either lies directly on the glacial till or is separated from it by a thin layer that is sandy, gravelly, or cobbly.

Erosion is the dominant hazard when this soil is used. This soil is well suited to terracing or contouring. These measures save moisture and help prevent further loss of surface soil. Crops grow well if terracing and contour farming are practiced, if an adequate supply of organic matter is maintained, and if adequate amounts of the proper fertilizers are applied. (Capability unit IIe–2; windbreak suitability group 1)

Lake Beaches

Lake beaches (La) (0 to 2 percent slopes) are around the borders of lakes and the edges of large ponds. They consist of mixed soil materials that in most places are sandy. Many areas of Lake beaches have stones on the surface. Most areas are nearly level, but some have short, steep, stony escarpments. Natural soil drainage ranges from excessive to very poor.

This land type is farmed with the adjoining soils because it lies in bands too narrow to be managed separately. Generally, the areas of Lake beaches are too droughty to be good for crops, but some areas are too wet. Most areas in this county are used for pasture, and some provide excellent habitat for wildlife. (Capability unit IVw–1; windbreak suitability group 8)

Lamoure Series

The Lamoure series consists of deep, poorly drained soils on flood plains that lie a few feet higher than the streams. They are flooded occasionally, and they have a seasonally fluctuating water table. These soils are composed of dark-colored silty materials that were deposited by floodwaters.

Little soil development has occurred in these materials because thin layers of alluvium are deposited during each flood. Typically, the Lamoure soils have a thick surface layer of limy, black silty clay loam and a subsurface layer of grayish silty clay loam.

The permeability of these soils is moderate, and the moisture-holding capacity is very high. The soils are free of stones. The reaction of the surface layer is alkaline.

These soils are flooded nearly every year in spring by melt water from the snow. About once in 10 years they are flooded by water from heavy rains during the growing season, and the crops are damaged.

Representative profile of Lamoure silty clay loam in an area of cultivated bottom land, 20 feet west and 25 feet north of corner fencepost (SE¼NE¼NE¼ sec. 4, T. 109 N., R. 46 W.):

Ap—0 to 11 inches, very dark gray (10YR 3/1) silty clay loam; cloddy; slightly sticky when wet; moderately alkaline; calcareous; abrupt, smooth boundary.

A12—11 to 17 inches, black (10YR 2/1) silty clay loam; weak, very fine, subangular blocky structure; friable when moist; moderately alkaline; calcareous; gradual, smooth boundary.

A13—17 to 34 inches, black (N 2/0) silty clay loam; moderate, very fine, subangular blocky structure; friable when moist; moderately alkaline; calcareous; clear, smooth boundary.

A3—34 to 54 inches +, very dark gray (5Y 3/1) and gray (5Y 5/1) silty clay loam; weak, very fine and fine, subangular blocky structure; friable when moist; moderately alkaline; calcareous.

The thickness of the A1 horizon ranges from 18 to 36 inches. The color of the A1 horizon ranges from black to very dark gray. The A1 horizon is mildly to moderately alkaline, and its lime content ranges from slight to very high. There is a C horizon below the A3 horizon, and in most places it consists of dark grayish-brown or olive-gray silty clay loam.

The Lamoure soils are higher on the flood plains than the very poorly drained Rauville soils, and they are slightly lower than the LaPrairie soils. They have an A horizon thicker than the one in the Colvin soils, which developed in lake-deposited materials, and they do not have a high-lime layer similar to the one in those soils.

Lamoure silty clay loam (Lm) (0 to 2 percent slopes).—This is a limy, dark-colored, poorly drained, nearly level soil on bottom lands.

The thick surface layer in most places is silty clay loam, but in some places it is silt loam or loam. Layers or pockets of gypsum are present in this soil in some places. In some spots the limy alluvium is covered with nonlimy, dark-colored sediments 1 foot to 3 feet thick that have been washed from slopes of the uplands. Thin sandy layers are likely to be present anywhere in the profile.

Wetness and occasional overflows are the only hazards in using this soil. This soil is well suited to crops, if it is adequately fertilized. It is suited to intensive farming, but if it is worked when too wet, the surface layer is likely to be made cloddy and compact. (Capability unit IIw–5; windbreak suitability group 3)

Lamoure and LaPrairie soils, frequently flooded (Lo) (0 to 2 percent slopes).—This unit of undifferentiated nearly level soils lies along streams and creeks. The areas consist mostly of Lamoure and LaPrairie loams and silty clay loams. Rauville soils are in old stream meanders and other low places. Also included in mapping this unit were sandy, gravelly, and stony materials that have been deposited along the streams.

Most areas of these soils are overflowed frequently. Some areas are above the level of the frequent overflows. These higher areas have been cut up so much by oxbows and stream channels that cultivation is not practical. Wild hay is harvested in some areas, but most of the acreage is used for pasture. Unpastured areas provide good shelter for wildlife. These soils could be made suitable for crops if flooding could be controlled. (Capability unit VIw–1; windbreak suitability group 8)

LaPrairie Series

The LaPrairie series consists of deep, moderately well drained, nearly level soils on bottom lands that are subject to occasional overflow. These soils developed in silty or loamy sediments that were deposited by streams.

As a rule, these soils do not have a developed profile. In most places they consist of about 3 feet of dark-colored, loamy soil, and the lower part of the 3-foot section contains lime. In places sandy or gravelly layers are below a depth of 3 feet.

The permeability of these soils is moderately rapid, and the moisture-holding capacity is very high. The surface layer to plow depth in most places is mildly alkaline.

The LaPrairie soils are free of stones, easy to work, and well suited to crops. Many of the areas, however, are along streams where they are not accessible to be used for crops.

Representative profile of LaPrairie loam in an area of bottom land of the South Branch Yellow Medicine River, 30 feet west and 10 feet south of fence line (NE¼SE¼SE¼ sec. 12, T. 111 N., R. 44 W.):

A1—0 to 23 inches, black (10YR 2/1) loam; weak to moderate, very fine, fine and medium, subangular blocky structure; friable when moist; mildly alkaline; noncalcareous; clear, smooth boundary.

A3—23 to 35 inches, very dark gray (10YR 3/1) loam; weak, fine and medium, subangular blocky structure; friable when moist; moderately alkaline; calcareous; gradual, smooth boundary.

C—35 to 54 inches +, dark-gray (10YR 4/1) loam; friable when moist; calcareous.

The LaPrairie soils have a thick, dark-colored A horizon similar to that of the Lamoure soils, but they are on higher, better drained places in the flood plains. Their profile also resembles that of the Terril soils on the uplands, but they developed in alluvium instead of in local colluvium, and the solum of the LaPrairie soils is alkaline rather than neutral.

LaPrairie loam (Lp) (0 to 2 percent slopes).—This is the only soil of the LaPrairie series mapped in the county. It is a nearly level soil on slightly higher places in the bottom lands. Almost all the areas are adjacent to a stream.

This soil has a thick, dark-colored surface layer that is more gray in the lower part than at the surface. The surface layer is limy in some places, especially near areas of Colvin soil. In some areas the surface layer is silt loam or silty clay loam. Included in mapping this soil was a small acreage that is well drained and not subject to overflow.

LaPrairie loam can be farmed intensively because it has no natural limitations except the occasional flooding. (Capability unit IIw-4; windbreak suitability group 1)

Lismore Series

The Lismore series consists of deep, moderately well drained, nearly level to very gently sloping soils on uplands. They developed in glacial till of loam or clay loam, or partly in loess that lies over the till in some places. The areas of these soils are in the southwestern part of the county. The drainage patterns in areas of Lismore soils are well defined, and there are no depressions or potholes.

In a typical profile, the surface layer is friable, dark-colored silty clay loam about 17 inches thick. The subsoil is mainly friable, olive-brown clay loam, also about 17 inches thick. The lower part of the subsoil is light olive brown and is limy. The underlying material is limy, mottled, olive-gray glacial till of clay loam texture.

The permeability of these soils is moderate, and the moisture-holding capacity is high or very high. The reaction of the surface layer in most places is neutral. The reaction of the subsoil and the underlying layers is alkaline.

The Lismore soils are well suited to corn, small grains, and alfalfa. They occupy only a small acreage in the county, and most of the acreage is used for crops.

Representative profile of Lismore silty clay loam in the border of a grassy field where the slope is 2 percent, 15 feet south of fence corner (NE¼NE¼NE¼ sec. 7, T. 109 N., R. 46 W.):

A1—0 to 12 inches, black (10YR 2/1) silty clay loam; moderate, very fine, subangular blocky structure; friable when moist, slightly sticky when wet; neutral; clear, smooth boundary.

A3—12 to 17 inches, dominantly very dark gray (10YR 3/1) silty clay loam; about 10 percent black (10YR 2/1) and about 10 percent very dark grayish-brown (10YR 3/2) wormcasts; weak to moderate, fine and medium, subangular blocky structure; friable when moist, slightly sticky when wet; some quartz, other grit, and pebbles; mildly alkaline; noncalcareous; clear, irregular boundary.

B21—17 to 22 inches, dominantly very dark grayish-brown (2.5Y 3/2) loam; about 15 percent olive-brown (2.5Y 4/4) and about 10 percent very dark gray (10YR 3/1) wormcasts; weak, medium, prismatic structure breaking to weak, very fine and fine, subangular blocky structure; friable when moist; some quartz, other grit, and pebbles; mildly alkaline; noncalcareous; clear, irregular boundary.

IIB22—22 to 28 inches, dominantly olive-brown (2.5Y 4/4) clay loam glacial till; about 5 percent very dark gray (10YR 3/1) and about 5 percent light olive-brown (2.5Y 5/4) wormcasts; moderate, medium, prismatic structure breaking to weak, medium, subangular blocky structure; friable when moist, slightly sticky when wet; moderately alkaline; light olive-brown casts are calcareous; clear, irregular boundary.

IIB3ca—28 to 34 inches, light olive-brown (2.5Y 5/4) clay loam; very weak, medium, prismatic structure; friable when moist, slightly sticky when wet; moderately alkaline; strongly calcareous; clear, irregular boundary.

IICca—34 to 60 inches +, olive-gray (5Y 5/2) and light olive-gray (5Y 6/2) clay loam; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; slightly plastic when wet; common white concretions of calcium carbonate, 5 to 25 millimeters in diameter; few black concretions of manganese oxide about 1 millimeter in diameter; moderately alkaline; strongly calcareous.

The range of texture of the A horizon is loam, silt loam, clay loam, and silty clay loam; silty clay loam is the most common. The range of texture of the B horizon is silty clay loam and clay loam. The B horizon is silty clay loam if it developed in a mixture of loess and till, and clay loam if it developed in unaltered glacial till. Colors in the B horizon range from very dark grayish brown to light olive brown. The most common depth from the surface to free lime is 26 to 28 inches.

The Lismore soils have horizons similar to those in the moderately well drained Svea soils that developed in Mankato or in Cary glacial till. Lismore soils differ from the Svea soils because they have smoother, less complex slopes, the lime in them has been leached to a greater depth, and the upper part of the solum developed in loess or in a mixture of loess and glacial till rather than in glacial till only.

Lismore silty clay loam, 0 to 3 percent slopes (LsA).—This soil is nearly level and very gently sloping. The areas are among Vienna soils, which are more strongly sloping, or adjacent to Hidewood soils that are in drainageways.

The surface layer is nearly 24 inches thick in some swales and near the base of stronger slopes. The surface layer, and in some places the upper part of the subsoil, developed in a mixture of loess and glacial till. The upper part of this soil in a few areas developed in a thin, discontinuous mantle of silt. Included in mapping this soil were a small acreage of a nearly level Vienna soil, which is well drained, and some spots of a Hidewood soil, which is somewhat poorly drained.

This Lismore soil is well suited to crops and has no serious limitations for intensive farming. (Capability unit I–1; windbreak suitability group 1)

Marsh

Marsh (Ma) (0 to 2 percent slopes) consists of undrained closed depressions and ponds that are covered by 1 to 3 feet of water, except in dry years. Cattails, reeds, sedges, and other water-loving plants grow at scattered places in the open water. The soils under the water in these areas have not been identified, but Parnell soils and Blue Earth soils are in most of the marshes. Marsh provides excellent habitats for wildlife. Several areas of Marsh in the county have been purchased by the Minnesota State Department of Conservation and are being developed into wildlife management units.

If an area of Marsh is drained, suggestions for use and management of the soil for crops are given under capability unit IIIw–1 or IIIw–2, depending on the nature of the soil. (Capability unit VIIIw–1; windbreak suitability group 9)

Muck

Muck consists of organic residues that are well decomposed and generally are mixed with some mineral matter. Muck in this county developed in upland depressions. It consists of decomposed sedges, reeds, and grasses, along with some silty material that was washed or blown into the depressions from the surrounding uplands.

In the areas of Muck the organic soil has a thickness of 12 to 42 inches; the usual thickness is about 20 inches. The underlying material is lacustrine material of silty clay loam texture or glacial till of clay loam texture. The Muck is black or nearly black, and the underlying material is very dark gray to gray and is limy.

The permeability is moderate or moderately slow, and the moisture-holding capacity is very high. The reaction in the surface layer generally is neutral. If the areas of Muck are drained, they are suited to all the crops commonly grown in the county.

Representative profile of Muck in a cultivated field in the center of a depressional area on the west side of road (NW¼SE¼SE¼ sec. 32, T. 113 N., R. 46 W.):

1—0 to 7 inches, black (10YR 2/1) muck; cloddy; soft when dry, friable when moist; neutral; noncalcareous; gradual, smooth boundary.

2—7 to 19 inches, black (10YR 2/1) muck; some tendency to platy structure breaking to weak, very fine, granular structure; friable when moist; neutral; noncalcareous; gradual, smooth boundary.

IIAg—19 to 30 inches, very dark gray (N 3/0) silty clay loam; common, medium, faint, olive (5Y 4/4) mottles; weak, medium, subangular blocky structure; friable when moist, sticky and plastic when wet; common krotovinas that contain light olive-brown (2.5Y 5/4) muck; neutral; noncalcareous; gradual, wavy boundary.

IIC1g—30 to 35 inches, very dark gray (5Y 3/1) silty clay loam; few, medium, faint, dark olive-gray (5Y 3/2) mottles; very weak, medium and coarse, subangular blocky structure; firm when moist, sticky and plastic when wet; few fragments of snail shells; moderately alkaline; calcareous; gradual, smooth boundary.

IIC2g—35 to 54 inches +, dark-gray (5Y 4/1) silty clay loam; firm when moist; moderately alkaline; calcareous.

Muck is more organic than the Blue Earth soils, and as a rule the surface layer does not contain free lime. Wherever the Muck is thin, the soil profile resembles that of the Parnell soils.

Muck (Mu) (0 to 2 percent slopes).—This is the only organic soil mapped in the county. In a few depressions the Muck is more than 42 inches thick. In some small spots the surface layer is limy.

Wetness is the main hazard in using this soil. Open-ditch drainage is needed before the areas can be cropped, and tile drainage is needed to achieve optimum production. (Capability unit IIIw–1; windbreak suitability group 2)

Oak Lake Series

The Oak Lake series consists of deep, moderately well drained, nearly level and very gently undulating soils on the Cary till plain. These soils developed in limy glacial till of silty clay loam texture. This till is relatively stone free. The Oak Lake soils have been extremely mixed by worms. The low, moist, limy glacial till and the high content of organic matter probably favored the high population of earthworms that was necessary to create the worm-worked subsoil of these soils.

In a typical profile, the surface layer is friable, black silty clay loam 12 inches thick. The friable, dark grayish-brown subsoil of silty clay loam is 16 to 20 inches thick. It has been thoroughly mixed by earthworms. The upper part has been mixed with soil from the surface layer, and the lower part has been mixed with soil from the underlying layer. The limy, mottled, light olive-gray underlying material is glacial till that consists of loam or clay loam.

The permeability is moderate, and the moisture-holding capacity is very high. The reaction in the surface layer is neutral.

All the crops that are common in the county grow well on these soils.

Representative profile of Oak Lake silty clay loam in a cropped field where the slope is 2 percent, 35 feet north of fence and 10 feet east of field edge (NW¼NW¼NW¼ sec. 5, T. 111 N., R. 46 W.):

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam; cloddy; friable when moist, slightly sticky when wet; neutral; abrupt, smooth boundary.

A12—7 to 12 inches, dominantly black (10YR 2/1) silty clay loam; about 25 percent dark grayish-brown (2.5Y 4/2) wormcasts; moderate, very fine, subangular blocky structure; friable when moist, slightly sticky when wet; neutral; grades to the next horizon.

A1&B2—12 to 16 inches, about 50 percent black (10YR 2/1) silty clay loam; about 50 percent very dark grayish-brown (2.5Y 3/2) wormcasts; moderate, very fine, subangular blocky structure; friable when moist, slightly sticky when wet; neutral; some of the wormcasts are calcareous; gradual, wavy boundary.

B2&B3ca—16 to 21 inches, dominantly dark grayish-brown (2.5Y 4/2) silty clay loam; about 35 percent light olive-brown (2.5Y 5/4) wormcasts and about 15 percent very dark gray (10YR 3/1) wormcasts; weak, very fine, subangular blocky structure; friable when moist, slightly sticky when wet; mildly alkaline; calcareous; very dark gray casts are noncalcareous; boundary very irregular because of worm activity.

B3ca—21 to 32 inches, light olive-brown (2.5Y 5/4) silty clay clay loam; common, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; very weak, medium, prismatic structure; friable when moist, slightly sticky when wet; strongly calcareous; moderately alkaline; gradual, smooth boundary.

C1ca—32 to 42 inches, grayish-brown (2.5Y 5/2) silty clay loam; common, coarse, distinct, dark yellowish-brown

(10YR 4/4) mottles; very weak, fine and very fine, subangular blocky structure; friable when moist, slightly sticky when wet; moderately alkaline; strongly calcareous; gradual, smooth boundary.

C2—42 to 60 inches +, light olive-gray (5Y 6/2) clay loam glacial till; many, coarse, prominent, dark yellowish-brown (10YR 4/4) mottles; fractures readily; friable when moist, slightly sticky when wet; moderately alkaline; calcareous.

The thickness of the A1 horizon ranges from 12 to 16 inches. The thickness of the B horizon ranges from 14 to 20 inches. Dark-colored wormcasts of soil from the A horizon and light-colored casts from the B3 and C horizons have been incorporated into the B2 horizon in varying proportions. In some places the texture of the A and B horizons is loam, and the soil contains pebbles and stones. The depth to free lime is extremely variable because of effects of earthworms. The C horizon is limy, mottled glacial till of clay loam or loam, and it is grayish brown to light olive brown.

Except for work of worms in the B horizon, the Oak Lake soils are similar to the Svea soils. They generally have a thicker A horizon, a more olive-colored B horizon, and more gentle slopes than the similar Singsaas soils. The Oak Lake soils have a nonlimy A horizon, they have a B horizon, and they do not have a high-lime zone directly below the A horizon like the one in the Hamerly soils. The degree of worm-working in the subsoil of the Oak Lake soils varies with the moisture supply and the texture of the soil at each site. Generally, the silty profiles have been worked by worms more thoroughly than the loamy profiles.

Oak Lake silty clay loam, 0 to 2 percent slopes (OlA).—This soil is nearly level and moderately well drained. It lies on the Cary till plain among areas of Singsaas soils that are on the higher slopes. Narrow, shallow drainageways of poorly drained Flom soils dissect many of the areas of this soil.

This soil has a thicker surface layer and subsoil than the Singsaas soils, which are well drained. In most places free lime is in the lower part of the subsoil in this soil, but in some profiles limy wormcasts are present throughout the subsoil. A few areas of this soil have loam texture and contain more pebbles and stones than the typical Oak Lake soils. The subsoil in the areas of loam has been less worked by worms than in the typical soil, probably because the supply of moisture was less favorable. Included in mapping of this soil were a few areas of Singsaas soil that are nearly level.

This soil has no serious limitations for intensive use for row crops. (Capability unit I–1; windbreak suitability group 1)

Oak Lake silty clay loam, 2 to 4 percent slopes (OlB).—This soil is gently undulating and moderately well drained. It lies on swells of the Cary till plain, on the lower parts of slopes, and in saddles among areas of the more strongly sloping, well-drained Singsaas soils.

The surface layer and the subsoil are each a few inches thinner than those in the soil that is described as typical for the series. A few areas have texture of loam and contain more pebbles and stones than the typical Oak Lake soil. The subsoil of the loam soil has been less worked by worms than the typical subsoil, probably because the supply of moisture was less favorable. The lower subsoil contains free lime, and in some places limy wormcasts have been mixed throughout the subsoil.

This soil can be farmed intensively. An occasional crop of grass helps supply organic matter that is necessary to maintain good tilth and control erosion. (Capability unit IIe–1; windbreak suitability group 1)

Oldham Series

The Oldham series consists of deep, poorly drained and very poorly drained soils that occupy the drained basins of shallow lakes and ponds. They developed in limy, lake-laid materials of silty clay loam.

In a typical profile, the surface layer is limy, sticky, dark-colored silty clay loam about 28 inches thick. The lower part of the surface layer is grayish, and it grades to the mottled, dark-gray, underlying material of silty clay loam. Few to common fragments of snail shells are present throughout the soil.

The permeability is moderately slow, and the moisture-holding capacity is very high. These soils are alkaline.

The common crops grow well if these soils are drained adequately and are fertilized and managed properly.

Representative profile of Oldham silty clay loam in a cropped field in a former lakebed, about 150 feet west of field border and 15 feet north into field (SE¼SE¼SW¼ sec. 32, T. 113 N., R. 46 W.):

Ap—0 to 5 inches, black (N 2/0) silty clay loam; weak, very fine, subangular blocky structure; friable when moist, sticky when wet; fragments of snail shells on surface; abrupt, smooth boundary.

A12g—5 to 8 inches, very dark gray (N 3/0) silty clay loam; weak, very fine and fine, subangular blocky structure; sticky and plastic when wet; strongly calcareous; abrupt, smooth boundary.

A3gca—8 to 28 inches, very dark gray (N 3/0) and dark gray (5Y 4/1) silty clay loam; few, medium, distinct, olive (5Y 4/4) mottles; weak, very fine, subangular blocky structure; sticky and plastic when wet; common fragments of snail shells; strongly calcareous; gradual, smooth boundary.

Cgca—28 to 50 inches +, dark-gray (5Y 4/1) silty clay loam; common, medium, distinct, olive (5Y 4/4) mottles; structureless; sticky and plastic when wet; common fragments of snail shells; strongly calcareous.

Texture of the A horizon ranges from medium to heavy silty clay loam. The lake-laid sediments of silty clay loam are in most places more than 4 feet thick and almost everywhere are at least 3 feet thick. The underlying material is glacial till of clay loam texture.

The Oldham soils differ from the Parnell soils because they are limy, have numerous fragments of snail shells throughout the solum, and developed in lake-laid materials. The Oldham soils are finer textured and contain less organic matter than the Blue Earth soils, which also developed in lakebeds.

Oldham silty clay loam (Om) (0 to 2 percent slopes).—This soil is nearly level. It is in lake basins similar to those in which the Blue Earth soil developed. This soil is less permeable than the Blue Earth soil and is more likely to become compact, but it is less likely to blow.

The surface layer of this Oldham soil is medium or heavy silty clay loam. In a few places the surface layer is silt loam and is less than 12 inches thick. In some areas the surface layer is nonlimy, and in those places fragments of snail shells are absent.

Wetness is the dominant hazard when this soil is used. The excessive lime content is likely to cause a fertility problem. Tile drainage is needed before this soil can be cropped intensively. (Capability unit IIIw–2; windbreak suitability group 3)

Parnell Series

The Parnell series consists of deep, very poorly drained soils in depressions and very wet drainageways in the glaciated uplands. These depressions are saucer shaped, and most of them occupy only a few acres. Most areas of Parnell soils developed in material that is stone free to a depth of 3 feet or more. The material is silt and clay that was washed or blown into the depressions and drainageways from the glacial till of the surrounding hillsides.

In a typical profile, the surface layer is sticky, black silty clay loam about 24 inches thick. The next layer, about 10 inches thick, is very dark gray silty clay loam that is transitional. The subsoil is sticky, mottled very dark gray and olive-gray silty clay loam about 6 inches thick. The underlying material, below a depth of 40 inches or more, is mottled, gray, limy silty clay loam.

The permeability is moderately slow, and the moisture-holding capacity is very high. The surface runoff is very slow, and in some places water remains in ponds. The reaction in the surface layer in most places is neutral.

Drainage of the Parnell soils is needed before they can be used for crops. The undrained areas are marshy. With surface drainage, the soils can be used for pasture or for crops in dry years. After adequate subsurface drainage they are well suited to corn, small grains, and alfalfa.

Representative profile of Parnell silty clay loam in a drained depression (west center of SW¼NW¼ sec. 3, T. 111 N., R. 44 W.):

Ap—0 to 12 inches, black (N 2/0) silty clay loam; cloddy; firm when moist, sticky when wet; weak plow sole in lower part; mildly alkaline; noncalcareous; abrupt, smooth boundary.

A12—12 to 24 inches, black (N 2/0) silty clay loam; weak, very fine, subangular blocky structure; friable when moist; neutral; gradual, smooth boundary.

A3g—24 to 34 inches, very dark gray (N 3/0) silty clay loam; few, fine, distinct, very dark grayish-brown (10YR 3/2) mottles; moderate, coarse and very fine, subangular blocky structure; sticky and plastic when wet; neutral; gradual, smooth boundary.

B2g—34 to 40 inches, very dark gray (N 3/0) and olive-gray (5Y 4/2, 5/2) silty clay loam; few, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; moderate, very fine and fine, subangular blocky structure; sticky when wet; neutral; gradual, smooth boundary.

C1g—40 to 54 inches +, gray (5Y 5/1) silty clay loam; common, medium, distinct, light olive-brown (2.5Y 5/4) mottles; sticky when wet; mildly alkaline; calcareous at a depth of 54 inches.

The texture of the A horizon ranges from silt loam to silty clay loam and clay loam; silty clay loam is dominant. The B horizon is silty clay loam or silty clay. The C horizon is glacial till that ranges in texture from silty clay loam or clay loam to silty clay.

The Parnell soils have a thicker A horizon, are leached more deeply, and are more highly gleyed than the poorly drained Flom soils that in many places surround areas of Parnell soils. The Parnell soils, unlike the Blue Earth and Oldham soils, are only in the small lakebeds, do not have a limy A horizon, and do not have extensive accumulations of snail shells.

Parnell silty clay loam (Pa) (0 to 2 percent slopes).—This soil occupies depressions. Some of the areas have been adequately drained. Almost all the areas are used for crops in dry years. In wet years the inadequately drained areas produce poor crops or become too wet for crops to grow.

The surface layer is 24 inches thick or more. A layer of muck up to 12 inches thick is present on the surface in some areas. Generally, the depth to free lime is 4 to 5 feet. In some areas, especially in very shallow depressions that in most years become dry by midsummer, the surface layer is slightly limy. Included in mapping this soil were a few seepy areas on hillsides. This Parnell soil is in depressions within areas of Fulda soil and is more clayey than the typical Parnell soil.

Wetness is the main hazard when this soil is used. After drainage, this soil is suitable for intensive use for row crops. An occasional crop of grass and legumes and the residues from high-yielding varieties of crops will supply the organic matter that is needed to maintain good tilth. (Capability unit IIIw-1; windbreak suitability group 2)

Poinsett Series

The Poinsett series consists of deep, well-drained, nearly level and gently sloping soils on uplands. These soils developed in silty material that was deposited by water on the undulating glacial topography to create a smooth landscape.

In a typical profile, the surface layer, about 9 inches thick, is friable, black silty clay loam. Next is a 5-inch transitional layer that is a mixture of material from the surface layer and from the subsoil. The subsoil, about 20 inches thick, is friable, dark yellowish-brown and dark grayish-brown silty clay loam. The lower part of it is limy and is light olive brown. The underlying material consists of limy, mottled, grayish-brown, water-laid sediments of silty clay loam.

The permeability is moderately rapid, and the moisture-holding capacity is high. The reaction in the surface layer in most places is neutral.

The Poinsett soils are silty and free of stones. They can be worked more easily, therefore, than the Barnes soils. They are also a little more productive, generally, than the Barnes soils.

Representative profile of Poinsett silty clay loam in a cultivated field where the slope is 2 percent, 20 feet south and 25 feet west of fence corner (NE¼NE¼ sec. 12, T. 110 N., R. 44 W.):

Ap—0 to 6 inches, black (10YR 2/1) silty clay loam; cloddy; slightly hard when dry, friable when moist, sticky and plastic when wet; neutral; abrupt, smooth boundary.

A12—6 to 9 inches, black (10YR 2/1) silty clay loam; moderate, fine, subangular blocky structure; friable; neutral; gradual, irregular boundary.

A3—9 to 14 inches, dominantly very dark gray (10YR 3/1) silty clay loam; about 40 percent very dark grayish-brown (10YR 3/2) wormcasts; moderate, coarse, prismatic structure breaking to moderate, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B21—14 to 22 inches, dominantly dark yellowish-brown (10YR 4/4) silty clay loam; about 20 percent very dark gray (10YR 3/1) wormcasts; weak, medium, prismatic structure breaking to moderate, fine, subangular and angular blocky structure; friable; neutral; gradual, smooth boundary.

B22—22 to 30 inches, dark grayish-brown (10YR 4/2) silty clay loam; moderate, coarse, prismatic structure breaking to moderate, medium, subangular and angular blocky structure; friable; thin, nearly continuous clay films on vertical surfaces of prisms; neutral; gradual, wavy boundary.

B3ca—30 to 34 inches, light olive-brown (2.5Y 5/4) silty clay loam; few, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, medium and fine, subangular blocky structure; friable; mildly alkaline; calcareous; clear, wavy boundary.

C1ca—34 to 46 inches, grayish-brown (2.5Y 5/2) silty clay loam; common, medium, distinct, yellowish-brown (10YR 5/8) mottles; massive; friable; common, round, hard and soft, white concretions of calcium carbonate 5 to 15 millimeters in diameter; moderately alkaline; strongly calcareous; gradual, smooth boundary.

C2—46 to 54 inches +, grayish-brown (2.5Y 5/2) silty clay loam; common, medium, distinct, yellowish-brown (10YR 5/8) mottles; massive; friable; horizontal breakage; mildly alkaline; calcareous.

The thickness of the A1 horizon ranges from 9 to 14 inches in uneroded areas. The texture of the A horizon ranges from silty clay loam to silt loam. The texture of the B and C horizons ranges from silt loam to heavy silty clay loam, and is variable by layers within the horizons in some places. The color of the B horizon ranges from dark yellowish brown to dark grayish brown and, in the lower part, to light olive brown. The thickness of the B horizon ranges from 14 to 20 inches. Free lime has been leached to a depth 24 to 30 inches below the surface. The C horizon in some places is stratified.

The Poinsett soils have a profile similar to that of the Kranzburg soils, which developed in loess. Poinsett soils, however, do not have a substratum of glacial till. The Poinsett soils are more silty than the Barnes soils and are nearly free of stones, even though they are intermingled with Barnes soils in some places.

Poinsett silty clay loam, 2 to 6 percent slopes (PoB).—This soil has long, smooth, gentle slopes. Included in mapping this soil were a few areas that are nearly level.

The silty, water-laid material in most places is very thick, but glacial till lies within a few feet of the surface in some places and crops out in a few. This soil is normally free of stones, but a few pebbles or stones are in it. Thin seams of sand or gravel are present in the underlying material in some places. Some spots of fine-textured Sinai soil lie within areas of this soil.

There is a slight hazard of erosion on this soil. The long, smooth slopes are generally suitable for contouring or terracing. These practices help control erosion and reduce runoff. (Capability unit IIe–2; windbreak suitability group 1)

Poinsett silty clay loam, 2 to 6 percent slopes, eroded (PoB2).—This soil has long, smooth, gentle slopes. As a result of erosion, the surface layer is thinner than the one in the profile described for the series.

The silty water-laid material in which this soil developed is very thick in most places, but the underlying glacial till is within a few feet of the surface in some places and crops out in a few. A few pebbles or stones are on or in the soil, although this soil normally is free of stones. Thin seams of sand and gravel are present in the underlying material in some places.

The hazard of erosion is moderate. The smooth slopes are well suited to terracing and contouring for control of erosion and runoff. (Capability unit IIe–2; windbreak suitability group 1)

Rauville Series

The Rauville series consists of deep, very poorly drained soils in old stream channels and other low, wet places along rivers and creeks and in wet, marshy drainageways that dissect steep, sloping uplands. These soils developed in limy alluvium.

In a typical profile, the surface layer, about 30 inches thick, is limy, black silty clay loam. This layer grades to the underlying material, which is limy, mottled, very dark gray to dark gray silty clay loam. The largest areas of Rauville soils in the county are in the broad glacial valley south of Lake Benton.

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The permeability of these soils is moderately slow, and the moisture-holding capacity is very high. The reaction in the surface layer is alkaline.

Some areas of Rauville soils provide grazing or wild hay, but most of them are idle. These soils are not suited to crops, because they are too low to be drained and are subject to frequent flooding.

Representative profile of Rauville silty clay loam in a meadow 20 feet east of road ditch on south side of marshy area (SE¼NW¼NW¼ sec. 30, T. 109 N., R. 45 W.):

A11ca—0 to 8 inches, black (N 2/0) silty clay loam; moderate, very fine, granular structure; friable when moist, sticky and plastic when wet; many roots; moderately alkaline; strongly calcareous; gradual, smooth boundary.

A12ca—8 to 17 inches, black (N 2/0) silty clay loam; weak, very fine, granular structure; friable when moist, sticky and plastic when wet; moderately alkaline; strongly calcareous; gradual, smooth boundary.

A13ca—17 to 30 inches, black (N 2/0) silty clay loam; weak, coarse, subangular blocky structure breaking to weak, very fine, subangular blocky structure; friable when moist, sticky and plastic when wet; moderately alkaline; strongly calcareous; gradual, smooth boundary.

A3ca—30 to 40 inches, very dark gray (N 3/0) to dark-gray (5Y 4/1) silty clay loam; very dark gray (5Y 3/1) when crushed; few, fine, faint, light olive-brown (2.5Y 5/6) mottles; very weak, very fine, granular structure; friable when moist, sticky and plastic when wet; moderately alkaline; strongly calcareous; gradual, smooth boundary.

Cg—40 to 54 inches +, dark-gray (5Y 4/1) silty clay loam; common, medium, distinct, olive-brown (2.5Y 4/4) mottles; plastic when wet; moderately alkaline; calcareous.

The thickness of the A1 horizon ranges from 20 to 36 inches. The texture of the A1 horizon ranges from silty clay loam to silt loam, but silty clay loam predominates. Sandy or gravelly layers are present in the C horizon in some areas.

Rauville soils occupy low places among areas of the Lamoure soils, which are poorly drained. They have a dark-colored A horizon similar to the one in the Parnell soils, which are in the uplands, but Rauville soils have a weakly developed, calcareous solum.

Rauville silty clay loam (Ra) (0 to 2 percent slopes).—This is the only Rauville soil mapped in the county. It occupies the lowest parts of nearly level bottom lands.

Marshes and springs on the bottom lands were included in mapping this soil. In some spots the surface layer is only slightly limy. In the Beotia-Dickey, silty variants, soil association, most areas of this soil have a substratum of sand and gravel at a depth of 3 feet or more.

Flooding and wetness are the main hazards in using this soil. If a major system for drainage and flood control were installed, some areas of this soil would be made suitable for crops. Maintenance of soil fertility would then become a problem because the surface layer is limy and alkaline. (Capability unit VIw–2; windbreak suitability group 9)

Sinai Series

The Sinai series consists of deep, moderately well drained, nearly level and very gently sloping soils on uplands. They developed in water-laid sediments of silty clay and silty clay loam.

In a typical profile, the surface layer, about 15 inches thick, is friable, black silty clay loam. The lower part of the surface layer has been mixed with subsoil. The surface layer blends into the subsoil, which is about 17 inches thick and is firm, dark grayish-brown and olive-brown silty clay loam to silty clay. The lower part of the subsoil is limy. The underlying material is stratified, limy, mottled grayish-brown and light brownish-gray silty clay loam or silty clay.

The permeability of these soils is moderately slow, and the moisture-holding capacity is high or very high. The reaction in the surface layer is neutral.

The Sinai soils are free of stones. They are fine textured and are difficult to work, unless a high level of organic matter is maintained and good management is followed to prevent excessive compaction. They are used to produce corn, small grains, and alfalfa.

Representative profile of Sinai silty clay loam in a cultivated field where the slope is 2 percent (NE¼SE¼NE¼ sec. 1, T. 110 N., R. 44 W.):

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam; very weak, very fine, subangular blocky structure; friable when moist, sticky when wet; neutral; clear, irregular boundary.

A12—7 to 12 inches, black (10YR 2/1) silty clay loam; weak, very fine, subangular blocky structure; friable when moist, sticky when wet; neutral; clear, irregular boundary.

A3&B1—12 to 15 inches, mixed black (10YR 2/1) and very dark grayish-brown (10YR 3/2, grading to 2.5Y 3/2) silty clay loam; moderate, medium and fine, angular and subangular blocky structure; friable to firm when moist, sticky when wet; A3 material consists of coated peds, worm channels, and fillings in crevices; B1 material consists of coated peds; neutral; clear, irregular boundary.

B21—15 to 23 inches, very dark grayish-brown (2.5Y 3/2) silty clay loam to silty clay; dark grayish brown (2.5Y 4/2), grading to dark grayish brown (10YR 4/2), when crushed; weak, medium and coarse, prismatic structure breaking to moderate to strong, fine and medium, angular blocky structure; hard when dry, firm when moist, sticky and plastic when wet; continuous clay films distinct on vertical surfaces, patchy on horizontal surfaces; neutral; clear, irregular boundary.

B22—23 to 26 inches, olive-brown (2.5Y 4/4) and dark grayish-brown (2.5Y 4/2) silty clay; olive brown (2.5Y 4/4), grading to light olive brown (2.5Y 5/4), when crushed; weak, medium, prismatic structure breaking to moderate, fine and medium, subangular and angular blocky structure; firm when moist, sticky and plastic when wet; continuous clay films on vertical surfaces, patchy clay films on horizontal surfaces of peds; mildly alkaline; clear, wavy boundary.

B3—26 to 32 inches, olive-brown (2.5Y 4/4), grading to light olive-brown (2.5Y 5/4), silty clay loam; few, fine, distinct, yellowish-brown (10YR 5/6) mottles; weak, coarse and medium, prismatic structure breaking to weak, fine and medium, subangular blocky structure; friable when moist, sticky when wet; patchy clay films; mildly alkaline; calcareous; gradual, wavy boundary.

C1ca—32 to 45 inches, grayish-brown (2.5Y 5/2) silty clay loam; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; massive to weak, medium, subangular blocky structure; friable when moist, slightly sticky when wet; thin sandy lenses are evidence of stratification; numerous, hard, white concretions of calcium carbonate, 5 to 15 millimeters in diameter; moderately alkaline; strongly calcareous; gradual boundary.

C2—45 to 54 inches, light brownish-gray (2.5Y 6/2) silty clay loam; many, coarse, distinct, yellowish-brown (10YR 5/6) mottles; stratified in some places; few concretions of manganese oxide and of calcium carbonate; moderately alkaline; calcareous.

The texture of the A horizon and of the C horizon ranges from silty clay loam to silty clay. The B horizon in most places is silty clay. In some places the B horizon has in it thin layers of silty clay loam. The color of the B horizon is very dark grayish brown, dark grayish brown, olive brown, or light olive brown. Tongues of material similar to the A horizon material extend into the B horizon in some places. Free lime has been leached to a depth of 24 to 36 inches below the surface. The color of the C horizon ranges from grayish brown to light brownish gray.

The Sinai soils occupy slightly higher positions in the landscape than the poorly drained, fine-textured Fulda soils. They differ from the Aastad soils, which developed in glacial till, because they developed in stratified, fine-textured, stone-free material.

Sinai silty clay loam, 0 to 2 percent slopes (ScA).—This soil is nearly level or very gently sloping. It lies adjacent to drainageways, in wet, nearly level areas, and on flat hilltops. It developed in clayey, water-laid sediments that were deposited on the undulating landscape of the till surface.

The surface layer is 12 to 16 inches thick. The subsoil is silty clay loam or silty clay. Glacial till is present in many places below the silty material at a depth of 36 inches or more. Included in mapping this soil were a few areas of moderately well drained soil that developed in fine-textured glacial till in the northern part of the county.

This soil is hard to work when dry, and it becomes cloddy and compact if worked when too wet. This soil is drought resistant and, with proper management, it ranks among the good soils in the county. The hazard of wind erosion is slight. The fine clayey particles tend to blow readily. (Capability unit IIs–2; windbreak suitability group 1)

Sinai silty clay loam, 2 to 4 percent slopes (ScB).—This soil is very gently sloping. It lies in areas that break away from the nearly level Sinai soils and on slight knolls amid areas of Fulda soils.

Glacial till is present below the silty material, which extends to a depth of 36 inches or more. Included in mapping this soil was a small acreage of a fine-textured soil in the northern part of the county that developed in glacial till.

The hazard of erosion is slight when this soil is used. Good soil management, especially the return of all crop residues, is needed to maintain good workability of this soil. (Capability unit IIe–1; windbreak suitability group 1)

Singsaas Series

The Singsaas series consists of deep, well-drained, gently undulating soils on the uplands of the Cary till plain. The landscape is one of swells and swales. Singsaas soils occupy the swells, and Oak Lake or Flom soils are in the swales. The Singsaas soils developed in limy glacial till, most of which is silty and is nearly free of stones.

The Singsaas soils have been worked intensively by worms. The low landscape and the fertile soil made possible the vast numbers of earthworms that were needed to produce the worm-worked subsoil. The activity of worms has been less in some exposed, high-lying places than in the main areas of these soils.

In a typical profile in a cultivated area, the surface layer, about 10 inches thick, is friable, dark-colored silty clay loam. The lower part of the surface layer has been worked by worms. The subsoil, about 7 inches thick, has been mixed by earthworms. Soil from the surface layer has been mixed into the upper part of the subsoil, and soil from the underlying layer has been mixed into the lower part. The limy, light olive-brown and grayish-brown underlying material in most places is clay loam, but in some places it is loam.

The permeability of these soils is moderately rapid, and the moisture-holding capacity is high. The reaction in the surface layer is neutral. These soils are highly responsive to management, and they can be used for intensive cropping if runoff and erosion are controlled.

Representative profile of Singsaas silty clay loam in a cropped area where the slope is 3 percent (NE¼SE¼SE¼ sec. 10, T. 111 N., R. 46 W.):

- Ap—0 to 6 inches, black (10YR 2/1), grading to very dark brown (10YR 2/2), silty clay loam; cloddy; friable when moist; neutral; abrupt, smooth boundary.
- A3&B2—6 to 10 inches, about 50 percent very dark brown (10YR 2/2) silty clay loam and about 50 percent very dark grayish-brown (10YR 3/2) and dark grayish-brown (10YR 4/2) wormcasts; weak to moderate, fine, subangular blocky structure; friable when moist; neutral; clear, wavy boundary.
- B2&Cca—10 to 17 inches, almost completely worm worked silty clay loam; about 35 percent very dark grayish-brown (10YR 3/2), 60 percent light olive-brown (2.5Y 5/3 and 5/4), and 5 percent black (10YR 2/1) wormcasts; weak to moderate, medium, prismatic structure breaking to weak to moderate, fine, subangular blocky structure; friable when moist; light-colored casts are most numerous in lower part; mildly alkaline; light-colored casts are strongly calcareous; gradual, wavy boundary.
- C1ca—17 to 28 inches, light olive-brown (2.5Y 5/4) clay loam; few horizontal streaks of grayish brown (2.5Y 5/2) and few very dark gray (10YR 3/1) and very dark grayish-brown (10YR 3/2) wormcasts; weak, fine and medium, subangular blocky structure; friable when moist; few, soft, white concretions of calcium carbonate, 5 to 15 millimeters in diameter; moderately alkaline; strongly calcareous; abrupt, wavy boundary.
- C2—28 to 39 inches +, light olive-brown (2.5Y 5/4) and some grayish-brown (2.5Y 5/2) clay loam; weak to moderate, medium, subangular blocky structure; friable when moist, but firmer than the horizon above; moderately alkaline; calcareous.

The texture of the A horizon is predominantly silty clay loam, but in some places it is loam, silt loam, or clay loam. The thickness of the B horizon is variable. A thin B horizon generally is limy throughout, and a thicker B horizon is limy only in the lower part. The B horizon has been slightly to intensively worked by worms. The most intensive work by worms has been in the soils that have the most gentle slopes. The color of the B horizon ranges from very dark grayish brown to dark yellowish brown, dark brown, and brown; and, in the lower part, to light olive brown. The C horizon is limy, mottled glacial till of clay loam or loam texture and grayish-brown, light olive-gray, or light olive-brown color.

The Singsaas soils resemble the Barnes soils, except for having a B horizon that has been intensively mixed by earthworms. Singsaas soils have a browner B horizon and are more sloping than the Oak Lake soils. They differ from the Buse soils because they do not have a limy A horizon and because they have a developed B horizon.

Singsaas silty clay loam, 2 to 6 percent slopes (SgB).—This soil is gently undulating and well drained. It lies on low slopes in the Cary till plain. The slopes are short and irregular, and some of the swells are high enough to slope in all directions. This soil has the profile that is described for the series.

In most places this soil is silty and nearly free of stones. In a few places, the texture is loam and pebbles and stones are common. The loamy till has been worked less by worms than the silty till. In most places the lower part of the subsoil is limy. The subsoil is thin in some places, and there it is limy throughout. Included in mapping this soil were a few small areas of Oak Lake soil, which is moderately well drained.

The hazard of erosion is slight on this soil. This soil is suited to intensive use for row crops wherever the slopes are uniform enough to permit contour farming or terracing for control of erosion. (Capability unit IIe–2; windbreak suitability group 1)

Singsaas silty clay loam, 2 to 6 percent slopes, eroded (SgB2).—Areas of this soil have slopes in the upper part of the range from 2 to 6 percent.

This soil has lost 4 to 6 inches of the original surface layer. The surface layer is grayer than that of the uneroded soil because subsoil has been mixed into it by tillage, and because organic matter has been lost by erosion and by excessive use for row crops. In some spots the surface layer is slightly limy because limy material from below that was mixed into the subsoil by worms has been incorporated by tillage into the surface layer. Most areas of this soil are silty and relatively free of stones, but in some areas the soil is loam and contains many stones and pebbles. The loamy till generally has been worked less by worms than the silty till.

There is a moderate hazard of water erosion. There is also a hazard of wind erosion when the fields are bare in spring. Contour farming or terracing will control erosion. An occasional sod crop helps replenish the supply of organic matter and helps maintain good soil tilth. (Capability unit IIe–2; windbreak suitability group 1)

Sioux Series

The Sioux series consists of excessively drained, undulating to very steep soils that are very shallow over sand and gravel. These soils developed in gravelly glacial outwash. They are on terrace escarpments and on some areas of gravelly glacial drift in the uplands.

A typical profile has a 10-inch surface layer of black gravelly sandy loam. At a depth of about 12 inches is limy coarse sand and gravel.

The permeability of these soils is very rapid, and the moisture-holding capacity is very low. The reaction in the surface layer is neutral or mildly alkaline. These soils are not suitable for crops. They are a good source of road gravel.

Representative profile of Sioux gravelly sandy loam in a meadow where the slope is 20 percent, about 100 feet south of road ditch and about 75 feet east of crest of slope (NW¼NW¼ sec. 31, T. 109 N., R. 45 W.):

- A11—0 to 5 inches, black (10YR 2/1) gravelly sandy loam; weak, medium, subangular blocky structure; very friable when moist; mildly alkaline; gradual, smooth boundary.
- A12—5 to 10 inches, black (10YR 2/1) gravelly sandy loam; weak, medium, subangular blocky structure; very friable when moist; mildly alkaline; calcareous; clear, wavy boundary.
- C1—10 to 12 inches, very dark brown (10YR 2/2), grading to very dark grayish-brown (10YR 3/2), gravelly loamy sand; very weak, medium and coarse, subangular blocky structure; very friable when moist; moderately alkaline; calcareous; abrupt, smooth boundary.

C2—12 to 36 inches +, variegated yellowish-brown (10YR 5/4) and brown (10YR 4/3) coarse sand and gravel; single grain; loose when moist; calcareous.

The thickness of the A horizon is less than 12 inches. The texture of the A horizon ranges from gravelly loamy sand to gravelly loam, but gravelly sandy loam predominates. The substratum, below a depth of about 12 inches, is sand and gravel. The depth to lime is variable. In some profiles free lime is present in the A1 horizon, but in others there is no free lime above the gravel. The proportions of sand, gravel, and cobblestones in the substratum are variable.

These soils are coarser textured than the Arvilla soils. They do not have a developed B horizon, and they have a solum thinner than that of the Arvilla soils. They differ from the Buse soils, which developed in glacial till, because they developed in gravelly glacial drift, and they have excessive internal drainage.

Sioux gravelly sandy loam, 5 to 40 percent slopes (SoF).—This soil is undulating to very steep. It lies on uplands among areas of Arvilla soils and on terrace escarpments bordering areas of Beotia and Fordville soils.

Some excellent gravel pits are located on this soil. In some places, however, the gravel is only a few feet thick and is underlain by glacial till or by silty alluvium. The gravelly material crops out in some eroded areas and lies as much as 12 inches beneath the surface in some uncultivated areas.

The hazard of drought is very severe on this soil. The hazard of erosion is very severe if the steep slopes are cultivated. This soil generally is not used for crops. Some very small areas are cropped with other soils because it is not practical to manage them separately. This soil provides some grazing in spring. (Capability unit VIIs–1; windbreak suitability group 8)

Svea Series

The Svea series consists of deep, moderately well drained, nearly level and gently undulating soils on uplands. These soils occupy lower parts of slopes, nearly level areas of the glacial plain, and slight rises within areas of poorly drained soils. They developed in glacial till of loam or clay loam texture.

A typical profile of a nearly level Svea soil has a surface layer, about 13 inches thick, that is friable, dark-colored clay loam. The lower part of the surface layer has had some subsoil mixed into it by the activity of earthworms. Beneath the surface layer is the subsoil, about 16 inches of friable clay loam that is dark grayish brown in the upper part. The lower part of the subsoil is limy and is light olive brown. The underlying material is limy, mottled light brownish-gray and light yellowish-brown glacial till of clay loam texture. In most places there are numerous concretions of lime in the upper part of the underlying material.

The permeability of these soils is moderate, and the moisture-holding capacity is high or very high. The reaction in the surface layer is neutral. These soils produce some of the best crops in the county if they are managed well, and almost all their acreage is cultivated.

Representative profile of Svea clay loam in a cultivated field where the slope is 2 percent, 40 feet south of first telephone pole east of corner (NW¼NW¼NW¼ sec. 23, T. 112 N., R. 45 W.):

Ap—0 to 8 inches, black (10YR 2/1) clay loam; cloddy to weak, fine and medium, subangular blocky structure; slightly hard when dry, friable when moist, slightly sticky and slightly plastic when wet; neutral; clear, smooth boundary.

A12—8 to 13 inches, dominantly black (10YR 2/1) clay loam; about 20 percent dark grayish-brown (2.5Y 4/2) wormcasts; weak, fine and medium, subangular blocky structure; friable when moist; neutral; clear, irregular boundary.

B2—13 to 23 inches, dark grayish-brown (2.5Y 4/2) to very dark grayish-brown (2.5Y 3/2) clay loam; few very dark gray (10YR 3/1) wormcasts and few light olive-brown (2.5Y 5/4) calcareous wormcasts; weak, medium and coarse, subangular blocky structure; friable when moist; neutral; clear, irregular boundary.

B3ca—23 to 29 inches, light olive-brown (2.5Y 5/4) clay loam; very weak, medium, subangular blocky structure; friable when moist; few, small, soft, white concretions of calcium carbonate; moderately alkaline; strongly calcareous; clear, wavy boundary.

C—29 to 54 inches +, light brownish-gray (2.5Y 6/2) and light yellowish-brown (2.5Y 6/4) clay loam; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; massive; firm when moist; mildly alkaline; calcareous.

The thickness of the A1 horizon in most places ranges from 8 to 16 inches. The texture of the A1 horizon is clay loam in most places, but it ranges to loam, silt loam, or silty clay loam. The color of the B2 horizon commonly is olive brown, light olive brown, and dark grayish brown. Free lime in most places has been leached from the upper horizons and has accumulated in the B3ca horizon, which is 18 to 30 inches below the surface.

The Svea soils have a thicker A horizon than the Barnes soils and a more olive, less brown B horizon. The Svea soils do not have a worm-worked B horizon, and in that way they differ from the Oak Lake soils.

Svea clay loam, 0 to 2 percent slopes (SvA).—This soil is nearly level and moderately well drained. The areas lie among areas of the Barnes soils, which are well drained, and adjacent to but slightly higher than areas of the Flom soils, which are poorly drained.

The dark-colored surface layer of this soil in most places is about 13 inches thick. Lime has been leached from the upper layers and has accumulated in the lower subsoil at a depth of 18 to 30 inches. In a few places in the uplands, free lime has been leached to a depth of 36 inches. In areas of this soil that are near areas of Vallers soils, free lime is present just below the surface layer. Included in mapping some areas of this soil are small areas of a Parnell soil in depressions, small areas of a Flom soil in narrow drainageways, and some spots of Sinai and Waubay soils.

This soil can be cropped intensively because it has no outstanding limitations. (Capability unit I–1; windbreak suitability group 1)

Svea clay loam, 2 to 4 percent slopes (SvB).—This soil is gently sloping and moderately well drained. The areas lie among areas of Barnes soils, which are well drained, and on slight knolls within areas of Flom soils, which are poorly drained. The slopes of this soil are short and irregular.

The surface layer of this soil is about 9 inches thick. The surface layer in some drainageways and near the base of some slopes, however, is almost 24 inches thick. In some small spots of this soil, the surface layer is lighter colored than typical because subsoil has been mixed into it by tillage. The subsoil in most places is thinner than that of the profile described for the series. Wherever the subsoil is thin, this soil resembles the Hamerly soils, except that it does not have a limy surface layer. Included in mapping this soil near the base of steeper slopes were some narrow bands of Terril soil.

The erosion hazard on this soil is slight. This soil is suited to intensive use for row crops. An occasional crop of grasses and legumes will supply organic matter that is needed to maintain good soil tilth. (Capability unit IIe–1; windbreak suitability group 1)

Sverdrup Series

The Sverdrup series consists of very deep, somewhat excessively drained, gently sloping and sloping soils on uplands. They developed in sandy glacial drift.

A typical profile of a very gently undulating, cultivated Sverdrup soil has a surface layer, about 12 inches thick, that is friable sandy loam. The upper part of the surface layer is black, and the lower part is very dark gray. The subsoil, about 11 inches thick, is friable. The upper half of the subsoil is very dark grayish-brown sandy loam, and the lower half is brown loamy sand. The underlying material grades from brown loamy sand to limy yellowish-brown sand.

The permeability of these soils is moderately rapid above the sandy underlying material, and very rapid in that material. The soils take in water readily, but their moisture-holding capacity is low. The reaction in the surface layer is neutral or slightly acid. Because the soils do not hold much water, small grains that mature early and have a low requirement for moisture are the most reliable crops.

Representative profile of Sverdrup sandy loam in a cultivated field where the slope is very gently undulating, 10 feet west of first telephone pole south of farmstead (SE¼NE¼NE¼ sec. 3, T. 109 N., R 44 W.):

Ap—0 to 5 inches, black (10YR 2/1) sandy loam; cloddy; soft when dry, friable when moist, nonsticky when wet; slightly acid; abrupt, smooth boundary.

A12—5 to 9 inches, black (10YR 2/1) sandy loam; weak, fine, subangular blocky structure; very friable when moist; neutral; clear, smooth boundary.

A3—9 to 12 inches, very dark gray (10YR 3/1) sandy loam; weak, medium and coarse, subangular blocky structure; very friable when moist; neutral; gradual, wavy boundary.

B21—12 to 16 inches, very dark grayish-brown (10YR 3/2) sandy loam; weak, medium and coarse, subangular blocky structure; very friable when moist; neutral; gradual, smooth boundary.

B22—16 to 23 inches, brown (7.5YR 4/4) loamy sand; very weak, coarse, prismatic structure breaking to weak, coarse, subangular blocky structure; very friable when moist; neutral; gradual, smooth boundary.

C1—23 to 32 inches, brown (10YR 4/3) loamy sand; single grain; loose when moist; neutral; gradual, smooth boundary.

C2ca—32 to 50 inches +, yellowish-brown (10YR 5/4) and dark yellowish-brown (10YR 4/4) medium sand; few pebbles; single grain; loose when moist; mildly alkaline; calcareous; amount of lime increases with depth.

The color of the A1 horizon commonly ranges from black to very dark gray or very dark brown, and to very dark grayish brown in eroded places. The texture of the A and B21 horizons ranges from sandy loam to fine sandy loam. The depth to loamy sand or sand ranges from 12 to 24 inches. The depth to free lime ranges from 24 to 36 inches in nearly level and gently sloping areas, and is less than 24 inches in sloping areas. The texture of the C horizon is sand or loamy sand.

The Sverdrup soils differ from the Arvilla soils, principally because they have a sandy rather than a gravelly substratum. They are coarser textured than the Flandreau soils, and they have a thinner solum over the loose sand. They are similar to the Dickey soils, but their underlying material is not so fine textured.

Sverdrup sandy loam, 2 to 6 percent slopes (SwB).—This soil is undulating and gently sloping and somewhat excessively drained. The areas lie among areas of well-drained soils that developed in glacial till or reworked material.

In most cropped areas of this soil, the surface layer has a brownish cast. Some organic matter has been lost by cropping and erosion, and some brownish subsoil has been mixed into the surface layer by tillage. Free lime has been leached from this soil to a depth of 24 to 36 inches. Thin layers of silty material are present in the sandy substratum in some areas. Glacial till is the substratum in some places and lies 3 to 4 feet below the surface. Included in mapping this soil were some areas in which the surface layer and the subsoil are loam but depth to sand is less than 24 inches. Also included was a small acreage that is nearly level.

The hazards of drought and erosion are moderately severe when this soil is used. This soil is sandy and easy to work, but it will blow if it is not protected. With contour farming and spring plowing, corn, small grains, and alfalfa grow fairly well in years of normal rainfall. (Capability unit IIIe–2; windbreak suitability group 4)

Sverdrup sandy loam, 6 to 12 percent slopes (SwC).—This soil is sloping and somewhat excessively drained.

The surface layer, which is the plow layer and is about 6 inches thick, has had subsoil mixed into it by tillage. Its content of organic matter is low as a result of cropping and erosion. In a few areas the underlying sand is only a few feet thick over glacial till. Free lime is present, generally at a depth of less than 24 inches, and in some eroded spots the surface layer contains lime. Included in mapping this soil was a small acreage of Sverdrup soil that has slopes of 12 to 18 percent.

The hazards of erosion and drought are severe when this soil is used. If this soil is used for crops, stripcropping will help to control erosion, reduce runoff, and increase the content of organic matter. (Capability unit IVe–2; windbreak suitability group 4)

Terril Series

The Terril series consists of deep, moderately well drained, gently sloping soils that have a very thick, black surface layer. These soils occupy narrow strips at the foot of moderate to very steep slopes and some gently sloping drainageways. They developed in silty or loamy sediments that were moved from higher areas by soil creep and local wash.

In a typical profile, the surface layer is dark-colored silt loam about 46 inches thick. Beneath the dark-colored surface layer is very dark grayish-brown to gray glacial till of loam or clay loam texture.

The permeability of these soils is moderate, and the moisture-holding capacity is very high. The reaction in the surface layer is neutral. The very thick, permeable, dark-colored surface layer makes the soils nearly ideal for production of row crops.

Representative profile of Terril silt loam on a roadside where the slope is 3 percent, 10 feet east and 5 feet north of fence corner (NW¼NE¼NW¼ sec. 4, T. 111 N., R. 44 W.):

Ap—0 to 6 inches, black (10YR 2/1) silt loam; massive; friable when moist; neutral to slightly acid; abrupt, smooth boundary.

A12—6 to 20 inches, black (10YR 2/1) silt loam; weak, medium and coarse, prismatic structure breaking to weak, fine and medium, subangular blocky structure; friable when moist; neutral; gradual, smooth boundary.

A13—20 to 40 inches, very dark gray (10YR 3/1) silt loam; weak, medium and coarse, prismatic structure breaking to weak, fine and medium, subangular blocky structure; friable when moist; neutral; gradual, smooth boundary.

A3—40 to 46 inches, very dark gray (10YR 3/1) and very dark grayish-brown (10YR 3/2) silt loam; friable when moist; neutral; gradual, smooth boundary.

AC—46 to 60 inches, very dark brown (10YR 2/2) and very dark grayish-brown (10YR 3/2) clay loam; friable when moist; neutral.

The texture of the A horizon ranges from silt loam to loam. The thickness of the A horizon ranges from 2 feet to 4 feet. The depth to free lime in the soil ranges from 3 feet to 6 feet.

The Terril soils have a thicker A1 horizon than the Svea, Brookings, or Lismore soils, all of which are also moderately well drained. The Terril soils in the county do not have a B horizon, and the depth to free lime is greater in them than in the Svea, Brookings, or Lismore soils.

Terril silt loam, 2 to 6 percent slopes (TeB).—This soil lies in narrow strips along the foot of steeper slopes and in the upper ends of gently sloping drainageways amid areas of the Barnes, Kranzburg, and other well-drained soils.

The surface layer of this soil is generally silt loam, but in some places it is loam. A few stones are on the surface and in the soil in places where this soil adjoins soils that developed in glacial till. This soil in areas of loess, however, is free of stones. Thin, gravelly, sandy, or cobbly layers are present in the underlying material in some places. Many small areas of this soil lie in strips too narrow to be shown on the soil map and have been included in mapping the adjoining soils. Included in mapping this soil was a small acreage of a nearly level Terril soil and a small acreage of a more sloping Terril soil. The sloping areas are along the foot of some of the steep slopes south of Lake Benton. Also included in mapping this soil was an area that consists mostly of fill material along the lake at Lake Benton. This fill material is used for building sites, streets, and a city park.

If this soil is used for crops, it is necessary to have the slopes above it protected from erosion. If erosion occurs on the higher soils, the eroded soil material is likely to injure or smother plants that are growing on this soil. Gullies are likely to be formed if this soil is not protected from the erosive action of flowing water. The hazard of erosion by water that falls on this soil, however, is slight. If runoff from higher soils is controlled, this soil normally produces good crops. (Capability unit IIe-1; windbreak suitability group 1)

Vallers Series

The Vallers series consists of deep, poorly drained, nearly level soils on uplands. Most areas are on the rims of depressions. Some areas are in drainageways, and some are in nearly level areas of the gently undulating glacial landscape where there are many areas of very poorly drained soils in depressions. The Vallers soils developed under grass vegetation in limy glacial till consisting of loam and clay loam. They developed in places where the amount of water that moved upward and was evaporated from the soil exceeded the amount that moved downward into and through the soil. The net upward movement of water resulted in a high accumulation of precipitated lime in the upper layers.

In a typical profile, the surface layer is very limy, black or very dark gray silty clay loam about 17 inches thick. The underlying material is limy, mottled, grayish glacial till of clay loam texture.

The permeability of these soils ranges from moderate to slow, and the moisture-holding capacity is high. The reaction in the surface layer ranges from mildly alkaline to strongly alkaline because the content of lime is high.

The crops that are common in the county grow well if the soils receive good management, corrective fertilization, and adequate drainage.

Representative profile of Vallers silty clay loam in a cultivated field where the slope is 2 percent, 85 feet south and 85 feet west of second electric pole from corner (NE¼NE¼ sec. 32, T. 112 N., R. 46 W.):

Apca—0 to 7 inches, black (10YR 2/1) silty clay loam; cloddy; slightly firm when moist, slightly sticky when wet; moderately alkaline; strongly calcareous; abrupt, smooth boundary.

A12ca—7 to 12 inches, black (10YR 2/1) silty clay loam; weak, very fine, subangular blocky structure; friable when moist; moderately alkaline; strongly calcareous; clear, smooth boundary.

A3gca—12 to 17 inches, very dark gray (2.5Y 3/1) and dark-gray (2.5Y 4/1) silty clay loam; few, fine, distinct, dark-brown (7.5YR 4/4) mottles; weak, very fine, subangular blocky structure; friable when moist; moderately alkaline; strongly calcareous; clear, smooth boundary.

C1gca—17 to 26 inches, mixed very dark gray (2.5Y 3/1) dark-gray (2.5Y 4/1), and grayish-brown (2.5Y 5/2) clay loam; common, fine, faint, olive-brown (2.5Y 4/4) mottles; weak, very fine, subangular blocky structure; friable when moist; crayfish krotovinas; few crystals of calcium sulfate; moderately alkaline; strongly calcareous; diffuse, smooth boundary.

C2gca—26 to 32 inches, grayish-brown (2.5Y 5/2) clay loam; common, medium, distinct, yellowish-brown (10YR 5/6) mottles; weak, very fine, subangular blocky structure; friable when moist; crayfish krotovinas; black concretions of manganese oxide 1 to 2 millimeters in diameter; moderately alkaline; strongly calcareous; gradual, smooth boundary.

C3g—32 to 48 inches +, gray (2.5Y 5/1) clay loam; many, fine, distinct, light olive-brown (2.5Y 5/6) mottles; very weak, very fine, subangular blocky structure; friable when moist; moderately alkaline; calcareous.

The texture of the A horizon ranges from loam to clay loam and silty clay loam; silty clay loam is dominant. In some places there is a thin, weakly developed B horizon. The number and the distinctness of the mottles are variable.

The Vallers soils differ from the Flom soils because they have a highly calcareous A horizon, and they do not have a developed B horizon. They have a thicker A horizon and a grayer, more mottled substratum than the Hamerly soils.

Vallers silty clay loam (Va) (0 to 2 percent slopes).—This soil is nearly level. It is on the rims of depressions and in other low, somewhat wet places in the uplands of glacial till.

The surface layer in most plowed fields has a light-colored crust when it dries. In some drainageways a surface layer more than 24 inches thick has accumulated. Fragments of gypsum and of snail shells are in many areas. Included in mapping this soil were some small areas of Flom and of Hamerly soils.

Wetness is the major hazard. When the soil is bare, there is likely to be a hazard of wind erosion. Grassed waterways are needed in some drainageways to prevent gullying. For optimum yields, this soil must be fertilized to correct the imbalance in fertility that is caused by its high content of lime. (Capability unit IIw–2; windbreak suitability group 3)

Vienna Series

The Vienna series consists of deep, well-drained, gently sloping and sloping soils on uplands. The slopes generally are long, smooth, and uniform. These soils developed in the southwestern part of the county in glacial till that is older than the till in other parts of the county. The drainage patterns in these areas are well defined, and there are no depressions or potholes.

A typical profile of an uneroded, gently sloping Vienna soil has a surface layer of friable, black silt loam that is about 10 inches thick. The subsoil, about 16 inches thick, is friable, very dark grayish-brown and brown loam and clay loam. In the upper part of the subsoil there are numerous dark-brown wormcasts. The lower part of the subsoil is limy. The underlying material is limy, light olive-brown glacial till of clay loam texture.

The permeability of these soils is moderately rapid, and the moisture-holding capacity is high. The reaction in the surface layer is neutral or slightly acid.

Nearly all the acreage of Vienna soils is cultivated. The principal crops are corn, small grain, and alfalfa.

Representative profile of Vienna silt loam in a grassy place at an abandoned farmstead where the slope is 2 percent, on the south side of farmstead, 10 feet east of farm drive (NW¼NE¼ sec. 7, T. 109 N., R. 46 W.):

A1—0 to 7 inches, black (10YR 2/1) silt loam; moderate, very fine, subangular blocky structure; friable; very fine grit and pebbles; neutral; clear, smooth boundary.

A3—7 to 10 inches, dominantly black (10YR 2/1) silt loam; 25 percent very dark grayish-brown (10YR 3/2) wormcasts; moderate, very fine, subangular blocky structure; friable; fine grit and a few small pebbles; neutral; clear, irregular boundary.

IIB21—10 to 15 inches, dominantly very dark grayish-brown (10YR 3/2) light clay loam; about 40 percent brown (10YR 4/3) wormcasts; moderate, medium, prismatic structure breaking to moderate, very fine and fine, subangular blocky structure; friable; neutral; clear, irregular boundary.

IIB22—15 to 21 inches, brown (10YR 4/3) loam; weak, medium, prismatic structure breaking to weak, fine and medium, subangular blocky structure; friable; thin, patchy clay films on peds; neutral to mildly alkaline; clear, irregular boundary.

IIB3ca—21 to 26 inches, brown (10YR 4/3) and olive-brown (2.5Y 4/4) light clay loam; very weak, medium, prismatic structure breaking to weak, fine, subangular blocky structure; friable; moderately alkaline; strongly calcareous; clear, irregular boundary.

IICca—26 to 54 inches +, light olive-brown (2.5Y 5/4) light clay loam; common, medium, distinct, dark-brown (7.5YR 4/4) mottles; structureless; friable when moist, slightly sticky when wet; common, soft, white concretions of calcium carbonate 5 to 25 millimeters in diameter; moderately alkaline; strongly calcareous.

The color of the A horizon ranges from black to very dark brown, very dark gray, or very dark grayish brown. The browner colors are the result of mixing with material from the B horizon through tillage and erosion. Stones and pebbles are on the surface and in the soil. A layer of loess modified by glacial till, up to 2 feet thick in some places, overlies the glacial till. This mixed material contains very fine quartz crystals, other grit, and a few pebbles. The color of the B horizon ranges from very dark grayish brown to light olive brown. The lower part of the B horizon is light olive brown. Free lime has been leached from the upper 15 to 30 inches of soil, and the least leaching has occurred on the strongest slopes. The underlying glacial till in most places is clay loam, but it ranges to loam. The till in most places is yellowish brown or light olive brown.

Vienna soils differ from Barnes soils because they developed on simple rather than on complex slopes. They have a slightly thicker solum than that of the Barnes soils, and their A horizon developed in glacial till that had been modified by silty. windblown material. The Vienna soils differ from the Kranzburg soils because they developed in glacial till instead of in stone-free loess.

Vienna silt loam, 2 to 6 percent slopes (VeB).—This soil has smooth, gentle slopes. It lies on gentle slopes and on ridgetops in close association with lower areas of the Lismore soils, which are moderately well drained.

The surface layer in most places is silt loam, but in some places it is loam or clay loam. In some places this soil, even if it is undisturbed, has a silt mantle that is less than 1 foot thick. Included in mapping this soil were small areas of Kranzburg soils.

The hazard of erosion, because of moderate surface runoff, is the main limitation to use of this soil. Applications of nitrogen and phosphorus are needed for the best growth of many crops. This soil is suitable for intensive farming if terraces are built to control erosion and runoff. (Capability unit IIe–2; windbreak suitability group 1)

Vienna silt loam, 2 to 6 percent slopes, eroded (VeB2).—This soil has long, smooth, gentle slopes, mostly in the upper part of the range from 2 to 6 percent.

In a few places the plow layer is mostly brown material that formerly was subsoil. The surface layer in some places is loam or clay loam.

The risk of erosion, because of the long slopes, is the main hazard when this soil is used. Terracing and contour farming will help to control erosion. A rotation that includes grasses and legumes would improve the tilth and increase the infiltration of water. Fertilizers that contain nitrogen and phosphorus are needed for most crops. (Capability unit IIe–2; windbreak suitability group 1)

Vienna silt loam, 6 to 12 percent slopes, eroded (VeC2).—This sloping soil lies on areas that grade towards the drainageways.

The plowed surface layer of this soil is about 4 to 6 inches thick. The subsoil is about 5 inches thinner than the one in the profile that is described as representative of the series. The plow layer is a mixture of yellowish-brown subsoil and the remaining dark-colored original surface soil. The surface layer in most places is silt loam, but in many places it is loam or clay loam. The subsoil in most places is loam or clay loam. Included in mapping this soil were small spots of the light-colored Buse soils on some hillsides, a few areas of Kranzburg soils, and some areas of uneroded Vienna soils in pastures and other uneroded places.

The hazard of erosion on this soil is severe. Excessive growing of row crops, in rows up and down the slope, has caused loss of soil. As a result, the supply of organic matter, the soil fertility, and the capacity to absorb water have been reduced. A program that includes terracing or stripcropping and a rotation that includes legumes and grasses as well as row crops would improve the productivity of this soil. (Capability unit IIIe-1; windbreak suitability group 1)

Waubay Series

The Waubay series consists of deep, moderately well drained, nearly level and gently sloping soils that developed in silty, water-laid sediments. These soils are on uplands where the glacial landscape has been filled in and made smooth by the water-laid sediments.

A typical profile of a nearly level Waubay soil has a black surface layer of silty clay loam about 15 inches thick. The subsoil, about 18 inches thick, is friable, dark grayish-brown and olive-brown silty clay loam in the upper part. The lower part of the subsoil is limy, mottled, light olive-brown silty clay loam. The underlying material consists of water-laid sediments that are limy, mottled, grayish-brown silty clay loam.

The permeability of these soils is moderate, and the moisture-holding capacity is high or very high. The reaction in the surface layer is neutral.

The Waubay soils are silty and free of stones. Row crops, small grains, and alfalfa grow well on them.

Representative profile of Waubay silty clay loam in a cultivated field 150 feet south of NE corner of SE¼ of section, 35 feet west of fence line (NE¼NE¼SE¼ sec. 1, T. 110 N., R. 44 W.):

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam; cloddy; friable when moist, sticky when wet; neutral; abrupt, smooth boundary.

A12—7 to 15 inches, black (10YR 2/1) silty clay loam; moderate, fine, subangular blocky structure; friable when moist; neutral; clear, wavy boundary.

B21—15 to 20 inches, about 50 percent dark grayish-brown (2.5Y 4/2) silty clay loam; about 50 percent very dark gray (10YR 3/1) wormcasts; weak, coarse, prismatic structure breaking to moderate, fine, subangular and angular blocky structure; slightly hard when dry, friable when moist; neutral; clear, irregular boundary.

B22—20 to 26 inches, material similar to that in the horizon above, except there are only a few wormcasts.

B23—26 to 30 inches, olive-brown (2.5Y 4/4) silty clay loam; weak, coarse, prismatic structure breaking to moderate, very fine and fine, subangular and angular blocky structure; slightly hard when dry, friable when moist; neutral; clear, irregular boundary.

B3ca—30 to 33 inches, light olive-brown (2.5Y 5/4) silty clay loam; few, fine, distinct, dark yellowish-brown (10YR 4/4) mottles; weak, medium, subangular blocky structure; friable; common threadlike streaks of lime; mildly alkaline; strongly calcareous; clear, wavy boundary.

C1ca—33 to 46 inches, grayish-brown (2.5Y 5/2) silty clay loam; common, medium, distinct, dark yellowish-brown (10YR 4/4) mottles; structureless; friable; irregular, common, soft and hard, white concretions of calcium carbonate 5 to 15 millimeters in diameter; moderately alkaline; strongly calcareous; clear, wavy boundary.

C2—46 to 54 inches +, grayish-brown (2.5Y 5/2) silty clay loam; common, medium, prominent, yellowish-brown (10YR 5/6) mottles; structureless; friable; mildly alkaline; calcareous.

The thickness of the A1 horizon ranges from 9 to 16 inches. The color of the B horizon is typically dark grayish brown, very dark grayish brown, and olive brown, and, in the lower part, light olive brown. The texture of the A, B, and C horizons is predominantly silty clay loam, but there is some silt loam, and in some places the C horizon is glacial till of clay loam texture. The color of the C horizon is commonly mottled grayish brown and light olive brown.

The Waubay soils are not so fine textured as the associated Sinai soils. They have a thicker A horizon and a more olive-colored B horizon than the Sinai soils. They are in lower positions on the slopes than the Poinsett soils, which are well drained.

Waubay silty clay loam, 0 to 2 percent slopes (WaA).—This soil is nearly level and moderately well drained. It lies among areas of the Poinsett soils, which are well drained.

In a few small areas of this soil, the surface layer is limy. In most areas the free lime has been leached to a depth of 20 to 30 inches. In a few areas the surface layer is silt loam. In most places the water-laid silty sediments are more than 4 feet thick, but in a few places they are less than 4 feet thick over glacial till. Included in mapping this soil were small areas of the poorly drained Flom soil and of the fine-textured Sinai soils.

There is no serious hazard of erosion or wetness when this soil is used. This soil is suited to intensive use for row crops. (Capability unit I-1; windbreak suitability group 1)

Waubay silty clay loam, 2 to 4 percent slopes (WaB).—This soil is very gently sloping and moderately well drained. Most areas lie below areas of more strongly sloping Poinsett soils, which are well drained, or on low knolls within areas of Flom or Fulda soils, which are poorly drained.

The surface layer is 3 to 6 inches thinner than the one in the profile described as representative of the series. The depth to free lime normally is 20 to 30 inches, but in a few small areas the subsoil is limy. The silty, water-laid sediments in which the soil formed are very thick in most places, but in a few places the underlying glacial till is less than 4 feet beneath the surface.

The hazard of erosion is slight when this soil is used. This soil is suited to intensive use for row crops. Legumes and grasses in the rotation and crop residues that are returned from high-yielding varieties of crops will help to maintain fertility and prevent erosion. A good supply of organic matter helps maintain the ability of the soil to absorb rainfall. (Capability unit IIe-1; windbreak suitability group 1)

Use and Management of the Soils

This section gives interpretations of the soils for use in production of crops, in the management of field and farmstead windbreaks, and in various kinds of engineering work.

Use and Management of Soils for Crop Production

This subsection discusses the capability classification of soils that is used by the Soil Conservation Service and describes the capability units in which the soils are placed. It also gives predictions of the yields to be expected when the different soils are used for crops and for pasture.

Most of the farmland in the county is used for production of corn, oats, flax, soybeans, and alfalfa. The crops are sold or are fed to livestock.

The sloping soils are subject to water erosion if they are cultivated and not protected. Terracing, contour farming, stripcropping, and management of crop residues help to control erosion and to increase the amount of water that enters the soil and is then available for growth of crops.

Wind erosion occurs most readily on the sandy soils and the clayey soils. Wind erosion can be reduced by keeping vegetation on the soil or by leaving the plowed surface rough until time to prepare a seedbed.

Drainage is needed for intensive farming of the wet, level or depressed soils. Open ditches are commonly used to remove surface water from low areas and closed depressions and to provide outlets for tile drainage systems.

Crops on most of the soils in the county respond to applications of fertilizer. The soils are especially low in phosphorus. The need for fertilizer depends on the kind of soil, the past and present management, and the crop that is grown. Soil tests provide part of the information that is needed to choose the best kinds and amounts of fertilizer.

Capability groups of soils

Capability classification is the grouping of soils to show, in a general way, their suitability for most kinds of farming. It is a practical classification based on the limitations of the soils, the risk of damage when they are used for the ordinary field crops or sown pastures, and the way they respond to treatment. The classification does not apply to most horticultural crops, or to rice and other crops that have their own special requirements. The soils are classified according to degree and kind of permanent limitations, but without consideration of major and generally expensive landforming that would change the slope, depth, or other characteristics of the soils; and without consideration of possible major reclamation.

In the capability system, all soils are grouped at three levels, the capability class, the subclass, and the unit. These are discussed in the following paragraphs.

Capability Classes, the broadest groupings, are designated by Roman numerals I through VIII. As the numerals increase, they 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 some limitations that reduce the choice of plants or require moderate conservation practices.

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

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

Class V. Soils subject to little or no erosion but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife food and cover. (There are no class V soils in Lincoln County.)

Class VI. Soils that have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife food and cover.

Class VII. Soils that have very severe limitations that make them unsuited to cultivation and that restrict their use largely to grazing, woodland, or wildlife.

Class VIII. Soils and landforms that have limitations that preclude their use for commercial plant production without major reclamation and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes.

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* is used in those areas where climate is the chief limitation to the production of common cultivated crops.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only subclasses indicated by *w*, *s*, and *c*, because the soils in it are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, or recreation.

Capability Units are soil groups within the subclasses. The soils in one capability unit are enough alike to be suited to the same crops and pasture plants, to require similar management, and to have similar productivity and other responses to management. Thus, the capability unit is a convenient grouping for making many statements about management of soils. Capability units are generally designated by adding an Arabic numeral to the subclass symbol, for example, IIe-1 or IIIe-2. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation, and the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraph. The Arabic numeral specifically identifies the capability unit within each subclass.

Management by capability units

In the following pages the capability units in Lincoln County are described and suggestions for the use and management of the soils are given. The names of soil series represented are mentioned in the description of each capability unit. This does not mean, however, that all the soils of a series are in a given capability unit. To find the capability classification of any given soil, refer to the "Guide to Mapping Units" at the back of this survey.

CAPABILITY UNIT I-1

This capability unit consists of deep, dark-colored, well drained and moderately well drained, medium and moderately fine textured, nearly level soils. They are members of the Barnes, Beotia, Forman, and Kranzburg series, which consist of well drained soils, and of the Aastad, Brookings, Lismore, Oak Lake, Svea, and Waubay series, which consist of moderately well drained soils. All the soils have high or very high moisture-holding capacity. They have few limitations that restrict their use.

These soils are well suited to all the crops grown in the county. The moderately well drained soils do not dry out so quickly in spring as the well drained soils and cannot be worked so early.

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The soils of this unit can be farmed intensively under a high level of management. Row crops can be grown for several years in succession. It is desirable to leave crop residues on the surface of fall-plowed fields to control wind erosion. An occasional green-manure crop or sod crop helps maintain good soil structure and tilth.

If hay or pasture is needed, a suitable rotation consists of row crops for 4 years, small grain for 1 year, and legume-grass hay or pasture for 1 year. If the hay or pasture is not needed, a green-manure crop can be planted with the small grain crop to provide cover and add organic matter.

CAPABILITY UNIT IIe-1

This unit consists mostly of deep, dark-colored, moderately well drained, mainly moderately fine textured, undulating and gently sloping soils of the uplands. These soils are members of the Brookings, Oak Lake, Sinai, Svea, Terril, and Waubay series. The Terril soil has a medium-textured surface layer; the Sinai soil is fine textured in the subsoil but is otherwise like the other soils in this unit.

The soils in this unit are fertile. They have moderate permeability and very high moisture-holding capacity. Crops grown on them withstand drought better than those on adjoining well-drained soils. The hazard of erosion is slight. Because the slopes are gentle and most of them are short, soil management that includes a good rotation usually is adequate to control erosion. Contouring and terracing are generally not practical, because these soils are only moderately well drained, and these practices tend to hold back water and make the soils too wet after a rainy period.

These soils are well suited to all the crops grown in the county. Crops on them respond well to good management. If the length of slope is more than 100 feet, a 4-year rotation consisting of 2 years of corn, 1 year of small grain, and 1 year of hay is suitable. If the length of slope is less than 100 feet, if the soil is in good tilth, and if the level of management is high, row crops can be grown more often than 2 years out of 4. Tillage of the soil to prepare a seedbed and to cultivate should be kept to a minimum. An occasional green-manure crop or sod crop may be needed to maintain good soil tilth.

Fall plowing of these soils is usually necessary, since they are too wet in spring to permit preparation of a good seedbed. A rough, plowed surface and crop residue on the soil will generally control wind erosion. Crop rows should be on a slight grade rather than on the contour, so that water does not collect between the rows. If terraces cross these soils, they should be graded terraces. Grassed waterways are needed wherever water collects, and especially where terrace outlets cross these soils. In some places diversion terraces above areas of these soils will prevent washing caused by runoff from higher land.

Most areas of these soils are used for crops. Some areas not accessible to farm machinery are in permanent pasture.

CAPABILITY UNIT IIe-2

This unit consists of deep, dark-colored, well-drained, medium-textured or moderately fine textured soils that are undulating or gently sloping. They are members of the Barnes, Beotia, Buse, Forman, Kranzburg, Poinsett, Singsaas, and Vienna series. Permeability of these soils is moderately rapid, and their moisture-holding capacity is high. The hazard of erosion is slight to moderate. These soils are somewhat droughty in the places where erosion and loss of organic matter have reduced their capacity to hold moisture.

If these soils are managed properly and erosion is controlled, all the common crops are suited. Practices to control erosion are needed. Some of the soils, especially those of the Barnes and Singsaas series, have short, undulating slopes and are not well suited to terracing and contour farming. On them a rotation that provides for sod crops one-third of the time will generally control erosion. An example of a suitable 6-year rotation consists of 2 years of row crops, 1 year of small grain, 2 years of meadow, and 1 year of flax or other small grain. The flax is grown to allow time for recharge of soil moisture and for decomposition of the sod. If contouring or terracing can be practiced, the rotation can be more intensive than the one described. The Kranzburg and Vienna soils generally have longer, smoother slopes and are better suited to contouring and terracing than the other soils in this unit.

Minimum tillage practices, such as plow planting and wheel-track planting, are practical measures for control of erosion on these soils. If plowing is done, it should be in spring unless corn is to be planted after 2 years or more of sod. Fall plowing of sod allows time for soil moisture to be replenished and for the sod to be decomposed. Some crop residue on the surface and a rough, plowed surface reduce the hazard of wind erosion on bare soil during winter and spring. Grassed waterways are needed wherever water collects and wherever terrace outlets cross these soils.

Some intensively cropped areas and some severely eroded spots have become infertile. Heavy applications of manure improve the content of organic matter, aid absorption of water, reduce runoff, help control erosion, and help restore productivity. Legumes and grasses in the crop rotation are also beneficial on these eroded or infertile spots.

Stones are sometimes pushed to the surface by action of frost and by tillage in areas of Barnes, Buse, Singsaas, and Vienna soils. Tillage is made easier if the stones are removed from time to time.

CAPABILITY UNIT IIe-3

This unit consists of moderately deep, dark-colored, well-drained, medium-textured, gently sloping soils on uplands, river terraces, and outwash plains. They are members of the Flandreau and Fordville series. They developed in 2 to 3 feet of medium-textured glacial till, outwash, or loess, and are underlain by sand and gravel. They have moderately rapid permeability and moderate moisture-holding capacity. These soils are somewhat droughty because they have a sandy or gravelly substratum. During and after prolonged droughts, crops on them are noticeably affected by the lack of moisture. The hazards of water erosion and of wind erosion are moderate on these soils. In some places more than half the original surface layer has been lost.

With contouring and other high level of management, these soils can be used for row crops 2 years out of 4. These soils are well suited to irrigation, and if water for irrigation is available, they can be used intensively for row crops. If row crops are grown year after year, a high level of fertility and intensive erosion control measures are necessary.

A good seedbed can be prepared easily in these soils. The hazards of wind erosion and of water erosion can be reduced by spring plowing. Stubble or cornstalks on the surface during winter hold snow and help provide moisture for the next crop.

The content of organic matter is likely to be low if crop residues have not been returned or if erosion has occurred. Heavy applications of manure and rotations that include legumes and grasses help to restore organic matter.

The sandy or gravelly substratum affects construction of terraces and waterways. If proposed terraces cross these soils, the risk of exposing the sand or gravel should be investigated. Grassed waterways help prevent the formation of gullies that might cut into the substratum. Drop-inlet structures are needed in some places where waterways end on streambanks.

CAPABILITY UNIT IIs-1

This unit consists of moderately deep, dark-colored, well-drained, medium-textured, nearly level soils on uplands, river terraces, and outwash plains. They are members of the Estelline, Flandreau, and Fordville series. These soils developed in 2 or 3 feet of medium-textured glacial till, outwash, or loess, and are underlain by sand or gravel. They have moderately rapid permeability and moderate moisture-holding capacity. They are somewhat droughty because they have a coarse-textured substratum. Wind erosion occurs in large open areas.

These soils produce good yields of the common crops in years when the rainfall is adequate and timely. Under irrigation they can be used intensively for row crops if good management is practiced. A rotation that consists of 3 years of row crops, 1 year of small grain, and 1 year of meadow is suitable if minimum tillage is practiced, all crop residues are returned, and adequate fertilizer is applied. Minimum tillage includes wheel-track planting or plow planting. If minimum tillage is not practiced, a less intensive rotation is more reliable.

Spring plowing reduces the hazard of wind erosion. Crop residues on the surface during winter help to hold snow and thus to provide moisture for the next crop.

All the soils in this unit have a surface layer that is easy to work and can be made into a good seedbed. Unless the rotation has been good and all crop residues have been returned to the soil, the content of organic matter is likely to be low. Depletion of organic matter reduces the infiltration rate and the water-holding capacity. Heavy applications of manure and a rotation that includes legumes and grasses will help restore the supply of organic matter.

Grassed waterways in the drainageways that cross these soils generally prevent cutting of gullies into the coarse-textured substratum. Drop-inlet structures are used in some places where waterways terminate on the streambanks.

CAPABILITY UNIT IIs-2

The one soil in this capability unit is Sinai silty clay loam, 0 to 2 percent slopes. It is a deep, dark-colored, moderately well drained, fine to moderately fine textured, nearly level soil. This soil has moderately slow permeability and very high moisture-holding capacity. It provides ample moisture for crops through most droughty periods but is clayey and somewhat difficult to work. It has slightly restricted drainage through the subsoil, but not enough to make tiling necessary. The fine particles in the surface layer are likely to blow when the soil is bare, unless good management practices are followed. If the soil is plowed when too wet, a dense, compact tillage pan develops below the plow layer and hard clods form that are difficult to break.

This soil, when properly managed, ranks among the best farming soils in the county. It is well suited to corn, oats, flax, and legume-grass hay.

Depending on the need for hay, the following rotations are suitable: 4 years of row crops, 1 year of small grain, and 1 year of meadow; or 3 years of row crops and 1 year of small grain in which is seeded a green-manure crop of alfalfa or sweetclover.

Good management is important on this soil. Alfalfa, sweetclover, and other deep-rooted legumes open channels in the clayey subsoil and help maintain adequate drainage. Crop residues help make the surface soil porous and enable it to dry out rapidly. Spring plowing is desirable, especially after a crop of soybeans, to avoid the risk of wind erosion during winter. If plowing must be done in fall, a rough surface with some crop residue on it reduces the risk of soil blowing. Heavy applications of manure on exposed spots also reduce the risk of blowing. Although this soil is nearly level, farming across the slope slows runoff and reduces the possibility of rilling. Grassed waterways also help control water that flows across this soil.

CAPABILITY UNIT IIs-3

The one soil in this unit is Hamerly loam, 0 to 3 percent slopes. It is a deep, dark-colored, moderately well drained, medium-textured, high-lime, nearly level and very gently undulating soil on the uplands. This soil has moderate permeability and high moisture-holding capacity. It contains excessive lime, which causes an imbalance in fertility. The loose, limy surface layer of this soil is subject to wind erosion.

Crops can be grown on this soil if the imbalance of fertility is corrected, and if wind erosion is controlled.

The imbalance of fertility can be corrected by applying a liberal amount of potash and an adequate amount of phosphate and by adding a large amount of organic matter, either in the form of barnyard manure or green-manure crops.

Wind erosion can be controlled if all crop residues are returned to the soil or if heavy applications of manure are made. This soil is generally too wet for spring plowing. If the plowed surface is left rough in fall and some crop residue is left on it, the risk of wind erosion is reduced. This soil is only moderately well drained, and it lies in small tracts on slight knolls in areas of poorly drained soils. Contouring to help control wind erosion is not advisable, because the wetness would thereby be increased. Drainage of the soil of this unit is not needed, but drainage of the adjoining soils makes this soil easier to manage.

Most of the areas of this soil are only a few acres in size. They are too small to be managed separately and are cropped with the adjoining soils. On the areas that are large enough to be managed separately, a satisfactory rotation consists of row crops for 3 years, small grain for 1 year, and meadow for 1 year.

A few areas of this unit are in permanent bluegrass pasture that can be improved by plowing and reseeding to more desirable pasture grasses.

CAPABILITY UNIT IIw-1

This unit consists of deep, dark-colored, poorly drained or somewhat poorly drained, moderately fine textured, nearly level to very gently sloping soils on uplands and in drainageways. They are members of the Flom and the Hidewood series. They have moderate permeability and very high moisture-holding capacity. The dark-colored surface layer is more than 12 inches thick, and in some drainageways it is several feet thick. These soils dry out and warm up in spring more slowly than the soils in class I, and wetness is the main hazard in using them.

Drainage of these soils is needed before they can be farmed intensively. Substantial increases in yields of all the common crops can be expected after the soils are drained. Tiling is needed to provide subsurface drainage, and open ditches are needed in most places as outlets for the tile systems. If the soils are not adequately drained, they sometimes must be worked when too wet, and severe compaction and clodding of the surface layer are then likely to take place. A tillage pan is likely to be formed below the plowed layer. Fall plowing of these soils is desirable to permit rapid preparation of a seedbed in spring.

Large open areas are subject to blowing if soil structure deteriorates because of intensive use for row crops and inadequate return of crop residues. Blowing of soil causes a further loss of organic matter.

If these soils are adequately drained and fertilized and all crop residues are returned, a suitable rotation consists of 4 years of row crops, 1 year of small grain, and 1 year of meadow. If the meadow crop is not needed, a green-manure crop should be planted with the small grain. A deep-rooted green-manure crop, such as alfalfa or sweetclover, helps maintain drainage through the subsoil. It is difficult to obtain a good stand of alfalfa, however, if the soil has not been adequately drained.

Some areas of these soils are in shallow drainageways that carry runoff water from the surrounding hillsides and uplands. Some of the drainageways need to be shaped and seeded to grasses to prevent formation of gullies. Tile drains, installed before a grassed waterway or terrace outlet is constructed, help to insure a good growth of grass.

CAPABILITY UNIT IIw-2

This unit consists of deep, dark-colored, poorly drained, limy, moderately fine textured, nearly level soils on lake plains and uplands. They are members of the Colvin and Vallers series. The Colvin soils are on the lake plain in the northeastern part of the county, and the Vallers soils are mostly on rims of depressions in the uplands. These soils have moderate permeability and high or very high moisture-holding capacity. They dry out and warm up more slowly in spring than the adjoining better drained soils. They are likely to be wet for short periods after heavy rains during the growing season. Wetness is the main hazard when they are farmed.

Some areas of these soils are subject to an imbalance of fertility because of their high content of lime. If an imbalance occurs, it can be corrected by applying liberal amounts of potassium and phosphorus in fertilizers and by supplying a large amount of organic matter. The organic matter can be added in the form of barnyard manure or grown as green-manure crops.

Tile drainage improves workability of the soils and yields of crops. The ground water in many places contains enough magnesium sulfate to cause disintegration of ordinary cement tile. Clay tile or alkali-resistant tile should be used. Outlets for tile are difficult to find in the areas of Colvin soil. This soil is flooded whenever there is a large amount of runoff from the adjoining uplands The areas can be protected by establishing waterways, diversion ditches, or dikes.

If these soils are adequately drained and are managed and fertilized well, they are suited to corn, small grains, and alfalfa. Under good management a rotation consisting of 4 years of row crops, 1 year of small grain, and 1 year of meadow is suitable. If the meadow crop is not needed, a green-manure crop can be planted in the small grain. Corn can be grown without following a specific rotation if the soil tilth is good, drainage is adequate, residues are returned, and fertility is maintained. An occasional crop of sod, or a deep-rooted legume such as alfalfa or sweetclover grown for green manure, helps to maintain fertility and to keep the subsoil permeable enough to insure good drainage.

Fall plowing of these soils is desirable to permit preparation of a seedbed at the right time in spring. Large open areas, however, are subject to wind erosion. Wind erosion can be controlled if the plowed surface is left rough and manure is applied in fall on the erodible spots.

CAPABILITY UNIT IIw-3

This unit consists of one soil, Fulda silty clay loam. It is a deep, dark-colored, poorly drained, nearly level soil on uplands. It has a fine-textured subsoil. This soil has moderately slow permeability and very high moisture-holding capacity. Wetness is the main hazard when it is farmed. The combination of wetness and clayey soil makes careful management necessary to maintain good soil tilth.

Tile drainage is needed to improve the workability of this soil and to obtain the best yields. After drainage and with good management, the soil produces excellent yields of corn, soybeans, small grains, and alfalfa. A rotation of row crops for 4 years, small grain for 1 year, and meadow for 1 year is suitable under a high level of management. If the meadow crop is not needed, a green-manure crop can be seeded in the small grain. An occasional crop of legumes and grasses or a green-manure crop helps to maintain good tilth, and the deep roots of alfalfa or sweetclover help to keep the subsoil permeable enough to provide good drainage.

This soil is somewhat slow to dry and becomes warm in spring. Fall plowing is advisable because plowing when the soil is too wet is likely to form hard clods that are difficult to break up. The plowed surface should be rough and some crop residue should remain on it during winter to prevent wind erosion. Liberal amounts of barnyard manure, green manure, and crop residues improve workability of the surface layer.

CAPABILITY UNIT IIw-4

This unit consists of one soil, LaPrairie loam. It is a deep, dark-colored, moderately well drained, medium-textured, nearly level soil on bottom lands that are subject to occasional overflow. This soil usually is flooded in spring by melt water from snow. It is also flooded sometimes after heavy rains during the growing season, and then crops are likely to be damaged. This soil has moderate permeability and very high moisture-holding capacity. There is little or no hazard of erosion, wetness, or drought.

This soil, when properly managed, is excellent for corn. If a high level of fertility is maintained, corn can be grown year after year. An occasional crop of legumes and grasses helps keep the surface layer loose and porous and the subsurface layers permeable. Many areas are in permanent pasture, and they furnish excellent grazing with a minimum of management.

Grassed waterways are needed in some places to confine runoff that flows from adjoining uplands across this soil. Stabilization of the streambank is needed in some places where a river or creek makes a sharp turn in an area of this soil.

CAPABILITY UNIT IIw-5

This unit consists of one soil, Lamoure silty clay loam. It is a deep, dark-colored, poorly drained, moderately fine textured, nearly level soil on bottom lands. It is flooded occasionally, especially by melt water during spring runoff. It is also flooded sometimes after heavy rains during the growing season, and then crops are damaged. This soil is alkaline. It has moderate permeability and very high moisture-holding capacity. Wetness is the major hazard when it is used.

Row crops can be grown several years in succession if a high level of management that includes minimum tillage is practiced. An occasional crop of a deep-rooted legume helps improve drainage through the soil. Return of crop residues helps keep the surface soil loose and porous. Many areas of this soil are in productive permanent pasture.

Tile drainage is difficult on most areas of this soil. Outlets with sufficient grade to carry the water are hard to establish on the bottom land. In many places where tiling is not practical, shallow, random surface ditches are used to remove surface water. Dikes to protect the soil from floods are practical in some places.

If this soil is worked when too wet, clods form that are difficult to break up.

In some places this soil contains enough lime to have a detrimental effect on growth of corn and to reduce yields. The detrimental effect can be controlled by applying a liberal amount of potassium and an adequate amount of phosphorus, and by supplying a large amount of organic matter in the form of barnyard manure or green-manure crops.

CAPABILITY UNIT IIw-6

The one soil in this unit is Divide silt loam. It is moderately deep and deep, dark colored, limy, nearly level, and somewhat poorly and poorly drained. This soil developed in 24 to 48 inches of medium-textured or moderately fine textured material that was deposited by water or wind and is underlain by limy sand and gravel. It is on river terraces and in glacial valleys in the southwestern part of the county. Permeability and moisture-holding capacity are moderate. Wetness is the main hazard in using this soil, but the surface layer has a high content of lime that sometimes causes a special problem of fertility.

When this soil is adequately drained and fertilized, and all crop residues are returned, a rotation consisting of 4 years of row crops, 1 year of small grain, and 1 year of meadow is suitable. If the hay cannot be utilized, a green-manure crop can be planted in the small grain.

Increased yields can be expected after adequate tile drainage. It is desirable to place tile, if possible, partly in the gravelly underlying material. Open ditches are needed in some places to provide outlets for the tile systems. Drop-inlet structures are needed if a waterway or a terrace outlet empties into a roadside ditch or a drainage ditch. Grassed waterways are needed wherever water flows across this soil.

Fall plowing makes it possible to prepare a good seedbed quickly in spring. Hard clods are likely to be formed if this soil is plowed or worked when wet.

Applications of fertilizer and organic matter generally improve yields in the places where excess lime causes an imbalance of fertility. A liberal amount of potassium and an adequate amount of phosphorus are needed. The organic matter can be supplied by applying barnyard manure or by growing green-manure crops. This soil tends to be wet and somewhat cold in spring, and a starter fertilizer that includes nitrogen helps crops make rapid early growth.

CAPABILITY UNIT IIIe-1

This capability unit consists of deep, dark-colored, well-drained, mainly medium-textured, sloping or rolling soils on uplands. They are members of the Barnes, Buse, Crofton, and Vienna series. These soils have moderately rapid permeability and moderate or high moisture-holding capacity. The erosion hazard is severe when they are cultivated. Runoff is rapid, and the soils are more droughty than similar but less sloping soils.

With proper management that includes control of erosion, the soils are suited to corn, small grains, and meadow. In areas of this unit that have slopes in the lower part of the range from 6 to 12 percent, terracing and a rotation that consists of a row crop for 2 years, small grain for 1 year, and meadow for 1 year provide for control of runoff and erosion. In areas that have slopes in the upper part of the range from 6 to 12 percent, stripcropping is generally more suitable than terracing for control of erosion. In some places diversion terraces are built to reduce the effective length of slope and contour farming is practiced.

In some areas of these soils, slopes are too irregular for terracing and contouring. On them, under a high level of management, a rotation in which a meadow crop is grown half the time provides for control of runoff and erosion. Spring plowing, heavy applications of manure, return of all crop residues, and disking instead of plowing for the small grain that follows corn are included in the high level of management for these soils. Heavy applications of manure are especially needed on severely eroded spots to increase yields and to reduce runoff and erosion.

Grassed waterways are needed for terrace outlets and in other places where water collects. Gullies can be shaped and seeded to provide grassed waterways. Some of the gullies require engineering structures to stabilize them enough to permit grass to grow.

About 10 percent of the acreage of soils in this capability unit is used for permanent pasture. Grazing management, especially rotation grazing, fertilization, and prevention of overgrazing are practices that improve growth of forage.

CAPABILITY UNIT IIIe-2

Most of the soils in this capability unit are shallow, dark colored, somewhat excessively drained, and moderately coarse textured. They are undulating and gently sloping soils on uplands and river terraces. They are members of the Arvilla, Barnes, Buse, Dickey, and Sverdrup series. The Barnes and Buse soils are deep, and in this capability unit they are in complexes with Arvilla soils. The soils of this capability unit have moderately rapid permeability, and most of them have low moisture-holding capacity. The hazard of drought is moderately severe, and the hazard of erosion is moderate.

These soils are normally too droughty for corn, except in years when the rainfall is both adequate and timely. If these soils are farmed on the contour and the rotation includes a sod crop, row crops can be grown 2 years out of 4. Contour farming and rotation of crops control erosion and help to conserve moisture.

On the soils that have slopes too irregular for contouring, a 4-year rotation that includes 2 years of row crops, 1 year of small grain, and 1 year of sod is suitable if the crops are plow planted and all crop residues are returned. If these good management practices are not followed, a rotation that includes only 1 year of a row crop and more sod provides for control of erosion.

A meadow crop grown for more than 1 year in a rotation on these soils tends to use up moisture and leave a supply that is not enough for the next crop of corn or small grain. If these soils are used for long-term hay or pasture, the sod should be left as long as a good stand remains.

Spring plowing is desirable to control erosion, particularly wind erosion. Stubble on the surface during winter traps and holds snow and so conserves moisture. Plow planting is a good practice whenever it is feasible. Control of wind erosion is helped by disking rather than plowing whenever small grain is planted after corn. A shelterbelt of a single row of trees helps to control erosion and conserve moisture. Wind stripcropping, in which close-growing crops and intertilled crops are grown in alternate narrow bands, is also used to control erosion and save moisture.

Fertilizer is used most efficiently on these sandy soils if each crop, rather than the rotation, is fertilized. Organic matter in the soils is used up rapidly. A good supply can be maintained by making heavy applications of manure, returning all crop residues, and including grasses and legumes in the crop rotation.

CAPABILITY UNIT IIIs-1

This unit consists of shallow, dark-colored, somewhat excessively drained, moderately coarse textured, nearly level soils on uplands and river terraces. They consist of an Arvilla soil and of a silty variant of the Dickey series. These soils are underlain by sand or gravel at a depth of 12 to 24 inches. They have moderately rapid permeability and low or moderate moisture-holding capacity. The hazard of drought on them is moderate. There is also a hazard of wind erosion if the soils are not managed properly.

These soils can be used for row crops 2 years out of 4 if they are fertilized adequately and all crop residues are returned. A suitable rotation consists of row crops for 2 years, small grain for 1 year, and meadow for 1 year. Corn grows well, however, only in years when rainfall is both adequate and timely. In some systems of farming, it is desirable to use these soils primarily for hay or pasture. When that is done, small grain can be grown for 1 year and meadow for 2 or more years. Corn is likely to be unprofitable because of drought, and small grain can be grown for several years in succession.

Spring plowing reduces the risk of wind erosion. Stubble and stalks on the surface during winter help to trap snow and thus conserve moisture. Plow planting of row crops is an excellent practice. Disking of cornstalks, rather than plowing, is desirable when the next crop is to be small grain. A single-row shelterbelt reduces the risk of wind erosion and the loss of moisture by evaporation and transpiration. Wind stripcropping, in which close-growing crops and intertilled crops are grown in narrow bands, also reduces the losses of soil and of moisture.

Fertilizer is used most efficiently if each crop, rather than the rotation, is fertilized. Heavy applications of barnyard manure and rotations that include legumes and grasses are needed to replenish organic matter and to help prevent wind erosion.

If these soils are irrigated, they are excellent for corn where adequate amounts of fertilizer and organic matter are applied.

CAPABILITY UNIT IIIw-1

This unit consists of deep, dark-colored, very poorly drained, moderately fine textured, nearly level soils and shallow organic soils in closed depressions and in wet drainageways of the uplands. They are Parnell silty clay loam and Muck. These soils have moderately slow permeability and very high moisture-holding capacity. Wetness is the major hazard when they are used. Practices to reduce compaction and maintain good tilth are needed on the Parnell soil. Crops on both soils are subject to frost. If corn is grown, a variety that matures early is desirable to reduce the risk of damage.

Drainage is needed before these soils can be cropped. Many areas have been drained only by open ditches, and they produce good corn in years when the rainfall is below normal. Tile drainage is needed to obtain a good crop of corn every year.

Open ditches are used to drain away surface water and, in some places, to provide outlets for tile drains. Grassed waterways are needed to control the flow of water from some closed depressions where the grade is steep and uncontrolled flow in open ditches might cause gullying. Drop inlets are needed where water from a shallow grassed waterway flows into an open ditch. Diversion terraces or field terraces are built on some of the surrounding slopes to divert runoff and to permit these soils to be cropped successfully.

These soils are usually too wet in spring to be plowed. If fall-plowed fields are left rough and some residue is left on the surface, wind erosion can be controlled. If the Parnell soil is worked when too wet, hard clods form that are difficult to break.

If these soils are drained and fertilized adequately and all crop residues are returned, row crops can be grown for several years in succession if the soils are adequately drained by tile, if they are kept in good tilth, if a high level of fertility is maintained, and if other good practices are followed. An occasional sod crop or green-manure crop helps to maintain good tilth in the surface soil and good permeability in the subsurface layers.

Although these soils have high natural fertility, fertilizer should be applied according to soil tests and the needs of the crop. Since the soils tend to remain wet and cold in spring, a starter fertilizer that contains nitrogen is needed to obtain rapid early growth. Fertilizer applied to a field that is not adequately drained cannot be fully utilized.

Many partly drained areas of these soils are used for pasture or meadow. Undrained areas provide excellent habitats for waterfowl and other wildlife.

CAPABILITY UNIT IIIw-2

This unit consists of deep, dark-colored, very poorly drained, medium and moderately fine textured, limy soils that are in old lake basins in the uplands. They are members of the Blue Earth and Oldham series. These soils have moderately slow permeability and very high moisture-holding capacity. Wetness is the major hazard when they are used for farming. Excess lime in the surface layer causes problems in maintaining soil fertility. Wind erosion occurs in some places. Crops on these soils are subject to frost, so a variety of corn that matures early is desirable.

Drainage is needed before these soils can be cropped. Many areas that have only surface drainage are being cropped, and results are fair to good in seasons when the rainfall is low. The soils are suited to all the common crops when they have been drained adequately.

Shallow ditches are commonly used to remove surface water. Open ditches provide underdrainage in some places, and some of them serve as outlets for tile drains. Tile should be made of clay or should be alkali resistant, because the soils in some places contain enough magnesium sulfate to cause disintegration of ordinary cement tile. Drop inlets are needed in some places where tile lines empty into drainage ditches.

These soils are likely to be too wet in spring to be plowed. Fall plowing aids in the preparation of a good seedbed. Since large open areas are subject to wind erosion, the plowed surface should be rough, and some crop residue should be left on it.

If these soils are drained and fertilized adequately and all crop residues are returned, row crops can be grown for several years in succession if the soils are adequately drained, if they are kept in good tilth, if a high level of fertility is maintained, and if other good practices are followed. An occasional crop of sod or of green manure helps to maintain good tilth in the surface soil and good permeability in the subsurface layers. A deep-rooted legume, such as sweetclover, leaves channels that improve drainage through the soil.

Excessive lime in some places causes poor nutrition of crops, especially corn. The harmful effects can be minimized by applying a liberal amount of potassium and an ample amount of phosphorus. Heavy applications of manure are advisable on spots that contain enough lime to make them light colored. These spots are subject to blowing if they are left untreated.

These soils tend to be wet and cold in spring, and a starter fertilizer that contains nitrogen enables crops to make rapid early growth.

In some of the low, wet depressions, good drainage of these soils is not feasible. Wet areas are suitable for permanent pasture or for conversion to marsh that makes a good habitat for waterfowl.

CAPABILITY UNIT IVe-1

This capability unit consists of deep, well drained and excessively drained, medium-textured, moderately steep soils on uplands. They are members of the Buse and the Barnes series. These soils have moderately rapid permeability and moderate or high moisture-holding capacity. The hazard of erosion is very severe, and the hazard of drought is severe, because of rapid runoff on the moderately steep slopes.

These soils, when properly managed, are fairly well suited to small grains and alfalfa. Corn is generally not profitable. Eroded spots can be made more productive with heavy applications of manure.

These soils are too steep for terracing. Contour stripcropping is a practice that is suitable for control of erosion. If stripcropping is practiced, a suitable 4-year rotation consists of 2 years of small grain and 2 years of meadow. Spring plowing helps reduce the hazard of erosion. Diversion terraces, in addition to contour stripcropping, are needed on some of the long slopes. Waterways need to be maintained, and in some places new ones are needed. Gullies should be shaped and seeded to make grassed waterways.

If stripcropping is not practiced, erosion can be controlled by growing hay or pasture crops. A nurse crop of small grain can be grown at intervals to reestablish the stand of hay or pasture.

A considerable acreage of this capability unit is in permanent pasture. Native grasses can be maintained by careful management of grazing. Pastures that are mostly Kentucky bluegrass can be made more productive by renovating and reseeding to a suitable legume-grass mixture.

CAPABILITY UNIT IVe-2

This unit consists of shallow, somewhat excessively drained, moderately coarse textured soils and deep, well-drained, medium-textured soils in which there are numerous sand and gravel pockets. They are rolling soils on uplands and are members of the Arvilla, Sverdrup, Barnes, and Buse series. The soils of this capability unit are slightly or moderately eroded. The hazards of erosion and drought are severe.

These soils are too droughty for many crops. Small grains, hay, and pasture are grown. Yields of corn are poor because a short drought damages the crop almost every year. If corn is grown, the variety should be one that matures early.

Hay and pasture are more suitable crops on these soils than corn and small grains. A small grain, such as oats or flax, is grown as a nurse crop whenever it is necessary to renew the stand of legumes or grasses.

Terraces generally are not built, because these soils are too shallow over sand and gravel. Waterways need to be maintained, and some of them need to be reestablished. Wherever sand and gravel have been exposed by erosion in waterways, a layer of soil should be replaced to help the growth of grass. Gullies should be shaped and seeded to form grassed waterways. In some gullies engineering structures are needed to stabilize them enough to permit grass to grow.

Much of the acreage of these soils is in permanent pasture. The best production of forage is obtained if pastures are grazed lightly in a system of rotation grazing.

CAPABILITY UNIT IVw-1

This unit consists of Lake beaches. The soil materials have variable texture and drainage. Most of the areas have a sandy surface layer that is underlain by material of finer texture. Many areas have a large number of stones and boulders.

Most areas of this land type are too sandy or droughty to make good cropland. Where adjoining soil areas have been drained, the Lake beaches generally are farmed with the drained soils, as they lie in bands too narrow to be farmed separately. In some places where the sandy surface layer is thin, deep plowing mixes finer textured soil material with the surface layer and improves its moisture-holding capacity.

Many areas of this land type are used for pasture. Beaches around the lakes and the undrained ponds are used for recreation and for wildlife habitats. Some of the beaches could be further developed for these uses.

CAPABILITY UNIT VIe-1

This unit consists of Buse loam, 18 to 25 percent slopes. It is a deep, excessively drained, medium-textured, steep soil on uplands. This soil has moderately rapid permeability and moderate moisture-holding capacity. It has a thin surface layer that has low fertility. Stones and boulders are common on the surface. The hazard of erosion is very severe. This soil is droughty because it has steep slopes, and runoff is very rapid.

This soil is suitable for pasture or for wildlife habitats. Almost all the acreage is in permanent pasture or range. A few small areas are used for cultivated crops because they are in fields of less sloping soils. Hay and pasture are the main crops. Oats are grown only to help reestablish permanent hay or pasture. Pastures of native grass can be maintained, protected, and improved by careful management.

Gullies should be shaped and seeded to form grassed waterways. Diversion terraces can be built on some slopes above these soils to prevent or retard formation of gullies. Some gullies need to be stabilized by engineering structures to permit grass to grow.

CAPABILITY UNIT VIe-2

This unit consists of shallow, somewhat excessively drained, moderately coarse textured soils and deep, well-drained, medium-textured soils that have in them numerous pockets of sand and gravel. The soils are members of the Arvilla and Buse series. These soils are moderately steep, are on uplands, and are slightly to moderately eroded. They have moderately rapid permeability and low moisture-holding capacity. The hazard of drought is very severe because of the low moisture-holding capacity and rapid runoff. The hazard of erosion is very severe, and fertility is low.

These soils are suitable for pasture and for wildlife habitats. They are used mainly for hay and pasture. Oats are grown as a nurse crop to reestablish permanent hay or pasture. When these areas are developed for wildlife, a combination of adapted shrubs, grasses, and legumes can be planted. Pastures of native grasses can be protected, improved, and maintained by careful management of the grazing.

CAPABILITY UNIT VIw-1

This capability unit consists of Lamoure and LaPrairie soils, frequently flooded. These soils are on bottom lands and in the larger upland drainageways and are frequently flooded. They are deep and dark colored. Most areas are silty and poorly drained, but some have variable textures and drainage. Most areas are cut by stream meanders. The hazard of flooding is severe. Some small, sandy areas are present, and they are somewhat droughty.

These soils are suitable for pasture or for wildlife. Most areas are not suitable for use as cropland, because they are flooded too often or they are cut too much by the streams or by old meanders. If the stream channels were improved in a major project, many areas would be made suitable for crops. The improved areas then would be suited to the crops and practices that are given for capability units IIw-4 and IIw-5. Some areas of these soils are wooded, but, generally, the species are unsuitable and the stand is too poor to make good woodland.

These soils produce excellent yields of wild hay and pasture. Weeds should be clipped and controlled in areas that are open and accessible. Some areas of Kentucky bluegrass are suitable for renovation and reseeding to more desirable grasses and legumes. If these soils are not used for pasture, they are desirable for wildlife. They can be further improved to furnish shelter for wildlife by planting a combination of conifers, shrubs, and grasses that tolerate wet soil and flooding.

Stabilization of streambanks is needed in some places where a creek or river makes a sharp turn and is cutting into an area of cropland or pasture.

CAPABILITY UNIT VIw-2

This unit consists of one soil, Rauville silty clay loam. It is a deep, dark-colored, very poorly drained, moderately fine textured, limy, nearly level, frequently flooded soil on bottom land. The hazards of wetness and of flooding are severe.

This soil is too low and wet to be drained and used as cropland. Some areas are used for pasture, and some provide food, water, and shelter for wildlife.

It is difficult to manage or improve the areas of this soil. If drainage can be accomplished, suggestions for use and management are the same as those given for the soils in capability unit IIIw-2.

CAPABILITY UNIT VIIe-1

This unit consists of deep, excessively drained, medium-textured, steep and very steep soils on uplands. They are members of the Arvilla and Buse series. Sand and gravel pockets are present in areas of the Buse-Arvilla complex. The hazard of erosion is very severe. Runoff is rapid, the soils are droughty, and soil fertility is low. Little soil development has occurred.

These areas are used for permanent pasture or for wildlife. They are too steep and droughty to be used as cropland. Yields of forage can be increased if a system of rotation grazing is followed and heavy overgrazing is not permitted. Renovation of pastures is not practical on these steep slopes.

Some of the north-facing slopes are wooded. Generally, the stand is too poor to furnish much timber. Areas that are not used for pasture can be improved for wildlife shelter by planting suitable conifers, shrubs, grasses, and legumes.

Gullies should be shaped and seeded. Some should have engineering structures (fig. 11) to stabilize them enough to permit grass to grow.

Figure 11.—**This gully in a steep Buse loam illustrates the severe hazard of erosion on soils in capability unit VIIe–1.**

CAPABILITY UNIT VIIs–1

This unit consists of gravelly and stony, undulating to very steep soils on uplands. They are members of the Buse and Sioux series. The hazard of erosion is very severe on the very steep soils. All the soils have low fertility. The Sioux soil is extremely droughty, and the Buse soil is extremely stony.

These soils are used for permanent pasture or to furnish shelter for wildlife. Most of the forage is produced in spring. The soils are too droughty, too stony, or too steep to permit renovation of pastures. The best yields of forage are obtained by rotation of grazing and prevention of overgrazing. If these soils are not used for pasture, they can be improved for wildlife shelter by planting suitable conifers, shrubs, grasses, and legumes.

A few areas of the Sioux soil are used for crops because they are in cropped fields and are too small to be used or treated separately.

Gullies should be shaped and seeded to form grassed waterways. Some need engineering structures that would stabilize them enough to permit grass to grow.

CAPABILITY UNIT VIIIw–1

This capability unit consists of Marsh. Drainage of the areas is not feasible, or the feasibility of drainage has not been determined.

Areas of Marsh produce some grazing or wild hay in dry years, but in most years they are covered with 1 foot to 3 feet of water. Cattails and other water-loving plants grow profusely along edges of the marshes and in scattered clusters in the open water.

Marsh provides excellent habitats for waterfowl and muskrats. Upland game birds find food, cover, and nesting places in and around the marshes.

Some of the areas can be drained. Suggestions for their use and management after drainage are similar to those given for capability unit IIIw–1 or IIIw–2, depending on the nature of the underlying soil.

Yield predictions

Table 2 gives predicted average yields per acre of the principal crops grown on the soils in the county. Yields are not given for Gravel pit (Gp). Yields are given for two levels of management. Those in columns A are obtained under an average level, and those in columns B are obtained under a high level of management.

The average level consists of the management followed by most farmers in the county. In this level, oats, flax, hay, and pasture crops are seldom fertilized. Starter fertilizer or manure is used for corn. Crops in the rotation are mainly corn and small grains, and the acreage of legume-grass hay on the farm is too small to permit effective rotation of crops. A green-manure crop is sometimes seeded with the small grain. Erosion control practices are not used extensively. Surface drainage is generally provided on wet soils, but not much tile drainage is installed. The stands of corn range from 10,000 to 15,000 plants per acre and are not usually adjusted to the type of soil or the amount of soil moisture. The seedbed is prepared and cultivated in the usual manner. Rotation grazing is not practiced.

The high level of management, which produces yields given in columns B, is followed by a few farmers. In the high level, fertilizer is applied according to soil tests. Manure is usually available and is used. An optimum stand of corn is planted; the number of plants in the stand is adjusted to the type of soil and the supply of moisture so that for every 5 bushels of the expected yield, 700 to 900 actual plants per acre are grown. The rotation includes a legume-grass mixture or green-manure crops. Erosion control practices are used where they are needed. The wet soils are drained by means of adequate surface drainage and some tile, but not necessarily by a complete drainage system. Other practices are the return of large amounts of crop residues to the soil and a minimum amount of tillage. It is necessary to control weeds, diseases, and insects. Pastures are seeded to a suitable mixture of grasses and legumes, and grazing is rotated or regulated. The immediate response of crops to these practices depends on past management of the soil.

The predictions of yields were based on information received from several sources. Yields were measured on experimental plots on some soils in the county. Records of yields and of soil management practices were reported by farmers for crops on some of the soils. Information was obtained from a study of the productivity of specific soils conducted jointly by the Soil Conservation Service, the Agricultural Extension Service, and the Department of Soils, University of Minnesota. Observations of crops were made and farmers were interviewed during the course of the soil survey. The predictions were judged in relation to soil properties that are known to affect growth of crops. The predictions were compared with those made for similar soils in other counties and were checked against average yields that are reported in data from the agricultural census.

The yields given in table 2 are those obtainable using present farming practices and varieties of crops. As agricultural technology advances, increased yields per acre might be obtained. It is also possible that plant diseases and pests might cause average yields to be less than those predicted here.

TABLE 2.—*Predicted average yields per acre of principal crops under two levels of management*

[In columns A are average yields obtained under the management commonly used; in columns B are average yields obtained under improved management. Absence of a yield figure indicates crop is not suitable for the soil or ordinarily is not grown on it]

Mapping unit	Corn		Oats		Flax		Rotation hay [1]		Rotation pasture		Permanent pasture	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Animal-unit-days* [2]	*Animal-unit-days* [2]	*Animal-unit-days* [2]	*Animal-unit-days* [2]
Aastad clay loam, 0 to 2 percent slopes	55	70	50	70	16	22	2.5	3.2	125	183	60	85
Arvilla sandy loam, 0 to 2 percent slopes	25	35	25	35	9	14	1.3	2.0	65	115	30	50
Arvilla sandy loam, 2 to 6 percent slopes	20	30	20	30	8	13	1.1	1.8	55	103	25	40
Arvilla sandy loam, 6 to 12 percent slopes, eroded	10	20	15	25	6	10	.8	1.4	40	80	20	30
Arvilla sandy loam, 12 to 18 percent slopes, eroded	----	----	10	20	5	8	.5	1.0	25	57	15	20
Barnes loam, 0 to 2 percent slopes	45	65	45	70	15	21	2.4	3.2	120	183	55	85
Barnes loam, 2 to 6 percent slopes	40	65	40	65	13	19	2.2	3.0	110	171	55	85
Barnes loam, 2 to 6 percent slopes, eroded	35	60	35	65	11	18	2.0	3.0	100	171	----	----
Barnes and Buse loams, 2 to 6 percent slopes, eroded	35	55	30	60	10	17	2.0	2.8	100	160	----	----
Barnes and Buse loams, 6 to 12 percent slopes	30	55	30	60	12	17	1.8	2.7	90	154	40	70
Barnes and Buse loams, 6 to 12 percent slopes, eroded	25	50	25	60	10	16	1.5	2.7	75	154	----	----
Barnes-Buse-Arvilla complex, 2 to 6 percent slopes	20	35	20	30	9	14	1.4	2.0	70	115	35	50
Barnes-Buse-Arvilla complex, 2 to 6 percent slopes, eroded	15	30	20	30	8	13	1.4	2.0	70	115	----	----
Barnes-Buse-Arvilla complex, 6 to 12 percent slopes, eroded	10	25	15	25	6	10	1.2	1.8	60	103	25	35
Beotia silt loam, 0 to 2 percent slopes	40	55	45	70	14	20	2.4	2.8	120	160	55	75
Beotia silt loam, 2 to 4 percent slopes	35	50	35	60	11	17	2.0	2.6	100	149	40	70
Blue Earth silt loam:												
Inadequately drained	35	50	25	30	8	12	----	----	----	----	[3] 150	[3] 250
Adequately drained	50	70	40	60	12	18	2.5	3.5	125	200	----	----
Brookings silty clay loam, 0 to 2 percent slopes	50	65	50	70	16	22	2.4	3.2	120	183	55	80
Brookings silty clay loam, 2 to 4 percent slopes	45	60	45	65	14	20	2.2	3.2	110	183	50	80
Buse loam, 18 to 25 percent slopes	----	----	----	----	----	----	.8	1.5	40	86	25	50
Buse loam, 25 to 40 percent slopes	----	----	----	----	----	----	----	----	----	----	15	30
Buse stony loam, 5 to 40 percent slopes	----	----	----	----	----	----	----	----	----	----	20	30
Buse-Arvilla complex, 12 to 18 percent slopes, eroded	----	----	10	20	4	7	1.0	1.5	50	86	20	25
Buse-Arvilla complex, 18 to 40 percent slopes	----	----	----	----	----	----	----	----	----	----	15	20
Buse-Barnes loams, 12 to 18 percent slopes	----	----	20	35	7	12	1.5	2.2	75	125	35	55
Buse-Barnes loams, 12 to 18 percent slopes, eroded	----	----	15	35	5	10	1.3	2.0	65	115	----	----
Colvin silty clay loam:												
Inadequately drained	35	50	35	45	10	15	1.5	2.5	75	143	50	65
Adequately drained	50	70	45	65	14	21	2.5	3.5	125	200	----	----
Crofton silty clay loam, 4 to 12 percent slopes	35	50	30	60	10	17	1.8	2.8	90	160	----	----
Dickey sandy loam, silty variant, 0 to 2 percent slopes	30	40	25	35	10	15	1.4	2.2	70	125	35	65
Dickey sandy loam, silty variant, 2 to 6 percent slopes	25	35	15	30	8	13	1.4	2.0	70	115	----	----
Divide silt loam:												
Inadequately drained	35	60	40	60	13	18	1.7	2.4	85	137	55	65
Adequately drained	40	65	45	65	15	20	2.3	3.5	115	200	----	----
Estelline silt loam, 0 to 2 percent slopes	35	50	40	65	12	18	2.2	2.8	110	160	55	75
Flandreau loam, 0 to 2 percent slopes	35	50	35	65	13	18	2.2	2.8	110	160	55	75
Flandreau loam, 2 to 6 percent slopes	30	45	30	60	10	16	1.8	2.4	140	137	35	65
Flom clay loam:												
Inadequately drained	45	60	50	55	15	18	1.5	2.5	75	143	50	65
Adequately drained	60	75	55	70	17	22	2.5	3.5	125	200	----	----
Fordville loam, 0 to 2 percent slopes	35	50	40	65	12	18	2.2	2.8	110	160	50	70
Fordville loam, 2 to 6 percent slopes	30	45	35	60	10	16	1.8	2.4	90	137	35	65
Fordville loam, 2 to 6 percent slopes, eroded	25	40	30	55	9	15	1.6	2.4	80	137	----	----
Forman clay loam, 0 to 2 percent slopes	45	65	45	70	15	21	2.4	3.2	120	183	55	85
Forman and Barnes soils, 2 to 6 percent slopes	40	65	40	65	13	19	2.2	3.0	110	171	55	80
Forman and Barnes soils, 2 to 6 percent slopes, eroded	35	60	35	65	11	18	2.0	3.0	100	171	----	----
Fulda silty clay loam:												
Inadequately drained	40	55	40	50	15	18	2.0	2.8	100	160	50	65
Adequately drained	60	75	50	70	17	22	2.8	3.5	140	200	----	----
Hamerly loam, 0 to 3 percent slopes	35	60	35	65	13	19	2.0	3.0	100	171	45	75
Hidewood silty clay loam:												
Inadequately drained	45	55	50	55	15	19	2.3	3.0	115	171	50	65
Adequately drained	55	65	60	70	17	22	2.8	3.5	140	200	----	----
Kranzburg silt loam, 0 to 2 percent slopes	45	60	45	70	15	21	2.2	3.2	110	183	50	80
Kranzburg silt loam, 2 to 6 percent slopes	40	60	40	65	13	19	2.0	2.8	100	160	45	70
Kranzburg silt loam, 2 to 6 percent slopes, eroded	35	55	35	65	11	18	2.0	2.8	100	160	----	----
Lake beaches	15	20	15	25	8	12	1.0	2.0	50	115	40	55
Lamoure silty clay loam	55	65	50	60	16	19	2.5	3.5	125	200	70	95
Lamoure and LaPrairie soils, frequently flooded	----	----	----	----	----	----	----	----	----	----	70	90

See footnotes at end of table.

TABLE 2.—*Predicted average yields per acre of principal crops under two levels of management*—Continued

Mapping unit	Corn		Oats		Flax		Rotation hay [1]		Rotation pasture		Permanent pasture	
	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Animal-unit-days* [2]	*Animal-unit-days* [2]	*Animal-unit-days* [2]	*Animal-unit-days* [2]
LaPrairie loam	60	75	55	65	16	21	2.5	3.5	125	200	80	100
Lismore silty clay loam, 0 to 3 percent slopes	50	65	50	70	15	21	2.5	3.2	125	183	55	80
Marsh	----	----	----	----	----	----	----	----	----	----	----	----
Muck:												
Inadequately drained	40	45	30	35	10	15	----	----	----	----	[3] 150	[3] 250
Adequately drained	50	70	50	60	15	20	2.5	3.5	125	200	----	----
Oak Lake silty clay loam, 0 to 2 percent slopes	60	75	55	75	17	23	2.5	3.2	125	183	60	85
Oak Lake silty clay loam, 2 to 4 percent slopes	50	70	40	70	15	21	2.5	3.2	125	183	60	85
Oldham silty clay loam:												
Inadequately drained	35	45	25	30	8	12	----	----	----	----	[3] 150	[3] 250
Adequately drained	50	75	40	55	12	18	2.5	3.5	125	200	----	----
Parnell silty clay loam:												
Inadequately drained	40	45	30	35	10	15	----	----	----	----	[3] 150	[3] 250
Adequately drained	65	75	60	65	15	20	2.5	3.5	125	200	----	----
Poinsett silty clay loam, 2 to 6 percent slopes	45	65	40	65	13	19	2.2	3.0	110	171	45	80
Poinsett silty clay loam, 2 to 6 percent slopes, eroded	40	60	30	65	11	18	2.0	3.0	100	171	----	----
Rauville silty clay loam	----	----	----	----	----	----	----	----	----	----	40	50
Sinai silty clay loam, 0 to 2 percent slopes	50	75	50	70	17	23	2.5	3.2	125	183	60	85
Sinai silty clay loam, 2 to 4 percent slopes	45	70	45	65	16	22	2.5	3.2	125	183	60	85
Singsaas silty clay loam, 2 to 6 percent slopes	45	65	40	65	14	20	2.4	3.2	120	183	55	80
Singsaas silty clay loam, 2 to 6 percent slopes, eroded	40	65	35	65	12	19	2.0	3.0	100	171	----	----
Sioux gravelly sandy loam, 5 to 40 percent slopes	----	----	----	----	----	----	----	----	----	----	10	15
Svea clay loam, 0 to 2 percent slopes	55	70	50	70	16	22	2.5	3.2	125	183	60	85
Svea clay loam, 2 to 4 percent slopes	50	65	45	65	14	20	2.5	3.2	125	183	60	85
Sverdrup sandy loam, 2 to 6 percent slopes	20	30	20	30	8	13	1.3	2.0	65	115	25	40
Sverdrup sandy loam, 6 to 12 percent slopes	15	25	15	25	6	10	1.1	1.8	55	103	----	----
Terril silt loam, 2 to 6 percent slopes	50	65	40	70	15	19	2.5	3.2	125	183	60	85
Vallers silty clay loam:												
Inadequately drained	35	55	40	50	12	17	1.5	2.5	75	143	50	65
Adequately drained	50	70	45	65	14	21	2.5	3.5	125	200	----	----
Vienna silt loam, 2 to 6 percent slopes	40	60	40	65	12	18	2.2	3.0	110	171	55	70
Vienna silt loam, 2 to 6 percent slopes, eroded	35	55	35	65	11	17	2.0	3.0	100	171	----	----
Vienna silt loam, 6 to 12 percent slopes, eroded	30	50	30	60	12	17	1.6	2.7	80	154	35	70
Waubay silty clay loam, 0 to 2 percent slopes	55	75	55	75	16	22	2.5	3.2	125	183	60	85
Waubay silty clay loam, 2 to 4 percent slopes	50	70	45	70	14	20	2.5	3.2	125	183	60	85

[1] Yields of hay are those to be expected if a mixture of alfalfa and bromegrass is grown. Yields are slightly less if alfalfa is grown alone.

[2] Animal-unit-days is a term used to express the carrying capacity of pasture. This value is obtained by multiplying the number of animal units carried per acre by the number of days the pasture can be grazed during a single grazing season without injury to the sod.

[3] These yields are expected if reed canarygrass is grown. If only native grasses and sedges are grown, yields are too variable to be predicted.

The climate, especially rainfall, is variable from year to year, and the predicted yields are averages to be expected over a period of about 10 years. Some differences in yields are to be expected on different areas of the same soil, because some variations in a soil are allowable when soils are classified.

Yields were not predicted for crops on soils not suited to them. The major crops can be grown on soils that are poorly suited to them because of shallow depth to gravel, steep slope, poor drainage, or a hazard of flooding, but yields are not likely to be worth the effort. Yields on several of the naturally wet soils have been predicted with and without adequate artificial drainage.

Field and Farmstead Windbreaks [1]

This section lists the trees and shrubs that can be grown for field and farmstead windbreaks. The soils have been placed in windbreak suitability groups, and performance ratings of the woody plants on soils of all but two of the groups are presented in table 3. A discussion of the windbreak suitability groups follows.

The total forest land in Lincoln County amounts to less than 1 percent of the land area. Hardwood trees grow along streams and on adjacent slopes. Green ash, American elm, boxelder, bur oak, cottonwood, wild plum, and chokecherry are some of the common trees. Trees are planted in Lincoln County to form field and farmstead windbreaks but not to establish forests.

Field windbreaks help control wind erosion. They can be established by planting single rows of trees at intervals across the landscape. Farmstead windbreaks reduce the loss of heat from dwellings and from animal shelters. Cattle can feed and thrive in the calm that is created by a good windbreak. Windbreaks catch snow (fig. 12) and reduce drifting in the areas near farm buildings.

[1] THOR K. BERGH, woodland conservationist, Soil Conservation Service, helped prepare this section.

Figure 12.—**Adequate windbreak on a Barnes loam, showing snow catch. The dark streaks are soil material that was eroded by wind and deposited here.**

Windbreak suitability groups of soils

To help select the most suitable trees and shrubs for field and farmstead windbreaks on each soil, the soils of the county have been placed in windbreak suitability groups. A windbreak suitability group is made up of soils that have similar characteristics affecting the growth of trees and shrubs. The group in which each soil has been placed is given in the "Guide to Mapping Units" just ahead of the map section of this survey.

The trees and shrubs suitable for field and farmstead windbreaks in Lincoln County are listed in table 3. Performance of each species on soils of the first seven groups has been rated as *preferred*, *acceptable*, or *not recommended*. The species rated as preferred are those suggested for use on the soils of the group indicated. Species rated as acceptable can be expected to grow but they are not so desirable as the preferred species. Species rated as not recommended are not suitable for planting on soils of the group.

These performance ratings are based on soil characteristics that affect growth and survival of the trees and shrubs listed in the table. Texture, drainage, depth, reaction, stoniness, and steepness and direction of slope are important soil characteristics. The descriptions of windbreak suitability groups that follow tell how these soil characteristics affect performance of the trees and shrubs. Suggestions about the preparation of sites for planting are also given.

Further information on planning, protection, and care of windbreaks is available at the local offices of the Soil Conservation Service and the Agricultural Extension Service.

TABLE 3.—*Performance ratings for various species of shrubs and trees on soils of the windbreak suitability groups* [1]

Species of shrubs and trees	Windbreak suitability groups [2]—							
	1	2	3	4	5	6: North and east slopes	6: South and west slopes	7
Ash, green	1	1	1	2	1	1	2	1
Buffaloberry	1	3	2	2	2	2	2	2
Caragana	1	3	2	2	2	1	2	2
Crabapple	1	2	3	2	2	2	3	1
Elm:								
American	1	2	2	2	2	1	2	2
Siberian	1	1	1	1	1	1	1	1
Hackberry	1	2	2	3	2	2	3	2
Honeylocust	1	2	3	1	1	1	2	1
Honeysuckle	1	1	1	2	1	1	2	1
Lilac, common	1	1	1	2	1	1	2	1
Maple:								
Ginnala	1	3	3	3	3	2	3	2
Soft	1	1	2	3	3	3	3	2
Pine, western yellow	1	3	3	2	2	1	2	1
Plum, American	1	2	3	2	2	1	2	1
Poplar:								
Norway or Siouxland	1	1	1	3	2	2	3	2
Robusta	1	1	1	3	2	2	3	2
Redcedar, eastern	1	3	3	1	1	1	1	1
Russian-olive	1	1	1	1	1	1	2	2
Spruce, Black Hills or Colorado	1	3	3	2	2	2	2	1
White-cedar, northern	1	1	3	3	3	3	3	3
Willow:								
Golden	1	2	1	3	3	2	3	3
Laurel	1	1	1	3	3	2	3	3
Purple-osier	1	1	1	3	3	2	3	2

[1] Performance ratings are 1, preferred; 2, acceptable; and 3, not recommended.
[2] Soils of groups 8 and 9 are too variable or too wet to be rated.

WINDBREAK SUITABILITY GROUP 1

This group consists of deep, medium and moderately fine textured, moderately well drained and well drained soils. In this group are soils of the Aastad, Barnes, Beotia, Brookings, Forman, Kranzburg, LaPrairie, Lismore, Oak Lake, Poinsett, Sinai, Singsaas, Svea, Terril, Vienna, and Waubay series. Most of the soils are on uplands. The Beotia soils, however, are on terraces and outwash plains, and the LaPrairie soil is on high parts of bottom lands.

These soils have few characteristics that are detrimental for growth and survival of the trees and shrubs that are listed in table 3. There is a hazard of wind erosion on most of the soils, and a hazard of water erosion on the sloping soils. The soils are deep, and their texture and natural drainage allow deep penetration of moisture and deep, uniform distribution of roots. Only the Sinai soils in this group have texture too fine for the best growth of trees and shrubs.

All the soils in this group have high or very high moisture-holding capacity, and they hold enough moisture to permit trees to survive during short periods of drought. The reaction of the surface soil and subsoil ranges from slightly acid to mildly alkaline. This is the range most suitable for the trees and shrubs listed in table 3.

WINDBREAK SUITABILITY GROUP 2

This group consists of deep, moderately fine and fine textured, poorly and very poorly drained, nearly level soils that are in depressions and on upland flats. They are soils of the Flom, Fulda, Hidewood, and Parnell series and Muck. Only the areas of these soils that have adequate surface drainage are in this group.

Wetness of the soils in group 2 limits the kinds of trees and shrubs that can be grown successfully. Willows and poplars grow well, but spruces do not. The soil texture is mostly favorable, but the Fulda soil has too fine textured a subsoil to permit the best growth of even the most suitable woody plants. Other soil characteristics, especially the depth, reaction, and moisture-holding capacity, are favorable. Trees or shrubs rarely die because of drought. Excess water is a problem, however, and surface water should be removed from a planted area by means of open ditches or tile. On these wet soils, weeds compete severely with the desired woody plants.

WINDBREAK SUITABILITY GROUP 3

The group consists of deep, moderately fine textured, poorly drained or very poorly drained, limy, nearly level soils on flats and in depressions in the uplands. They are soils of the Blue Earth, Colvin, Divide, Lamoure, Oldham, and Vallers series. If any of these soils do not have adequate surface drainage, however, they have windbreak suitability similar to the soils of group 9.

These soils are as wet as those in group 2, and they also are limy. This combination of wetness and high lime content reduces the number of species that will make good growth. The excessive lime interferes with the uptake of nutrients in many woody plants. Chlorosis, usually caused by a deficiency of available iron, occurs in many trees and shrubs on the high-lime soils. The affected plants are yellowish green and stunted, and they are likely to die unless the condition is corrected.

Removal of water from the surface is needed before trees are planted on these soils, and further accumulation of surface water needs to be prevented. Drainage by open ditches or by tile is also needed because a high water table prevents deep rooting. After these soils are drained, their depth, texture, and moisture-holding capacity are favorable for the growth of trees and shrubs.

WINDBREAK SUITABILITY GROUP 4

This group consists of soils of the Arvilla, Dickey, and Sverdrup series. These are nearly level, undulating, and sloping soils on uplands, stream terraces, and terrace escarpments. They are moderately coarse textured, and some are shallow over sand or gravel.

The soils in this group are not well suited to most trees and shrubs. They have very low moisture-holding capacity because they are shallow and sandy or gravelly. Windbreaks are likely to have high mortality if drought occurs while the trees or shrubs are young. Trees planted on these soils usually grow slowly and are stunted. They also tend to have shorter life than the same species growing on deep, medium-textured soils.

The hazard of wind erosion is severe on these soils. Field windbreaks are effective for control of wind erosion, but care is needed while the trees or shrubs are young to keep them from being damaged by windblown particles of soil. Cover of grass or the remains of a crop of corn or sorghum will provide a barrier against wind erosion during winter. If windbreaks are planted on the contour, moisture is saved that helps the trees make uniform, rapid growth.

WINDBREAK SUITABILITY GROUP 5

This group consists of deep, mainly medium-textured, moderately well drained and well drained, nearly level, undulating, and sloping, limy soils on uplands. They are members of the Buse, Crofton, and Hamerly series. The Crofton soil has a moderately fine textured surface layer.

These soils are limy, but they are better drained than the limy soils of group 3. Many areas are droughty because water is lost as runoff. In many places the surface layer is thin, fertility is low, and tilth is poor because organic matter and nutrients have been lost through erosion and excessive row cropping. The droughtiness, low fertility, and poor tilth cause trees and shrubs to grow slowly and cause high mortality among the young plants.

The excessive lime is likely to affect the uptake of plant nutrients. Chlorosis, resulting from the lack of available iron, occurs in plants growing on these soils.

If windbreaks can be planted on the contour, they help to control erosion, and they hold moisture that aids their growth and chance for survival. Since competing plants take moisture that is needed by the young trees, grass and weeds should be controlled until the trees shade the ground.

WINDBREAK SUITABILITY GROUP 6

This group consists of deep, medium-textured, well-drained and excessively drained, moderately steep, steep, and very steep soils on uplands. They are members of the Barnes and Buse series. Performance ratings have been made separately for windbreaks on north and east slopes and on south and west slopes of the soils in this group.

Excessive runoff and the resulting droughty root zone make growth and survival of trees and shrubs doubtful on these soils. The droughty conditions are most severe on the hot, dry, south and west slopes. More species of trees and shrubs can be grown on the cooler, more moist, north and east slopes. The north and east slopes along most streams in the county are naturally wooded, and south and west slopes are naturally grassed.

Most areas of these soils are in pasture. Erosion is likely to be very severe if the sod is broken up. The soils are too steep and erodible to permit plowing and fallowing of planting sites. Planting sites can be prepared by furrowing on the contour or by scalping away the sod for individual trees or shrubs.

WINDBREAK SUITABILITY GROUP 7

This group consists of moderately deep, medium-textured, well-drained, nearly level, gently sloping and sloping soils on uplands and stream terraces. They are members of the Estelline, Flandreau, and Fordville series. These soils are underlain by sand or gravel at a depth of 2 to 3 feet.

These soils are moderately deep, and as a result they have moderate moisture-holding capacity. Trees and shrubs on them are affected by drought sooner than those on the deep soils in group 1, but not so soon as those on the shallow soils of group 4. The surface layer and subsoil of these soils is loam or silt loam, almost ideal for the penetration and distribution of tree roots. The soil reaction is slightly acid to mildly alkaline, suitable for most of the trees and shrubs listed.

Windbreaks on gently sloping and sloping areas of these soils should be planted on the contour, if that is practical, to control erosion and conserve moisture. Near areas of sandy soils and in exposed places, wind erosion is likely to injure or kill the young trees or shrubs. Weeds and grass should be controlled while the trees or shrubs are young because competition for moisture is likely to be critical.

WINDBREAK SUITABILITY GROUP 8

This group consists of some soils of the Arvilla, Buse, Lamoure, LaPrairie, and Sioux series, and of Lake beaches. Each area needs to be checked to determine if planting is practical and, if planting is practical, to determine the suitability of that particular site for windbreaks.

WINDBREAK SUITABILITY GROUP 9

This group consists of marshes in the uplands and of wet, marshy places along streams that are unsuitable for trees unless drained. The areas consist of Marsh and of a Rauville soil. If the areas of Marsh are drained, the underlying soil determines whether that area is most like the soils of windbreak suitability group 2 or group 3. Drained areas of the Rauville soil are similar to the soils of group 3.

Engineering Properties of Soils[2]

This soil survey contains information about the soils of Lincoln County that can be used by engineers to—

1. Make soil and land use studies that will aid in selecting and developing industrial, business, residential, and recreational sites.
2. Make estimates of runoff and erosion, for use in designing drainage systems and planning dams and other structures for conservation of soil and water.
3. Make preliminary evaluation of soil and ground conditions that will aid in selecting locations of highways, airports, pipelines, and cables and in planning detailed investigations at the selected locations.
4. Locate probable sources of gravel and other construction materials.
5. Correlate performance of engineering structures with soil mapping units to develop information that will be useful in designing and maintaining certain engineering practices and structures.
6. Determine the suitability of soil mapping units for cross-country movement of vehicles and construction equipment.
7. Supplement the information obtained from other published maps and reports and aerial photographs to make maps and reports that can be used readily by engineers.
8. Make a general estimate of the hazards or useful properties of various soils for highway and earth construction when definite laboratory data are not available.

Used with the soil map to identify the soils, the engineering interpretations in this subsection can be useful for many purposes. It should be emphasized, however, that the interpretations may not eliminate the need for sampling and testing at the site of specific engineering works involving heavy loads and where the excavations are deeper than the depths of the layers reported. Furthermore, engineers and others should not apply specific values to the estimated values given for bearing capacity of soils. Nevertheless, the soil map is useful for planning more detailed field investigations and for suggesting the kinds of problems that may be expected.

Soil science terms that may have different meanings in other fields, such as soil, sand, silt, clay, gravel, topsoil, subsoil, and substratum, are defined in the Glossary.

Further information pertaining to parent materials and geology is given under "Parent Material" in the section "Formation and Classification of the Soils" and under "Physiography, Relief, and Drainage" in the section "General Nature of the County."

Some of the information useful for engineering can be obtained from the soil map. It may be necessary, however, to refer to other parts of this survey. By using the information in the soil map, the descriptions of soil profiles, and the tables in this subsection, the soils engineer can plan a detailed survey of the soil at a construction site.

Engineering classification systems

Two systems of classifying soils, the one used by the American Association of State Highway Officials (AASHO) and the Unified, are in general use among engineers. Most highway engineers classify soil material in accordance with the system approved by the American Association of State Highway Officials (*1*).[3] Some engineers prefer to use the Unified classification system, which was established by the Waterways Experiment Station, Corps of Engineers (*11*). Both systems are used in this section. These classification systems are explained in the PCA Soil Primer (*5*).

Engineering test data and interpretations of soils

Soil samples from nine soil profiles were tested by standard AASHO procedures to help evaluate the soils for engineering purposes. Only selected layers of each soil were sampled. The results of these tests are presented in table 4.

In table 5 the soils of the county and their map symbols are listed and certain characteristics that are significant to engineering use are described. The classifications shown in this table were estimated from actual test data and from the detailed descriptions of profiles of representative soils that are given in the section "Descriptions of the Soils."

Permeability of each soil, as it occurs in place, was estimated. The estimates were based on soil structure and porosity and were compared, wherever possible, with permeability tests that had been made on undisturbed cores of similar material.

The available water capacity, expressed in inches of water per inch of soil depth, is the approximate amount of capillary water in the soil when it is wet to field capacity. When the soil is at the wilting point of common crops, this amount of water will wet the soil material to a depth of one inch without deeper percolation.

The shrink-swell potential is an indication of the volume change to be expected of the soil material with changes in moisture content. This potential is based on tests of volume change or on observations of other physical properties or characteristics of the soil.

HIGHWAY ENGINEERING.—The suitability of each soil as

[2] DAVID C. RALSTON, assistant State conservation engineer, Soil Conservation Service, helped prepare this section.

[3] Italic numbers in parentheses refer to Literature Cited, p. 82.

a source of topsoil, sand and gravel, and road fill is given in table 6.

The suitability of a soil as a source of topsoil depends mainly on the thickness and quality of the surface layer, but a steep soil is less suitable than one that is level or gently sloping. Each particular deposit of sand and gravel needs to be examined to determine if the material is suitable for the use intended. Suitable sources of sand and gravel are available in the Arvilla, Beotia, Fordville, Estelline, Sioux, and Divide soils. The Sverdrup soils are underlain by medium to fine sand. Fine to medium sand is present in the Dickey soils in a layer that makes up about 2 of the upper 4 feet of the profile. The Flandreau soils in the southwestern part of the county have in their profile medium to fine sand that is similar to that in the Dickey soils. Flandreau soils in other parts of the county are similar to the Sverdrup soils with respect to underlying sands; that is, they have a sandy substratum that is of variable quality as a source of sand for construction. Wherever the very poorly drained Rauville soils are closely associated with Divide soils, they generally are underlain by sand and gravel.

In rating the suitability of soils for road fill, only the material below the surface layer has been considered. Some soils, for example, Muck and the Blue Earth soil, have a thick, highly organic surface layer. They are generally not suitable for road fill, because of the depth to the substratum of mineral soil.

Fulda and Sinai soils, because of their high content of clay, have a high shrink-swell potential. If a subgrade consists mostly of such material, the pavement is likely to crack or warp when changes occur in the moisture content.

The silty, poorly drained soils are highly susceptible to the action of frost. Frost heaves and the subsequent frost boils affect the pavement of highways in the county. Heaving by frost can be expected if 10 percent or more of the soil material passes a No. 200 sieve. The Blue Earth, Colvin, Crofton, and Lamoure soils in this county are those most susceptible. The excessively drained and the well-drained soils are least susceptible if adequate drainage of the road is provided. Examples of the least susceptible soils are those of the Barnes, Buse, Kranzburg, Fordville, Arvilla, Flandreau, Sverdrup, and Dickey series. The water table in all of these soils is deep. Frost heaves also are likely to be formed wherever materials in the subgrade are not uniform and have different rates of expansion. Some deposits of glacial till contain lenses or pockets of fine sand or silt that cause differential frost heave. Where the subgrade for the highway is laid over glacial till, it should contain a thick enough layer of material that it is not susceptible to frost heave, so that the pavement will not be damaged when freezing occurs.

The bearing capacity of most of the soils is good for location of highways. Exceptions are the soils on alluvial plains, in depressions, and in old lakebeds, especially soils of the Blue Earth, Oldham, Rauville, Parnell, and Colvin series. Engineers and others, however, should not apply specific values to the estimates given for bearing capacity of soils.

Main features of the soils that affect location of highways are given in table 6.

Conservation Engineering.—Soil features that affect water management practices are given in several columns of table 6. These features have been determined on the basis of estimates given in table 5, descriptions of the soils, and field observations and experience.

Some good sites for farm ponds are in the deep drainageways that have side slopes of steep Buse soils. These drainageways provide good reservoir areas because Buse soils have a slow seepage rate. The underlying glacial till of the Buse soils is suitable for embankments. It has fair stability and compaction characteristics and slow permeability when compacted. Borings should be made in the reservoir area, before a pond site is selected, to determine the presence or extent of sandy lenses or gravelly pockets. The soil features listed under road fill apply also in the construction of embankments.

Dikes or levees are usually constructed on the Lamoure soils, LaPrairie soils, and Lamoure and LaPrairie soils, frequently flooded. Most of the material in the bottom lands is suitable for use if it is well compacted, since water needs to be impounded for only short periods. Material from Lamoure and LaPrairie soils, frequently flooded, tends to be variable.

Artificial drainage of the wet soils is needed for optimum production of crops. Surface drainage and tile drainage are needed on the very poorly drained Blue Earth, Oldham, Parnell, and Muck soils. The very poorly drained Rauville soils are difficult to drain because they occupy the lowest parts of bottom lands and necessary outlets are not available. Rauville soils are also subject to frequent overflow.

Tile drainage is beneficial on the somewhat poorly drained or poorly drained Colvin, Flom, Fulda, Divide, Hidewood, and Vallers soils. Tile drainage has not been a general practice on these soils in the county, and damage to crops and reduced yields have been extensive in abnormally wet growing seasons. If suitable outlets could be obtained, Lamoure soils would be improved by tile drainage. The ground water in many areas of Colvin, Divide, and Vallers soils contains an excessive amount of magnesium sulfate. This compound causes ordinary cement tile to disintegrate, and clay tile or resistant cement tile are needed if drains are installed.

Little irrigation has been done in the county. The lack of a good water supply is a major limiting factor. The nearly level Beotia, Kranzburg, and Dickey soils that occupy broad areas in the southwestern part of the county have characteristics that make them well suited to sprinkler irrigation.

If row crops are grown intensively, terraces are the most practical measure for water management and erosion control on slopes of less than 12 percent. Systems of parallel terraces can be laid out on many sloping areas of Kranzburg and Vienna soils. Barnes soils have slopes that are more irregular, and, on them, cuts and fills are likely to be needed for good alinement of terraces. Compaction of soil in the terrace channel is likely to be a problem if terraces are constructed in spring. The problem of compaction is less severe if terraces are constructed in fall because freezing and thawing help restore good soil structure before the next growing season. Diversion terraces are built mainly on slopes steeper than 12 percent.

Grassed waterways are needed to conduct water in drainageways without permitting excessive erosion. Sod is difficult to establish in waterways on highly erodible soils, especially on sandy and gravelly soils. On Sverdrup, Fordville, Flandreau, and Arvilla soils, replacement of

TABLE 4.—*Engineering test data for soil*

Soil name and location	Parent material	Minnesota report number SS61–	Depth	Horizon	Moisture-density [2]	
					Maximum dry density	Optimum moisture
			Inches		*Lb. per cu. foot*	*Percent*
Barnes loam:						
NE¼NE¼NW¼ sec. 29, T. 112 N., R. 44 W.	Glacial till (Mankato age).	1663	0–10	A1	86	29
		1664	16–22	B2	99	19
		1665	41–54	C	114	15
NE¼NW¼NW¼ sec. 4, T. 110 N., R. 46 W.	Glacial till (Cary age).	1666	0–6	Ap	95	23
		1667	15–23	B21	98	21
		1668	34–48	C2	109	17
Forman clay loam:						
NW¼SW¼ sec. 1, T. 112 N., R. 44 W.	Glacial till (Mankato age).	1669	0–7	Ap	93	24
		1670	15–26	B2	98	20
		1671	33–48	C	103	19
Fulda silty clay loam:						
NE¼NE¼SE¼ sec. 12, T. 110 N., R. 44 W.	Lacustrine deposit in Altamont moraine.	1675	0–8	Ap	85	30
		1676	13–28	B2g1	90	25
		1677	40–54	Cg	100	21
NW¼NE¼NW¼ sec. 28, T. 113 N., R. 46 W.	Lacustrine deposit in Altamont moraine.	1678	0–7	Ap	86	29
		1679	15–21	B2 and A1	92	26
		1680	26–48	Cg	99	20
NW¼NW¼NW¼ sec. 10, T. 110 N., R. 45 W.	Ground moraine (Cary age).	1672	0–10	Ap	80	35
		1673	16–25	B2	88	29
		1674	31–54	Cg	91	27
Sinai silty clay loam:						
NE¼SE¼NE¼ sec. 1, T. 110 N., R. 44 W.	Lacustrine deposit in Altamont moraine.	1681	0–7	Ap	91	25
		1682	15–23	B21	90	26
		1683	32–45	Ccal	108	16
NW¼NE¼NW¼ sec. 28, T. 113 N., R. 46 W.	Lacustrine deposit in Altamont moraine.	1684	0–9	Ap	84	27
		1685	18–28	B2	92	27
		1686	34–48	Cca	98	23
850 feet E. and 50 feet N. of SW. corner of SE¼SW¼SW¼ sec. 31, T. 111 N., R. 45 W.	Locally sorted water-laid material (Cary ground moraine).	1660	0–7	Ap	80	32
		1661	16–26	B21	90	28
		1662	37–48	C	96	24

[1] Tests performed by the Minnesota Department of Highways, in cooperation with U.S. Department of Commerce, Bureau of Public Roads, in accordance with standard procedures of the American Association of State Highway Officials (AASHO) (*1*).

[2] Based on "The Moisture-Density Relations of Soils Using a 5.5-lb. Rammer and a 12-in. Drop," AASHO Designation T 99–57, Method C (*1*).

[3] Mechanical analyses according to AASHO Designation T 88–57. Results by this procedure frequently may differ somewhat from results that would have been obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 mm. in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and

samples taken from selected soil profiles [1]

Mechanical analysis [3]									Liquid limit	Plasticity index	Classification	
Percentage passing sieve—					Percentage smaller than—						AASHO [4]	Unified [5]
¾-in.	No. 4 (4.7 mm.)	No. 10 (2.0 mm.)	No. 40 (0.42 mm.)	No. 200 (0.074 mm.)	0.05 mm.	0.02 mm.	0.005 mm.	0.002 mm.				
									Percent			
100	98	96	84	54	47	30	16	9	49	6	A–5(5)	OL
100	99	96	88	64	55	43	28	21	40	10	A–4(6)	ML
100	92	88	79	57	46	37	24	18	39	9	A–4(4)	ML–CL
100	98	95	85	64	56	42	23	16	43	11	A–7–5(7)	OL
100	99	97	90	68	63	50	37	31	45	18	A–7–6(11)	ML–CL
100	97	94	86	66	57	44	32	24	35	13	A–6(7)	ML–CL
100	98	95	86	64	56	46	29	22	44	12	A–7–5(7)	OL
100	99	97	89	68	63	52	39	32	46	19	A–7–6(11)	ML–CL
100	97	94	86	70	63	54	43	32	45	20	A–7–6(12)	ML–CL
-------	100	98	96	91	84	69	46	35	56	19	A–7–5(15)	OH
-------	100	94	93	91	88	76	55	45	63	30	A–7–5(20)	MH–CH
-------	--------	100	98	96	91	71	46	38	48	22	A–7–6(14)	ML–CL
-------	100	99	97	91	83	61	36	25	51	12	A–7–5(11)	OH
-------	100	96	95	91	83	63	39	29	52	20	A–7–5(14)	MH
-------	100	98	98	96	91	73	48	35	45	21	A–7–6(13)	CL
100	99	96	86	78	74	50	27	17	57	10	A–5(11)	OH
-------	100	97	96	93	87	73	49	38	57	23	A–7–5(17)	MH
-------	--------	--------	100	97	94	88	77	61	66	38	A–7–6(20)	CH
-------	100	98	92	77	67	55	34	25	48	14	A–7–5(11)	OL
-------	100	93	90	83	77	61	41	30	49	15	A–7–5(12)	ML
-------	100	99	98	69	59	44	33	25	31	12	A–6(8)	CL
-------	--------	100	98	92	83	62	35	24	52	14	A–7–5(12)	OH
-------	100	95	94	91	87	66	43	33	51	18	A–7–5(13)	MH
-------	100	99	99	98	94	76	54	41	47	20	A–7–6(13)	ML–CL
-------	--------	100	99	95	88	71	41	29	53	15	A–7–5(13)	OH
-------	--------	100	99	97	93	75	48	38	47	19	A–7–6(13)	ML–CL
-------	--------	--------	100	98	93	73	49	35	45	18	A–7–6(12)	ML–CL

the material coarser than 2 mm. in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for use in naming textural classes for soils.

[4] Based on "The Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes," AASHO Designation M 145–49 (*1*). SCS and the Bureau of Public Roads have agreed to consider that all soils having plasticity indexes within two points of A-line are to be given a borderline classification, for example, ML–CL.

[5] Based on the Unified Soil Classification System, Technical Memorandum No. 3–357, v. 1, Waterways Experiment Station, Corps of Engineers, March 1953, (*11*).

TABLE 5.—*Estimated properties*

[Because five of the mapping units have variable characteristics, their properties are not shown. These are Buse stony loam, 5 to 40

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification
			USDA texture
	Feet	*Inches*	
Aastad (AaA)	3–5	0–19	Clay loam
		19–32	Clay loam
		32–46	Clay loam
Arvilla (ArA, ArB, ArC2, ArD2)	10+	0–9	Sandy loam
		9–16	Sandy loam
		16–48	Coarse sand and gravel
Barnes (BaA, BaB, BaB2, BbB2, BbC, BbC2, BcB, BcB2, BcC2). (For properties of the Buse soils in mapping units BbB2, BbC, and BbC2, see the Buse series; for properties of the Buse and Arvilla soils in mapping units BcB, BcB2, and BcC2, see the Buse and Arvilla series, respectively.)	10+	0–12	Loam
		12–24	Loam
		24–54	Loam
Beotia (BeA, BeB)	10+	0–12	Silt loam
		12–45	Silt loam
		45–54	Sand and gravel
Blue Earth (Bh)	0	0–42	Silt loam
		42–54	Silty clay loam
Brookings (BkA, BkB)	3–5	0–12	Silty clay loam
		12–33	Silty clay loam
		33–54	Clay loam
Buse (BlE, BlF, BoD, BoD2, BrD2, BrF). (For properties of the Barnes soils in mapping units BoD and BoD2, see the Buse series, and for properties of the Arvilla soils in mapping units BrD2 and BrF, see the Arvilla series.)	10+	0–9	Loam
		9–45	Clay loam
Colvin (Co)	0–2	0–16	Silty clay loam
		16–60	Silty clay loam
Crofton (CrC)	10+	0–7	Silty clay loam
		7–54	Silty clay loam
Dickey (DcA, DcB)	10+	0–12	Sandy loam
		12–32	Loamy sand
		32–64	Silty clay loam
		64–68	Clay loam
Divide (Dv)	0–2	0–14	Silt loam
		14–27	Loam
		27–54	Sand and gravel
Estelline (EsA)	10+	0–6	Silt loam
		6–25	Silt loam
		25–42	Sand and gravel
Flandreau (FaA, FaB)	10+	0–11	Loam
		11–26	Loam
		26–46	Sandy loam to loamy sand
		46–60	Silt loam
Flom (Fc)	0–2	0–13	Clay loam
		13–21	Clay loam
		21–54	Clay loam
Fordville (FdA, FdB, FdB2)	10+	0–11	Loam
		11–26	Loam
		26–42	Sand and gravel

significant to engineering

percent slopes (BnF); Gravel pit (Gp); Lake beaches (La); Lamoure and LaPrairie soils, frequently flooded (Lo); and Marsh (Ma)]

Classification—Continued		Estimated percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4	No. 10	No. 200				
					Inches per hour	*Inches per inch of soil*	*pH value*	
OL	A-7	95–100	90–95	65–70	2. 5–5. 0	0. 22	6. 6–7. 3	Moderate.
ML or CL	A-7	95–100	95–100	65–70	0. 2–2. 5	. 19	6. 6–7. 3	Moderate.
ML or CL	A-7 or A-6	95–100	90–95	65–75	0. 8–2. 5	. 17	7. 4–8. 4	Moderate.
SM	A-2	75–85	70–80	15–25	2. 5–5. 0	. 14	6. 6–7. 3	Low.
SM	A-2	75–85	70–80	12–25	2. 5–5. 0	. 10	6. 1–7. 3	Low.
GM-GW or SM-SW	A-1	50–70	35–50	5–15	5. 0–10. 0+	. 015	7. 4–8. 4	Low.
OL or ML	A-7 or A-5	95–100	90–100	55–65	2. 5–5. 0	. 20	6. 6–7. 3	Moderate.
ML or CL	A-6 or A-7	95–100	95–100	60–70	2. 5–5. 0	. 18	6. 6–7. 8	Moderate.
ML or CL	A-6 or A-7	90–100	85–95	60–70	0. 8–2. 5	. 17	7. 4–8. 4	Moderate.
ML or CL	A-4 or A-7	100	100	85–95	2. 5–5. 0	. 20	6. 1–7. 3	Low.
ML or CL	A-4 or A-6	100	100	85–95	2. 5–5. 0	. 18	6. 1–6. 5	Low to moderate.
SM-SW or GM-GW	A-1	50–70	35–45	5–12	5. 0–10. 0+	. 015	7. 4–8. 4	Low.
OL	A-4, A-5, or A-7	100	100	95–100	0. 80–5. 0	. 25	7. 4–8. 4	Low to moderate.
ML or MH	A-7	95–100	95–100	85–95	0. 20–2. 5	. 18	7. 4–8. 4	Moderate to high.
OL	A-7	100	95–100	85–95	0. 80–5. 0	. 22	6. 6–7. 3	Moderate.
ML or CL	A-7 or A-6	100	95–100	85–95	0. 80–2. 5	. 19	6. 6–7. 3	Moderate.
CL	A-6	95–100	90–100	65–75	0. 80–2. 5	. 17	7. 4–8. 4	Moderate.
ML	A-7	95–100	90–100	55–65	0. 80–5. 0	. 19	7. 4–8. 4	Moderate.
ML or CL	A-6 or A-7	90–100	85–95	60–70	0. 80–2. 5	. 17	7. 4–8. 4	Moderate.
CL or ML	A-5 or A-7	100	100	90–95	0. 80–5. 0	. 23	7. 4–8. 4	Low to moderate.
CL or ML	A-6 or A-7	100	100	85–95	0. 80–2. 5	. 18	7. 9–8. 4	Low to moderate.
ML	A-4 or A-7	100	100	85–95	0. 80–5. 0	. 20	7. 4–7. 8	Moderate.
CL	A-6 or A-7	100	100	85–95	0. 80–2. 5	. 17	7. 9–8. 4	Moderate.
SM	A-2	100	95–100	25–35	2. 50–5. 0	. 14	6. 6–7. 3	Low.
SM	A-2	100	95–100	12–25	2. 50–10. 0	. 05	6. 6–7. 3	Low.
ML or CL	A-4 or A-6	100	100	80–90	0. 80–5. 0	. 17	7. 4–8. 4	Moderate.
CL	A-6	95–100	90–100	65–75	0. 80–2. 5	. 17	7. 9–8. 4	Moderate.
OL or ML	A-4 or A-7	100	90–100	70–80	2. 50–5. 0	. 22	7. 4–8. 4	Low to moderate.
ML	A-4 or A-6	95–100	90–95	65–75	0. 80–2. 5	. 18	7. 9–8. 4	Moderate.
SM-SW or GM-GW	A-1	50–70	35–45	5–12	5. 00–10. 0+	. 015	7. 9–8. 4	Low.
ML or OL	A-4 or A-7	100	100	85–95	2. 50–5. 0	. 20	6. 1–7. 3	Low.
ML	A-4 or A-6	100	100	85–95	2. 50–5. 0	. 18	6. 1–6. 5	Low to moderate.
SM-SW or GM-GW	A-1	50–70	35–45	5–12	5. 00–10. 0+	. 015	7. 4–8. 4	Low.
ML	A-4	100	95–100	55–65	2. 50–5. 0	. 19	6. 1–7. 3	Low.
ML	A-4	100	95–100	50–60	2. 50–5. 0	. 15	6. 1–6. 5	Low.
SM or SM-SP	A-2	100	95–100	8–30	2. 50–10. 0	. 05	6. 6–7. 3	Low.
ML or CL	A-4 or A-6	100	100	85–95	0. 80–5. 0	. 15	6. 6–7. 8	Low to moderate.
OL	A-7	95–100	95–100	75–85	0. 80–5. 0	. 23	6. 6–7. 8	Moderate.
CL	A-7	95–100	95–100	75–85	0. 80–2. 5	. 20	6. 6–7. 8	Moderate.
CL or ML	A-7 or A-6	90–100	85–95	65–75	0. 80–2. 5	. 17	7. 4–8. 4	Moderate.
ML	A-4	95–100	90–100	50–60	2. 50–5. 0	. 20	6. 6–7. 3	Low.
ML	A-4	90–100	90–100	50–60	2. 50–5. 0	. 17	6. 1–7. 3	Low.
SM-SW or GM-GW	A-1	50–70	35–50	5–12	5. 00–10. 0+	. 015	7. 4–8. 4	Low.

TABLE 5.—*Estimated properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification
			USDA texture
	Feet	*Inches*	
Forman (FmA, FrB, FrB2). (For properties of the Barnes soils in mapping units FrB and FrB2, see the Barnes series.)	10+	0–8	Clay loam
		8–27	Clay loam
		27–54	Clay loam
Fulda (Fu)	0–2	0–13	Silty clay loam
		13–40	Silty clay
		40–54	Silty clay loam or silty clay
Hamerly (HaA)	3–5	0–13	Loam
		13–54	Clay loam
Hidewood (Hd)	0–2	0–14	Silty clay loam
		14–38	Silty clay loam
		38–52	Clay loam
Kranzburg (KrA, KrB, KrB2)	10+	0–10	Silt loam
		10–26	Silty clay loam
		26–54	Clay loam
Lamoure (Lm)	0–2	0–34	Silty clay loam
		34–54	Silty clay loam
LaPrairie (Lp)	3–5	0–23	Loam
		23–54	Loam
Lismore (LsA)	3–5	0–17	Silty clay loam
		17–34	Clay loam
		34–60	Clay loam
Muck (Mu)	0	0–19	Muck
		19–54	Silty clay loam
Oak Lake (OlA, OlB)	3–5	0–16	Silty clay loam
		16–42	Silty clay loam
		42–60	Clay loam
Oldham (Om)	0	0–28	Silty clay loam
		28–50	Silty clay loam
Parnell (Pa)	0	0–24	Silty clay loam
		24–54	Silty clay loam
Poinsett (PoB, PoB2)	10+	0–14	Silty clay loam
		14–34	Silty clay loam
		34–54	Silty clay loam
Rauville (Ra)	0	0–30	Silty clay loam
		30–54	Silty clay loam
Sinai (ScA, ScB)	3–5	0–12	Silty clay loam
		12–32	Silty clay
		32–54	Silty clay loam
Singsaas (SgB, SgB2)	10+	0–6	Silty clay loam
		6–17	Silty clay loam
		17–39	Clay loam
Sioux (SoF)	10+	0–10	Gravelly sandy loam
		10–36	Coarse sand and gravel
Svea (SvA, SvB)	3–5	0–13	Clay loam
		13–29	Clay loam
		29–54	Clay loam
Sverdrup (SwB, SwC)	10+	0–9	Sandy loam
		9–16	Sandy loam
		16–50	Loamy sand and sand

significant to engineering—Continued

Classification—Continued		Estimated percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4	No. 10	No. 200				
					Inches per hour	*Inches per inch of soil*	*pH value*	
OL or ML	A–7	95–100	90–95	60–70	2. 50–5. 0	. 20	6. 6–7. 3	Moderate.
ML or CL	A–7	95–100	95–100	65–70	0. 20–2. 5	. 18	6. 6–7. 3	Moderate.
ML or CL	A–7 or A–6	95–100	90–95	65–75	0. 80–2. 5	. 17	7. 4–8. 4	Moderate.
OH	A–7	100	95–100	90–95	0. 80–5. 0	. 23	6. 6–7. 3	Moderate to high.
MH	A–7	100	95–100	90–95	0. 20–0. 8	. 20	6. 6–7. 8	High.
CL or CH	A–7	100	95–100	95–100	0. 05–0. 8	. 18	7. 9–8. 4	Moderate to high.
ML or OL	A–7	95–100	95–100	55–65	0. 80–5. 0	. 20	7. 4–8. 4	Moderate.
ML or CL	A–6 or A–7	90–100	85–95	60–70	0. 80–2. 5	. 17	7. 9–8. 4	Moderate.
OL or OH	A–7	100	95–100	95–100	0. 80–5. 0	. 23	6. 6–7. 8	Moderate.
CL	A–7	100	95–100	95–100	0. 80–2. 5	. 19	6. 6–8. 4	Moderate.
CL	A–6	95–100	90–100	65–75	0. 80–2. 5	. 17	7. 9–8. 4	Moderate.
OL or ML	A–7 or A–5	100	95–100	85–95	2. 50–5. 0	. 20	6. 1–7. 3	Moderate.
ML or CL	A–6 or A–7	95–100	95–100	85–95	2. 50–5. 0	. 18	6. 6–7. 3	Moderate.
CL	A–6	95–100	90–100	65–75	0. 80–5. 0	. 17	7. 4–8. 4	Moderate.
OL or OH	A–5 or A–7	100	100	90–95	0. 80–2. 5	. 23	7. 4–8. 4	Moderate.
CL or ML	A–6 or A–7	100	100	85–95	0. 80–2. 5	. 20	7. 9–8. 4	Moderate.
OL or ML	A–4	100	95–100	65–75	0. 80–5. 0	. 22	7. 4–8. 4	Low to moderate.
ML	A–4	100	95–100	65–75	0. 80–5. 0	. 19	7. 9–8. 4	Low.
OL or OH	A–7 or A–5	95–100	95–100	80–90	0. 80–5. 0	. 22	6. 6. 7. 3	Moderate.
ML or CL	A–6 or A–7	95–100	95–100	70–80	0. 80–2. 5	. 19	6. 6–8. 4	Moderate.
CL	A–6	95–100	90–100	65–75	0. 80–2. 5	. 17	7. 4–8. 4	Moderate.
Pt	--------------	100	100	95–100	0. 20–2. 5	. 35	6. 6–7. 8	Low.
ML or MH	A–7	100	95–100	80–90	0. 20–2. 5	. 20	7. 4–8. 4	Moderate to high.
OL	A–7	100	90–100	80–90	0. 80–5. 0	. 22	6. 6–7. 3	Moderate.
ML or CL	A–7 or A–6	100	90–100	80–90	0. 80–2. 5	. 20	6. 6–7. 8	Moderate.
ML or CL	A–6 or A–7	95–100	95–100	65–75	0. 80–2. 5	. 17	7. 9–8. 4	Moderate.
OH or MH	A–7	100	100	95–100	0. 80–2. 5	. 23	7. 4–8. 4	Moderate to high.
ML or MH	A–7	95–100	95–100	70–80	0. 20–0. 8	. 18	7. 4–8. 4	Moderate to high.
OH	A–7	100	95–100	90–95	0. 80–2. 5	. 25	6. 6–7. 8	Moderate to high.
MH or CH	A–7	95–100	95–100	80–90	0. 20–0. 8	. 18	6. 6–8. 4	Moderate to high.
OL	A–7 or A–5	100	100	80–90	2. 50–5. 0	. 20	6. 6–7. 3	Moderate.
CL	A–6 or A–7	100	100	80–90	2. 50–5. 0	. 18	6. 6–7. 8	Moderate.
CL	A–6 or A–7	100	95–100	85–95	0. 80–2. 5	. 17	7. 4–8. 4	Moderate.
OL	A–7 or A–5	100	100	95–100	0. 80–2. 5	. 25	7. 4–8. 4	Moderate.
ML or MH	A–7	100	100	95–100	0. 20–0. 8	. 19	7. 9–8. 4	Moderate to high.
OL or OH	A–7	100	95–100	90–95	0. 80–5. 0	. 22	6. 6–7. 3	Moderate to high.
MH	A–7	100	95–100	90–100	0. 20–2. 5	. 19	6. 6–7. 8	High.
ML or CL	A–7 or A–6	100	95–100	95–100	0. 05–0. 8	. 17	7. 9–8. 4	Moderate.
OL or ML	A–5 or A–7	95–100	90–100	80–90	0. 80–5. 0	. 21	6. 6–7. 3	Moderate.
ML or CL	A–7 or A–6	95–100	90–100	80–90	2. 50–5. 0	. 19	6. 6–7. 8	Moderate.
ML or CL	A–6 or A–7	95–100	95–100	65–75	0. 80–2. 5	. 17	7. 9–8. 4	Moderate.
SM	A–2	60–70	45–55	12–20	2. 50–10. 0+	. 10	6. 6–7. 8	Low.
SM–SW or GM–GW	A–1	50–70	35–45	5–12	5. 00–10. 0+	. 015	7. 9–8. 4	Low.
OL or ML	A–7 or A–5	95–100	95–100	60–70	2. 50–5. 0	. 22	6. 6–7. 3	Moderate.
ML or CL	A–6 or A–7	95–100	95–100	60–70	0. 80–2. 5	. 19	6. 6–7. 8	Moderate.
ML or CL	A–6 or A–7	90–100	85–95	60–70	0. 80–2. 5	. 17	7. 4–8. 4	Moderate.
SM	A–2	95–100	95–100	25–35	2. 50–5. 0	. 13	6. 1–7. 3	Low.
SM	A–2	95–100	95–100	25–35	2. 50–10. 0	. 12	6. 1–7. 3	Low.
SM–SP	A–3 or A–2	95–100	95–100	5–12	5. 00–10. 0	. 07	6. 6–8. 4	Low.

TABLE 5.—*Estimated properties*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification: USDA texture
	Feet	*Inches*	
Terril (TeB)	3–5	0–40	Silt loam
		40–60	Clay loam
Vallers (Va)	0–2	0–12	Silty clay loam
		12–48	Clay loam
Vienna (VeB, VeB2, VeC2)	10+	0–10	Silt loam
		10–26	Clay loam
		26–54	Clay loam
Waubay (WaA, WaB)	3–5	0–15	Silty clay loam
		15–33	Silty clay loam
		33–54	Silty clay loam

TABLE 6.—*Engineering*

[Gravel pit (Gp) and Marsh

Soil series and map symbols	Suitability as a source of—			Soil features affecting engineering practices—	
	Topsoil [1]	Sand and gravel	Road fill [2]	Highway location	Farm ponds: Reservoir area
Aastad (AaA)	Good to fair; some areas are stony.	Not suitable	Fair; fair shear strength; good to fair workability; moderate volume change.	Moderate susceptibility to frost action.	Moderately slow permeability; slow seepage rate; nearly level; some sites suitable for pits.
Arvilla (ArA, ArB, ArC2, ArD2).	Good to poor; surface layer is thin and sandy; eroded in some places.	Good to fair; materials desired are only a few feet thick in some places.	Subsoil fair to good; deeper material good; good shear strength; low compressibility; good compaction characteristics.	Slopes erode easily; good bearing capacity.	Rapid permeability and seepage rate; unsuitable for water impoundments.
Barnes (BaA, BaB, BaB2).	Good to fair; surface layer in some places is thin and eroded; some areas are stony.	Not suitable	Fair; fair shear strength; medium compressibility; good to fair workability.	Moderate susceptibility to frost action.	Moderate permeability; slow seepage rate; most slopes not suitable.
Barnes and Buse (BbB2, BbC, BbC2).	Fair to poor; surface layer in many places is thin; some areas are eroded; some areas are stony.	Not suitable	Fair; fair shear strength; medium compressibility; good to fair workability.	Some small pockets of sand and gravel cause differential frost heaving; sloping soils are erodible.	Moderate permeability; slow seepage rate; investigate for lenses or pockets of sand and gravel.

See footnotes at end of table.

significant to engineering—Continued

Classification—Continued		Estimated percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4	No. 10	No. 200				
					Inches per hour	*Inches per inch of soil*	*pH value*	
OL	A-4	95–100	95–100	85–95	0. 80–5. 0	. 23	6. 1–7. 3	Low to moderate.
ML or CL	A-4 or A-6	90–100	90–100	70–80	0. 80–2. 5	. 18	6. 6–8. 4	Low to moderate.
OL or ML	A-7	95–100	95–100	80–90	0. 80–5. 0	. 22	7. 4–8. 4	Moderate.
ML or CL	A-6	95–100	95–100	60–70	0. 20–2. 5	. 17	7. 9–8. 4	Moderate.
OL or ML	A-4 or A-6	95–100	95–100	65–75	0. 80–5. 0	. 20	6. 6–7. 3	Low to moderate.
CL	A-6 or A-7	95–100	95–100	70–80	2. 50–5. 0	. 18	6. 6–7. 8	Moderate.
CL	A-6	95–100	90–100	65–75	0. 80–2. 5	. 17	7. 9–8. 4	Moderate.
OL	A-7 or A-5	100	100	80–90	0. 80–5. 0	. 22	6. 6–7. 3	Moderate.
CL	A-6 or A-7	100	100	85–95	0. 80–2. 5	. 18	6. 6–7. 8	Moderate.
CL	A-6 or A-7	100	100	85–95	0. 20–2. 5	. 17	7. 4–8. 4	Moderate.

interpretations of the soils

(Ma) are not listed in this table]

Soil features affecting engineering practices—Continued					Limitations for septic tank fields
Farm ponds—Con.	Agricultural drainage	Irrigation (sprinkler)	Terraces and diversions	Waterways	
Embankment					
Fair stability; fair compaction characteristics; slow permeability when compacted; good resistance to piping.	Not needed; moderately well drained.	Deep soil; high water-holding capacity; moderately slow permeability in subsoil makes suitability for irrigation doubtful.	Moderately well drained; slight grade essential; few stones and boulders in some areas; fair slope pattern.	Firm subsoil may be difficult to vegetate when exposed; some stones; other features favorable.	Severe; seasonal high water table in some places; slow percolation rate.
Upper 2 feet have fair stability and moderate permeability when compacted; sand and gravel in deeper layers have fair stability and rapid permeability when compacted.	Not needed; excessively drained.	Shallow; 1 to 2 feet over sand and gravel; low water-holding capacity; rapid intake rate; frequent applications of water are needed.	Shallow to sand and gravel; terrace channels are droughty and erodible; poor to fair slope pattern; stones and boulders in some areas; low fertility.	Shallow to sand and gravel; droughty; erodible; low fertility; difficult to vegetate.	Slight to severe; gravelly substratum may permit contamination of water; some steep slopes.
Fair stability; fair compaction characteristics; slow permeability when compacted; good resistance to piping; moderate erodibility.	Not needed; well drained.	Deep soil; high water-holding capacity; medium intake rate.	Most soil features favorable; some irregular slopes; cuts and fills are needed for good alinement; some areas are stony.	Substratum has low fertility; some stones and boulders.	Slight.
Fair stability; fair compaction characteristics; slow permeability when compacted; good resistance to piping; moderate erodibility.	Not needed; well drained.	Deep soils; medium to high water-holding capacity; medium intake rate; undulating and rolling; erodible.	Most soil features favorable; many irregular slopes; cuts and fills are needed for good alinement; some areas are stony.	Substratum has low fertility; somewhat droughty; some stones and boulders.	Slight.

TABLE 6.—*Engineering interpretations*

Soil series and map symbols	Suitability as a source of—			Soil features affecting engineering practices—	
	Topsoil [1]	Sand and gravel	Road fill [2]	Highway location	Farm ponds: Reservoir area
Barnes-Buse-Arvilla (BcB, BcB2, BcC2).	Poor; surface layer in most places is thin and stony.	Good to not suitable; small pockets of gravel and sand.	Fair to good; glacial till has pockets of gravel and sand; fair shear strength; medium to low compressibility; good to fair workability.	Susceptible to differential frost heaving; sloping, gravelly soils are eroded easily.	Rapid permeability and seepage in gravelly pockets.
Beotia (BeA, BeB)	Good	Good to fair; thickness of overburden ranges from 3 to 5 feet.	Subsoil fair to poor; deeper material good; good to fair shear strength; low volume change; good bearing capacity.	Moderate susceptibility to frost action in upper 3 to 5 feet; none below 5 feet.	Moderately rapid permeability and seepage rate in upper 3 to 5 feet; rapid rates below 5 feet; not suitable for farm ponds or pits.
Blue Earth (Bh)	Good; surface layer in most places contains more than 10 percent organic matter, contains many shell fragments and is calcareous; waterlogged in some places.	Not suitable	Upper layer not suitable; underlying material fair when drained; fair shear strength; medium compressibility; high water table.	High water table; high susceptibility to frost action; high compressibility; poor bearing strength.	High water table; suitable for pits.
Brookings (BkA, BkB)	Good	Not suitable	Subsoil poor; deeper material fair; fair shear strength; medium compressibility; good to fair workability.	Seasonal high water table in some places; moderate to high susceptibility to frost action.	Moderate permeability; slow seepage rate; most areas nearly level; some suitable sites for pits.
Buse (BlE, BlF)	Poor; surface layer is thin and in many places is stony or eroded.	Not suitable; few very small gravelly or sandy pockets.	Fair; fair shear strength; medium compressibility.	Few small pockets of sand and gravel can cause differential frost heaving; moderately steep or steep and erodible.	Moderate permeability; slow seepage rate; look for pockets or lenses of sand or gravel.
Buse, stony (BnF)	Not suitable	Not suitable, except possible few gravelly or sandy areas.	Not suitable	Many stones and boulders; high potential for differential frost heaving.	Stony; investigate each site closely.
Buse-Arvilla (BrD2, BrF).	Poor; thin surface layer; many areas eroded.	Good to not suitable; sand or gravel is present in small pockets.	Fair to good; glacial till is part sand and gravel; fair shear strength; medium to low compressibility; good to fair workability.	Susceptible to differential frost heaving; gravelly, sloping soils erode easily.	Gravelly soils have rapid permeability and rapid seepage rate; generally unsuitable.

See footnotes at end of table.

of the soils—Continued

Soil features affecting engineering practices—Continued					Limitations for septic tank fields
Farm ponds—Con.: Embankment	Agricultural drainage	Irrigation (sprinkler)	Terraces and diversions	Waterways	
Fair stability; slow to moderate permeability if well mixed and compacted; moderate erodibility.	Not needed; well drained.	Some deep and some shallow soils; high to low water-holding capacity; medium to rapid intake rate.	Shallow soils over gravel are droughty and highly erodible; many irregular slopes; some stones.	Low fertility; gravelly soils are droughty and highly erodible; stones and boulders in some areas.	Slight.
Poor to fair stability and moderate permeability when compacted in upper 3 to 5 feet; sand and gravel below 5 feet have rapid permeability when compacted.	Not needed; well drained.	Deep soil; 3 to 5 feet to sand and gravel; moderate to high water-holding capacity. Medium intake rate above the sand and gravel; highly suitable.	Soil features favorable; slope patterns good.	Soil features favorable.	Slight to severe; gravelly substratum can permit contamination of nearby water supplies.
Upper 3½ feet not suitable; high organic-matter content; deeper material has fair stability and slow permeability when compacted; high water table.	Moderate permeability; high water table; surface and subsurface drainage needed; ground water in some places has high content of magnesium sulfate.	Deep soil; high water-holding capacity; medium to slow intake rate high water table; drainage needed.	Not needed; nearly level; little hazard of erosion.	High water table; drainage needed before waterway is built and vegetation is planted.	Severe; high water table; moderate to slow percolation rate.
Upper 3 feet, poor to fair stability and moderate erodibility; till has fair stability, slow to moderate permeability when compacted; medium compressibility, and poor to fair resistance to piping.	Not needed; moderately well drained.	Deep soil; high water-holding capacity; medium intake rate.	Moderately well drained; good slope pattern; few limitations; slight grade essential.	Soil features favorable; waterlogging in some wet years makes vegetation difficult to establish.	Slight to moderate seasonal high water table in some places; moderate percolation rate.
Fair stability and compaction; slow permeability when compacted; good resistance to piping; moderately erodible.	Not needed; well drained.	Moderately steep or steep, erodible soil.	Too steep	Low fertility; moderately steep or steep, erodible, and droughty; some areas are stony.	Severe; slope makes construction and operation difficult; moderate percolation rate.
Stony; not suitable	Not needed	Stony; generally not suitable for irrigation.	Stony	Not needed; stony grassland.	Severe; stones and boulders.
Fair stability; slow to moderate permeability if mixed and compacted; moderate to high erodibility.	Not needed; well drained or excessively drained.	Sloping to steep; erodible; generally not suitable.	Moderately steep or steep; erodible; irregular slopes; low fertility; shallow or gravelly areas are droughty; some areas suitable for diversions.	Low fertility; moderately steep or steep; shallow or gravelly areas are droughty; some areas are stony.	Severe; slope makes construction and operation difficult; rapid percolation rate.

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TABLE 6.—*Engineering interpretation*

Soil series and map symbols	Suitability as a source of— Topsoil [1]	Sand and gravel	Road fill [2]	Soil features affecting engineering practices— Highway location	Farm ponds: Reservoir area
Buse-Barnes (BoD, BoD2).	Poor; thin surface layer; many areas eroded.	Not suitable	Fair; fair shear strength; good to fair workability; medium compressibility; fair compaction characteristics.	Some small pockets of sand and gravel may cause differential frost heaving; moderately steep, erodible.	Moderate permeability; slow seepage rate; look for pockets or lenses of sand or gravel.
Colvin (Co)	Good; calcareous surface layer; wet part of the time.	Not suitable	Poor to fair when drained; fair shear strength; medium compressibility; good to fair workability.	Seasonal high water table; moderate susceptibility to frost action.	Seasonal high water table; suitable for pits.
Crofton (CrC)	Poor; thin surface layer; many areas eroded.	Not suitable	Poor to fair; fair to poor shear strength; poor workability and compaction characteristics; fair bearing capacity.	Moderate to high susceptibility to frost action; moderate erodibility.	Moderate permeability; slow seepage rate; look for lenses of sand.
Dickey, silty variant (DcA, DcB).	Fair; surface layer is sandy, thin in many places.	Not suitable; sandy layer is less than 3 feet thick; sand is mixed with finer material.	Upper 5 feet fair to good if mixed; deeper layers are fair; high susceptibility to frost action.	Side slopes highly erodible; high potential for differential frost heaving; excessive natural drainage.	Rapid permeability in upper 3 feet; moderate permeability and slow seepage rate below 3 feet.
Divide (Dv)	Good; calcareous surface layer; seasonal high water table.	Good to fair; seasonal high water table.	Subsoil fair to poor; deeper layers good; seasonal high water table; good to fair shear strength; very low compressibility; good compaction characteristics.	Seasonal high water table; moderate to very high susceptibility to frost action in upper 2 to 5 feet.	Moderate permeability in upper 2 to 5 feet; rapid permeability in sand and gravel below 5 feet; seasonal high water table; suitable for pits.
Estelline (EsA)	Good	Good to fair; thickness of overburden ranges from 2 to 3 feet.	Subsoil fair to poor; deeper layers good; good to fair shear strength; low volume change; good bearing capacity.	Moderate susceptibility to frost action in upper 2 to 3 feet.	Moderately rapid permeability and seepage rate in upper 2 to 3 feet; rapid permeability below 3 feet; not suitable for farm ponds or pits.

See footnotes at end of table.

of the soils—Continued

Soil features affecting engineering practices—Continued						Limitations for septic tank fields
Farm ponds—Con. Embankment	Agricultural drainage	Irrigation (sprinkler)	Terraces and diversions	Waterways		
Fair stability; fair compaction; slow permeability when compacted; good resistance to piping; moderate erodibility.	Not needed; well drained.	Moderately steep; erodible; generally not suitable.	Moderately steep; some areas are stony; some areas suitable for diversions.	Low fertility; moderately steep; droughty; erodible; some stones and boulders.		Moderate; slope makes construction and operation difficult; rapid percolation rate.
Fair stability; fair compaction characteristics; slow permeability when compacted; moderate erodibility; seasonal high water table.	Seasonal high water table; moderate permeability; subject to flooding; surface drainage is beneficial, but subsurface drainage is needed for best production; ground water may have high content of magnesium sulfate.	Deep soil; high water-holding capacity; medium intake rate; seasonal high water table; drainage needed.	Not needed; nearly level.	Seasonally high water table; subsurface drainage is helpful during construction and establishment of vegetation.		Moderate to severe; seasonal high water table; moderate percolation rate.
Fair stability; slow permeability when compacted; fair to poor resistance to piping; moderate erodibility.	Not needed; well drained.	Deep soil; moderate water-holding capacity; medium intake rate; undulating and sloping; moderate erodibility.	Soil features favorable; slope pattern good.	Low fertility; high erodibility.		Slight to severe; some slopes too steep; dense clay substratum in some areas has slow percolation rate.
Fair stability; moderate to rapid permeability when compacted; poor resistance to piping; high erodibility in upper 3 feet; slow permeability below 3 feet when compacted and good resistance to piping.	Not needed; excessive natural drainage.	Deep soil; 3 feet (range 2 to 4 feet) of sandy loam and sand; low water-holding capacity and rapid intake rate; deeper material is finer textured; frequent applications of water are required.	Sandy soil; terrace channels are droughty and erodible; low fertility; good slope pattern.	Sandy soil; droughty; erodible; low fertility; establishment of vegetation is difficult.		Slight.
Upper 2 to 5 feet, fair stability and moderate permeability when compacted; deeper sand and gravel, rapid permeability when compacted; seasonal high water table.	Moderate permeability; subsurface drainage needed for best production.	Moderately deep and deep soil; moderate to high water-holding capacity; medium intake rate; seasonal high water table; subsurface drainage needed.	Not needed; nearly level.	Seasonal high water table; subsurface drainage aids in construction and in establishment of vegetation; gravelly substratum is highly erodible.		Moderate to severe; seasonal high water table; gravelly substratum may permit contamination of ground water; rapid percolation rate.
Poor to fair stability and moderate permeability when compacted in upper 3 feet; sand and gravel below 3 feet have rapid permeability when compacted.	Not needed; well drained.	Moderately deep soil; 2 to 3 feet to sand and gravel; moderate water-holding capacity and medium intake rate above the sand and gravel; highly suitable for irrigation.	Gravelly substratum, if exposed, is droughty and highly erodible; other soil features favorable; good slope pattern.	Droughty, low fertility, and high erodibility wherever gravelly substratum is shallow or exposed.		Slight to severe; rapid percolation rate; gravelly substratum may permit contamination of ground water.

TABLE 6.—*Engineering interpretations*

Soil series and map symbols	Suitability as a source of—			Soil features affecting engineering practices—	
	Topsoil [1]	Sand and gravel	Road fill [2]	Highway location	Farm ponds
					Reservoir area
Flandreau (FaA, FaB)	Good; thin surface layer in some places.	Good to not suitable; sandy substratum is thin in some places and is underlain by finer material.	Fair to good if mixed; good to fair shear strength; low to medium compressibility; fair to good compaction.	Sloping soil erodes easily; slightly susceptible to differential frost heaving.	Moderately rapid permeability and seepage rate; not suitable for farm ponds or pits.
Flom (Fc)	Fair to good; seasonal high water table.	Not suitable	Fair to poor; seasonal high water table; fair shear strength and compaction characteristics; good workability when drained.	Seasonal high water table; moderate susceptibility to frost action.	Moderate permeability; slow seepage rate; seasonal high water table; suitable for pits.
Fordville (FdA, FdB, FdB2).	Good	Good to fair; in some places gravel is only a few feet thick; thickness of overburden ranges from 2 to 3 feet.	Subsoil fair; deeper layers good; good shear strength; low compressibility.	Moderate susceptibility to frost action in upper 2 to 3 feet; none below 3 feet.	Moderately rapid permeability and seepage rate in upper 2 to 3 feet; rapid below 3 feet; not suitable for farm ponds or pits.
Forman (FmA)	Fair; thin surface layer.	Not suitable	Fair; fair shear strength; good to fair workability; moderate volume change.	Moderate susceptibility to frost action.	Moderately slow permeability; slow seepage rate; nearly level; suitable for pits if surface water is available.
Forman and Barnes (FrB, FrB2).	Fair; thin surface layer in many places.	Not suitable	Fair; fair shear strength; medium compressibility; good to fair workability.	Moderate susceptibility to frost action.	Moderate to moderately slow permeability; slow seepage rate; slope not suitable for farm ponds.
Fulda (Fu)	Fair to poor; seasonal high water table.	Not suitable	Poor to fair if drained and if used in well-drained sites; fair to poor shear strength and workability; medium to high compressibility.	Seasonal high water table; high susceptibility to frost action.	Slow permeability; slow seepage rate; seasonal high water table; suitable for pits.
Hamerly (HaA)	Fair to good; calcareous surface layer; thin surface layer in some places.	Not suitable	Poor to fair; fair shear strength; medium compressibility; fair to good compaction characteristics.	Seasonal high water table in some places; moderate susceptibility to frost action.	Moderate permeability; slow seepage rate; suitable for pits if surface water is available.

See footnotes at end of table.

of the soils—Continued

Soil features affecting engineering practices—Continued					Limitations for septic tank fields
Farm ponds—Con.: Embankment	Agricultural drainage	Irrigation (sprinkler)	Terraces and diversions	Waterways	
Upper 3 feet, fair stability and moderate permeability when mixed and compacted; below 3 feet, permeability when compacted ranges from slow to rapid.	Not needed; well drained.	Moderately deep over sandy material; moderate water-holding capacity and medium intake rate in upper 3 feet; highly suitable for irrigation.	Sandy subsoil, if exposed, is droughty and highly erodible; fair to good slope pattern; other soil features favorable.	Sandy subsoil at depth of 2 to 3 feet is droughty and erodible if exposed; low fertility.	Slight; sandy substratum may permit contamination of ground water.
Seasonal high water table; fair stability; slow permeability when compacted; good resistance to piping.	Moderate permeability; seasonal high water table; surface drainage permits farming; subsurface drainage needed for best production.	Deep soil; high water-holding capacity; slow intake rate; seasonal high water table; subsurface drainage needed.	Not needed; nearly level.	Seasonal high water table; subsurface drainage helps in construction and in establishment of vegetation.	Moderate to severe; seasonal high water table; moderate percolation rate.
Upper 2 to 3 feet, fair stability and moderate permeability when compacted; sand and gravel below 3 feet, rapid permeability when compacted.	Not needed; well drained.	Moderately deep soil; 2 to 3 feet to sand and gravel; moderate water-holding capacity and medium intake rate; highly suitable for irrigation.	Gravelly substratum, if exposed, is droughty and highly erodible; few stones and boulders; fair slope pattern.	Gravelly substratum at depth of 2 to 3 feet is droughty and erodible if exposed; low fertility.	Slight to severe; rapid percolation rate; gravelly substratum may permit contamination of ground water.
Fair stability and compaction characteristics; slow permeability when compacted; good resistance to piping.	Not needed; well drained.	Deep soil; high water-holding capacity; moderately slow permeability in subsoil; suitability doubtful.	Moderately slow permeability in subsoil; slight grade essential; few stones and boulders; fair slope pattern.	Firm, compact subsoil is difficult to vegetate if exposed; few stones and boulders.	Moderate; moderate percolation rate.
Fair stability; fair compaction characteristics; slow permeability when compacted; good resistance to piping; moderate erodibility.	Not needed; well drained.	Deep soils; high water-holding capacity; medium to slow intake rate; suitability doubtful.	Subsoil in some areas has moderately slow permeability; slight grade essential; few stones and boulders; fair slope pattern.	Firm, compact subsoil in some areas is difficult to vegetate if exposed; few stones and boulders.	Slight to moderate; moderate percolation rate in places.
Poor stability; poor compaction characteristics; slow permeability when compacted; high shrink-swell potential; seasonal high water table.	Slow permeability; seasonal high water table; surface drainage permits farming; subsurface drainage needed for best production.	Deep soil; high moisture-holding capacity; slow intake rate; seasonal high water table; subsurface drainage needed; suitability doubtful.	Not needed; nearly level.	Seasonal high water table; subsurface drainage helps in construction and in establishment of vegetation; dense, clayey subsoil is difficult to work and to vegetate.	Severe; seasonal high water table; dense clay substratum in some areas has slow percolation rate.
Fair stability and compaction characteristics; slow permeability when compacted.	Not needed; moderately well drained.	Deep soil; medium intake rate; moderate to high water-holding capacity; seasonal high water table in some places.	Poor slope pattern; few stones and boulders.	Low fertility; waterlogged in some wet seasons making establishment of vegetation difficult.	Slight to moderate; seasonal high water table in some places; moderate percolation rate.

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TABLE 6.—*Engineering interpretations*

Soil series and map symbols	Suitability as a source of—			Soil features affecting engineering practices—	
	Topsoil [1]	Sand and gravel	Road fill [2]	Highway location	Farm ponds: Reservoir area
Hidewood (Hd)	Good; seasonal high water table.	Not suitable	Subsoil poor; deeper layers fair; seasonal high water table; fair shear strength; moderate volume change.	Seasonal high water table; moderate susceptibility to frost action.	Moderate permeability; slow seepage rate; seasonal high water table; suitable for pits.
Kranzburg (KrA, KrB, KrB2).	Good; thin, eroded surface layer on some sloping areas.	Not suitable	Subsoil fair to poor; deeper layers fair; fair shear strength; moderate volume change.	Side slopes in upper 3 feet moderately erodible; moderate susceptibility to frost action.	Moderate permeability; slow seepage rate; slope generally too low for farm ponds; some level sites suitable for pits if surface water is available.
Lake beaches (La)	Poor; variable; stony, sandy, or wet.	Not suitable; sand is thin in most places.	Not suitable to good; check each site; seasonal high water table.	Seasonal high water table; susceptible to differential frost heaving.	Variable; check each site; seasonal high water table; some nearly level sites are suitable for pits.
Lamoure (Lm)	Fair; thick surface layer; seasonal high water table.	Not suitable	Upper 3 feet not suitable to poor; deeper layers fair to poor; seasonal high water table; fair shear strength; moderate to high volume change.	Seasonal high water table; occasional overflow; moderate susceptibility to frost action; poor bearing capacity; high compressibility.	Moderate permeability, variable seepage rate because thin, sandy strata are present in some places; seasonal high water table; suitable for pits.
Lamoure and LaPrairie (Lo).	Fair to good; variable soil; frequently flooded.	Not suitable; few local pockets of sand or gravel.	Not suitable to poor; check each site; high water table in some places.	Frequently flooded; high water table in some places; moderate to high susceptibility to frost action.	Variable soil; suitable for pits.
LaPrairie (Lp)	Good; thick surface layer.	Not suitable; underlying material sandy in some places but silty in most.	Upper 2 to 3 feet not suitable to poor; deeper layers poor to good; fair to poor shear strength; fair workability; poor compaction characteristics.	Occasionally flooded; moderate to high susceptibility to frost action.	Moderate permeability; variable seepage rate because some thin sandy strata are present; some sites suitable for pits.
Lismore (LsA)	Good	Not suitable	Fair; fair shear strength; moderate volume change; fair to good compaction characteristics.	Seasonal high water table in some areas; moderate susceptibility to frost action.	Moderate permeability; slow seepage rate; some sites suitable for pits if surface water is available.

See footnotes at end of table.

of the soils—Continued

Soil features affecting engineering practices—Continued					Limitations for septic tank fields
Farm ponds—Con.: Embankment	Agricultural drainage	Irrigation (sprinkler)	Terraces and diversions	Waterways	
Seasonal high water table; fair stability; moderate to slow permeability when compacted.	Moderate permeability; seasonal high water table; surface drainage permits farming; subsurface drainage needed for best production.	Deep soil; high water-holding capacity; medium intake rate; seasonal high water table; subsurface drainage needed.	Not needed; nearly level.	Seasonal high water table; subsurface drainage aids construction and establishment of vegetation; stones and cobblestones in underlying till in some places.	Moderate to severe; seasonal high water table; moderate percolation rate.
Upper 3 feet, poor to fair stability and moderate to high erodibility; deeper till, fair stability and low permeability when compacted.	Not needed; well drained.	Deep soil; high water-holding capacity; medium intake rate; erosion hazard on sloping areas.	Soil features favorable; good slope pattern.	Erosion hazard on sloping areas; stones, cobblestones, sand, or gravel in underlying till in most areas; few limitations.	Moderate; moderate percolation rate.
Variable; stony in some places; generally fair stability and moderate permeability when mixed and compacted.	Seasonal high water table; variable texture, sandy in most places.	Variable; sandy in most places; seasonal high water table; suitability doubtful.	Not needed; nearly level.	Low fertility; sandy in most places; some stones and boulders; seasonal high water table.	Severe; seasonal high water table.
Thick surface layer has high organic-matter content; high compressibility; poor shear strength; moderate permeability when compacted; suitable for temporary impoundments.	Seasonal high water table; occasional overflow; surface drainage permits farming; subsurface drainage needed for best production; good outlets not available in many areas.	Deep soil; high water-holding capacity; medium intake rate; seasonal high water table; subsurface drainage needed.	Not needed; nearly level.	Seasonal high water table; occasional overflow; subsurface drainage aids construction and establishment of vegetation.	Severe; occasional overflow; seasonal high water table; moderate percolation rate.
Variable soil; high organic-matter content; not suitable for embankments; suitable for temporary impoundments.	Frequently flooded; wetness variable; drainage generally not practical unless major floods are controlled.	Deep soils; frequently flooded; wetness variable; not suitable.	Not needed	Frequently flooded; wet soil in some places hinders construction and establishment of vegetation.	Severe; frequently flooded; moderate to rapid percolation rate.
Thick surface layer has high organic-matter content and high compressibility; suitable for temporary impoundments.	Generally not needed; moderately well drained; moderate permeability.	Deep soil; high water-holding capacity; medium intake rate.	Not needed; nearly level.	Occasionally flooded; soil features favorable.	Severe; occasionally flooded; rapid percolation rate.
Fair stability; slow permeability when compacted; good compaction characteristics; good resistance to piping.	Not needed; moderately well drained.	Deep soil; high water-holding capacity; medium intake rate.	Moderately well drained soil; slight grade essential; good slope pattern; stones and boulders in some areas.	Soil features favorable; waterlogged in some wet seasons and establishment of vegetation is difficult; some areas stony.	Slight to moderate; seasonal high water table in some places; moderate percolation rate.

TABLE 6.—*Engineering interpretatations*

Soil series and map symbols	Suitability as a source of—			Soil features affecting engineering practices—	
	Topsoil [1]	Sand and gravel	Road fill [2]	Highway location	Farm ponds: Reservoir area
Muck (Mu)	Poor if used alone; oxidizes readily and is erodible; fair to good if mixed with mineral soil.	Not suitable	Not suitable; underlying material is fair when drained; fair shear strength; moderate to high volume change.	High water table; high compressibility; high susceptibility to frost action.	1 foot to 3½ feet of organic soil over material that has moderately slow to moderate permeability; slow to moderate seepage rate; suitable for pits.
Oak Lake (OlA, OlB)	Good	Not suitable	Upper 2 feet not suitable; high organic-matter content; deeper material fair; fair shear strength; medium compressibility; fair compaction characteristics; good workability.	Seasonal high water table in some places; moderate susceptibility to frost action.	Moderate permeability; slow seepage rate; many nearly level areas; some sites suitable for pits if surface water is available.
Oldham (Om)	Good to fair; surface layer contains 8 to 10 percent organic matter, contains many shell fragments, and is calcareous; waterlogged in some places.	Not suitable	Fair to poor when drained; fair shear strength; medium compressibility; high water table.	High water table; high susceptibility to frost action; high compressibility; poor bearing strength.	High water table; suitable for pits.
Parnell (Pa)	Fair; sometimes waterlogged.	Not suitable	Upper 2 feet not suitable; high organic-matter content; deeper material poor to fair when drained; fair shear strength.	High water table; moderate susceptibility to frost action.	Moderately slow permeability; slow seepage rate; high water table; most sites suitable for pits.
Poinsett (PoB, PoB2)	Good; surface layer is thin and eroded in some places.	Not suitable	Subsoil poor; deeper layers fair; fair shear strength; fair compaction characteristics; moderate to high volume change.	Side slopes moderately erodible; moderate susceptibility to frost action.	Moderate permeability; slow seepage rate; slopes mostly not suitable for farm ponds.
Rauville (Ra)	Poor; usually waterlogged; surface layer is calcareous.	Not suitable	Not suitable; high organic-matter content; high water table.	High water table; high susceptibility to frost action; frequently flooded; high compressibility; poor bearing capacity.	Moderate to moderately slow permeability; moderate to slow seepage rate; high water table; suitable for pits.
Sinai (ScA, ScB)	Fair; surface layer has high clay content.	Not suitable	Subsoil poor; deeper layers poor to fair; fair shear strength; fair workability; high volume change.	Seasonal high water table in some places; moderate susceptibility to frost action.	Moderate to slow permeability; slow seepage rate; some sites suitable for pits if surface water is available.

See footnotes at end of table.

of the soils—Continued

Soil features affecting engineering practices—Continued					Limitations for septic tank fields
Farm ponds—Con.: Embankment	Agricultural drainage	Irrigation (sprinkler)	Terraces and diversions	Waterways	
1 foot to 3½ feet of organic soil not suitable for embankments; deeper material has fair stability and compaction characteristics when drained.	High water table; surface and subsurface drainage needed.	Organic soil; high water-holding capacity; high water table; drainage needed.	Not needed; nearly level.	High water table; drainage needed.	Severe; high water table; moderate percolation rate.
Fair stability; slow permeability when compacted; moderate erodibility.	Not needed; moderately well drained.	Deep soil; high water-holding capacity; medium intake rate.	Moderately well drained; slight grade essential; fair slope pattern.	Soil features favorable; waterlogged in some wet seasons; then establishment of vegetation is difficult; few stones.	Slight to moderate; seasonal high water table in some places; moderate percolation rate.
Fair stability and compaction characteristics; slow permeability when compacted; good resistance to piping; high water table.	Moderate permeability; high water table; surface and subsurface drainage needed; ground water in some places has high content of magnesium sulfate.	Deep soil; high water-holding capacity; medium to slow intake rate; high water table; drainage needed.	Not needed; nearly level; little hazard of erosion.	High water table; drainage needed before waterway is built and vegetation is planted.	Severe; high water table; moderate to slow percolation rate.
Fair stability; slow permeability when compacted; good resistance to piping; suitable if drained.	Moderately slow permeability; high water table; surface and subsurface drainage needed.	Deep soil; high water-holding capacity; slow intake rate; high water table; drainage needed.	Not needed; nearly level.	High water table; drainage needed before waterway is built and vegetation is planted.	Severe; high water table; slow percolation rate.
Fair stability; slow permeability when compacted; fair resistance to piping; erodible.	Not needed; well drained.	Deep soil; high water-holding capacity; medium intake rate; erodible.	Soil features favorable; good slope pattern.	Soil features favorable; erodible.	Moderate; moderate percolation rate.
High organic-matter content; high water table; high compressibility; not suitable.	Moderately slow permeability; high water table; frequently flooded; surface and subsurface drainage needed; good outlets not available in most places.	Deep soil; high water-holding capacity; medium to slow intake rate; frequently flooded; high water table; suitability doubtful.	Not needed; nearly level.	High water table; flooded frequently; drainage needed before waterway is built and vegetation is planted.	Severe; high water table; flooded frequently; slow percolation rate.
Poor stability; poor compaction characteristics; slow permeability when compacted; high to moderate shrink-swell potential.	Not needed; moderately well drained.	Deep soil; high water-holding capacity; slow intake rate.	Moderately well drained; clayey, compact subsoil; slight grade essential.	Dense clayey subsoil hinders construction, and hinders growth of vegetation; waterlogged in some wet seasons.	Severe; dense, clayey subsoil and substratum; slow percolation rate in some places; seasonal high water table in some aplces.

TABLE 6.—*Engineering interpretations*

Soil series and map symbols	Suitability as a source of— Topsoil [1]	Suitability as a source of— Sand and gravel	Suitability as a source of— Road fill [2]	Soil features affecting engineering practices— Highway location	Soil features affecting engineering practices— Farm ponds: Reservoir area
Singsaas (SgB, SgB2)	Good; some areas eroded; some stony.	Not suitable	Upper 2 feet poor to not suitable; high organic-matter content; below 2 feet fair to poor; fair shear strength; fair compaction characteristics; good workability.	Moderate susceptibility to frost action.	Moderate permeability; slow seepage rate; slope generally not suitable for farm ponds.
Sioux (SoF)	Not suitable; surface layer is thin and gravelly.	Good; material desired is only a few feet thick in some areas.	Good; good shear strength; very low compressibility; good compaction characteristics.	Slopes erode easily	Rapid permeability; rapid seepage rate; not suitable.
Svea (SvA, SvB)	Good to fair; some areas stony.	Not suitable	Fair; fair shear strength; fair workability; moderate volume change; fair bearing capacity.	Seasonal high water table in some places; moderate susceptibility to frost action.	Moderate permeability; slow seepage rate; some nearly level sites suitable for pits.
Sverdrup (SwB, SwC)	Good to fair; surface layer is sandy and in some places is eroded and thin.	Fair to poor for sand; sand ranges from clean to dirty; predominantly medium to fine sand.	Good; good shear strength; good compaction characteristics; low compressibility.	Side slopes erode easily.	Rapid permeability; rapid seepage rate; not suitable.
Terril (TeB)	Good; very thick surface layer.	Not suitable	Upper 3½ feet not suitable; deeper layers fair to poor; fair to poor shear strength; medium compressibility.	High susceptibility to frost action in upper 3½ feet; moderate in deeper layers.	Upper 3½ feet, high organic-matter content; moderate permeability; moderate seepage rate; deeper layers, slow seepage rate.
Vallers (Va)	Fair; surface layer has high lime content; seasonal high water table.	Not suitable	Fair; fair shear strength; medium compressibility; good workability when drained; seasonal high water table.	Seasonal high water table; moderate susceptibility to frost action.	Moderately slow permeability; slow seepage rate; seasonal high water table; suitable for pits.

See footnotes at end of table.

of the soils—Continued

Soil features affecting engineering practices—Continued					Limitations for septic tank fields
Farm ponds—Con. Embankment	Agricultural drainage	Irrigation (sprinkler)	Terraces and diversions	Waterways	
Fair stability; slow permeability when compacted; moderate erodibility.	Not needed; well drained.	Deep soil; high water-holding capacity; medium intake rate.	Most soil features favorable; many slopes irregular; cuts and fills needed for good alinement; some areas stony.	Low fertility if substratum is exposed; some stones and boulders; few limitations.	Slight.
Good stability; rapid permeability when compacted; erodible.	Not needed; excessively drained.	Very shallow soil; less than 1 foot over sand and gravel; very low water-holding capacity; very rapid intake rate; suitability very doubtful.	Very shallow over sand and gravel; poor slope pattern; low fertility; droughty; stones and boulders in some areas.	Very shallow over sand and gravel; very droughty; erodible; low fertility; establishment of vegetation is difficult.	Slight to severe; rapid percolation rate; gravelly substratum permits contamination of ground water; some slopes too steep.
Fair stability; fair compaction characteristics; slow permeability when compacted; medium compressibility; good resistance to piping; moderate erodibility.	Not needed; moderately well drained.	Deep soil; high water-holding capacity; medium intake rate.	Moderately well drained; slight grade essential; fair slope pattern; few stones and boulders in some areas; most soil features favorable.	Soil features favorable; waterlogged in some wet seasons; then establishment of vegetation is difficult; few stones.	Moderate; seasonal high water table in some places; rapid to moderate percolation rate.
Fair stability; moderate to rapid permeability when compacted; poor resistance to piping; high erodibility.	Not needed; excessively drained.	Sandy soil; 1 to 2 feet of sandy loam over loamy sand; low water-holding capacity; rapid intake rate; frequent applications needed.	Shallow soil over sand or loamy sand; channels are droughty and highly erodible; fair to good slope pattern; low fertility.	Shallow to sand or loamy sand; droughty; erodible; low fertility; establishment of vegetation is difficult.	Slight to severe; rapid percolation rate; sandy substratum may permit contamination of ground water.
Upper 3½ feet, high organic-matter content; not suitable; deeper layers, fair compaction characteristics, fair stability.	Not needed; moderately well drained.	Deep soil; high water-holding capacity; medium intake rate.	Moderately well drained; slight grade essential; good slope pattern; few limitations.	Soil features favorable.	Slight.
Fair stability; slow permeability when compacted; good resistance to piping; erodible.	Seasonal high water table; moderately slow permeability; surface drainage permits farming; subsurface drainage needed for best production; ground water may have high content of magnesium sulfate.	Deep soil; high water-holding capacity; medium intake rate; seasonal high water table; subsurface drainage needed.	Not needed; nearly level.	Seasonal high water table; subsurface drainage aids construction and establishment of vegetation; low fertility; high lime content.	Moderate to severe; seasonal high water table; moderate percolation rate.

TABLE 6.—*Engineering interpretations*

Soil series and map symbols	Suitability as a source of—			Soil features affecting engineering practices—	
	Topsoil [1]	Sand and gravel	Road fill [2]	Highway location	Farm ponds: Reservoir area
Vienna (VeB, VeB2, VeC2).	Good to fair; surface layer in some places thin and eroded; some areas stony.	Not suitable	Fair; fair shear strength; good workability; good compaction characteristics; moderate volume change.	Moderate susceptibility to frost action.	Moderate permeability; slow seepage rate.
Waubay (WaA, WaB).	Good	Not suitable	Poor to fair; fair to poor shear strength and bearing capacity; high volume change.	Seasonal high water table in some places; moderate susceptibility to frost action; side slopes moderately erodible.	Moderately slow permeability; slow seepage rate; not suitable for farm ponds; some sites suitable for pits if surface water is available.

[1] Ratings refer to the surface layer.

topsoil is needed in a new waterway to encourage growth of grass. Tile drainage is needed to establish a good grass sod in waterways on many areas of wet soils such as the Flom, Vallers, Hidewood, and Parnell.

The well-drained Barnes, Kranzburg, Poinsett, and Vienna soils generally are well suited to filter fields for septic tanks. The sandy or gravelly Sioux, Beotia, Estelline, Sverdrup, and Arvilla soils are also well suited if there is no danger of contaminating a nearby water supply.

Formation and Classification of the Soils

This section consists of two main parts. The first part relates the five factors of soil formation to the soils of Lincoln County with particular emphasis on the parent materials. The second part deals with the classification of the soils.

Factors of Soil Formation

Soil is produced by the action of soil-forming processes on materials deposited or accumulated by geologic agencies. The characteristics of the soil at any given point are determined by the physical and mineralogical composition of the parent materials; the climate under which the soil material has accumulated and existed since accumulation; the plant and animal life on and in the soil; the relief, or lay of the land; and the length of time the processes of soil formation have acted on the soil material.

Climate and vegetation are active factors of soil formation. They act on the parent material and slowly change it into a natural body that consists of genetically related layers, called horizons. The effects of climate and vegetation are conditioned by relief. The parent material also affects the kind of soil that can be formed and, in extreme cases, determines it almost entirely. Finally, time is needed for the changing of the parent material into a soil. It may be much or little, but some time is always required for formation of soil horizons. In most soils a long time is required 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 unless conditions are specified for the other four. Some of the processes of soil formation are unknown.

Parent material

The soils of Lincoln County have been formed in a number of different kinds of parent material. All these materials except the organic deposits are of glacial origin. The major kinds of parent material in the county are glacial till, loess, lacustrine sediments, glacial outwash, alluvium, colluvium, and organic material. The glacial till exposed in the county is from the Wisconsin glaciation (*4*). In that glaciation there were several substages. Till from the Tazewell, Cary, and Mankato substages is present in the county. About 75 percent of the acreage of soils in the county developed in glacial till, about 10 percent developed in wind-deposited material called loess, and about 15 percent developed in the other forms of parent material. The glacial till, loess, and lacustrine materials are discussed in this section in their order of deposition.

Glacial till, Tazewell substage.—This glacial till is the oldest in the county. It was deposited south and west of the Bemis moraine (fig. 13). Most of this till has been covered by loess. Wherever the loess is very thin or the till is exposed on gentle slopes, Vienna soils developed. On steeper slopes, Buse soils developed. The Tazewell glacial till is difficult to distinguish from the younger Cary or Mankato till. Generally, soils in the Tazewell glacial till in Lincoln County have larger and more numerous lime concretions in the substratum than do the soils in younger till. On most of the steeper slopes the Tazewell till is yellowish brown, but the younger till is light olive brown. The Taze-

of the soils—Continued

Soil features affecting engineering practices—Continued						Limitations for septic tank fields
Farm ponds—Con.	Agricultural drainage	Irrigation (sprinkler)	Terraces and diversions	Waterways		
Embankment						
Fair stability; slow permeability when compacted; good resistance to piping; moderate erodibility.	Not needed; well drained.	Deep soil; high water-holding capacity; medium intake rate; moderate erodibility.	Most soil features favorable; good slope pattern; some areas stony.	Low fertility if substratum is exposed; some areas stony.		Slight.
Fair stability; slow permeability when compacted; fair to poor resistance to piping; erodible.	Not needed; moderately well drained.	Deep soil; high water-holding capacity; medium intake rate.	Moderately well drained; slight grade essential; good slope pattern; few limitations.	Soil features favorable; waterlogged in some wet seasons; then establishment of vegetation is difficult.		Slight to moderate; seasonal high water table in some places; moderate percolation rate.

[2] Ratings refer to material below the surface layer unless otherwise specified.

well landscape has long, simple slopes in a well-developed, dendritic drainage pattern. Closed depressions, a characteristic of the landscape in till of Cary or Mankato age, are normally absent in the Tazewell till.

Loess.—After the Tazewell substage of the Wisconsin glaciation, fine particles of soil were blown out of the flood plains and stream terraces of the valley of the Big Sioux River and deposited on the glacial till plains. This silty material, called loess, has a silt loam or silty clay loam texture. It is nearly homogeneous and does not have the stones and pebbles that are common in glacial till. The loess mantle in the Kranzburg-Vienna and the Beotia-Dickey, silty variants, soil associations has thickness that is around 30 inches. It is somewhat thicker than 30 inches in level areas and thinner in sloping areas. In most places a thin sandy, gravelly, or pebbly layer is present between the loess and the till. The deposition of loess tended to smooth and fill in irregularities in the surface of the glacial ground moraine. The slopes are longer, smoother, and more regular in the parts covered by loess than in the other parts of the county. The major soils developed in loess are the Kranzburg soils on uplands and the Beotia soils on outwash plains and terraces.

Glacial till, Cary substage.—The deposition of loess was followed by the Cary substage of the Wisconsin glaciation. The Bemis moraine and the Cary ground moraine consist of glacial till of Cary age. In most places along the southwestern side of the Bemis moraine, there is a band of gravelly outwash, up to 1 mile wide, that is nearly level and undulating. Arvilla, Sioux, Fordville, Beotia, and Estelline soils developed in this outwash. In the rolling to hilly parts of the Bemis moraine the till has a loam texture. In some places the till has numerous silt pockets. This silt may be post-Tazewell loess. Barnes, Buse, and associated soils developed in the till of the Bemis moraine.

The Cary ground moraine has gently undulating relief. The till resembles loess in some places, but normally it is silty clay loam and has in it some stones. This silty till was probably left by the glacier that moved across the loess-mantled surface (*3*). Singsaas and Oak Lake soils are the principal soils that developed in till of the Cary ground moraine. At the eastern end of this ground moraine the slopes are more strongly undulating, and Barnes and Svea soils developed. Also within the Cary ground moraine are a few areas of clayey, water-laid materials, in which Fulda and Sinai soils developed.

Glacial till, Mankato substage.—The next important glacial event, after the Cary substage, was the Mankato substage of the Wisconsin glaciation. In Lincoln County the Mankato till consists of the Altamont and Gary end moraines, the less conspicuous Canby and Marshall end moraines, and the nearly level to undulating ground moraines lying between the various end moraines (see fig. 13).

The Mankato glacial till is the youngest that is exposed in Lincoln County. The inherent fertility of soils in this glacial till is similar to that of the soils in the Cary and the Tazewell glacial till. Barnes, Buse, Svea, Flom, and Parnell soils developed in the Mankato till. Mankato till in most places is loam, except in the nearly level and very gently undulating, benchlike ground moraine in the northeastern part of the county (see fig. 13), where it is clay loam. The Forman and Aastad soils developed in the clay loam till.

A distinctive landform in the Altamont moraine consists of flat-topped hills and a nearly level, smoothly sloping landscape composed of stratified silty clay and silty clay loam sediments. These sediments are probably of lacustrine origin, and were deposited in temporary lakes that formed in the ice during the glacial period (*3*).

Fulda and Sinai soils developed in the sediments of silty clay that are on the nearly level hilltops. Waubay and Poinsett soils developed in the sediments of silty clay loam that are on nearly level and gently sloping hilltops. Crofton soils developed in sediments of silty clay loam that are on the steeper side slopes.

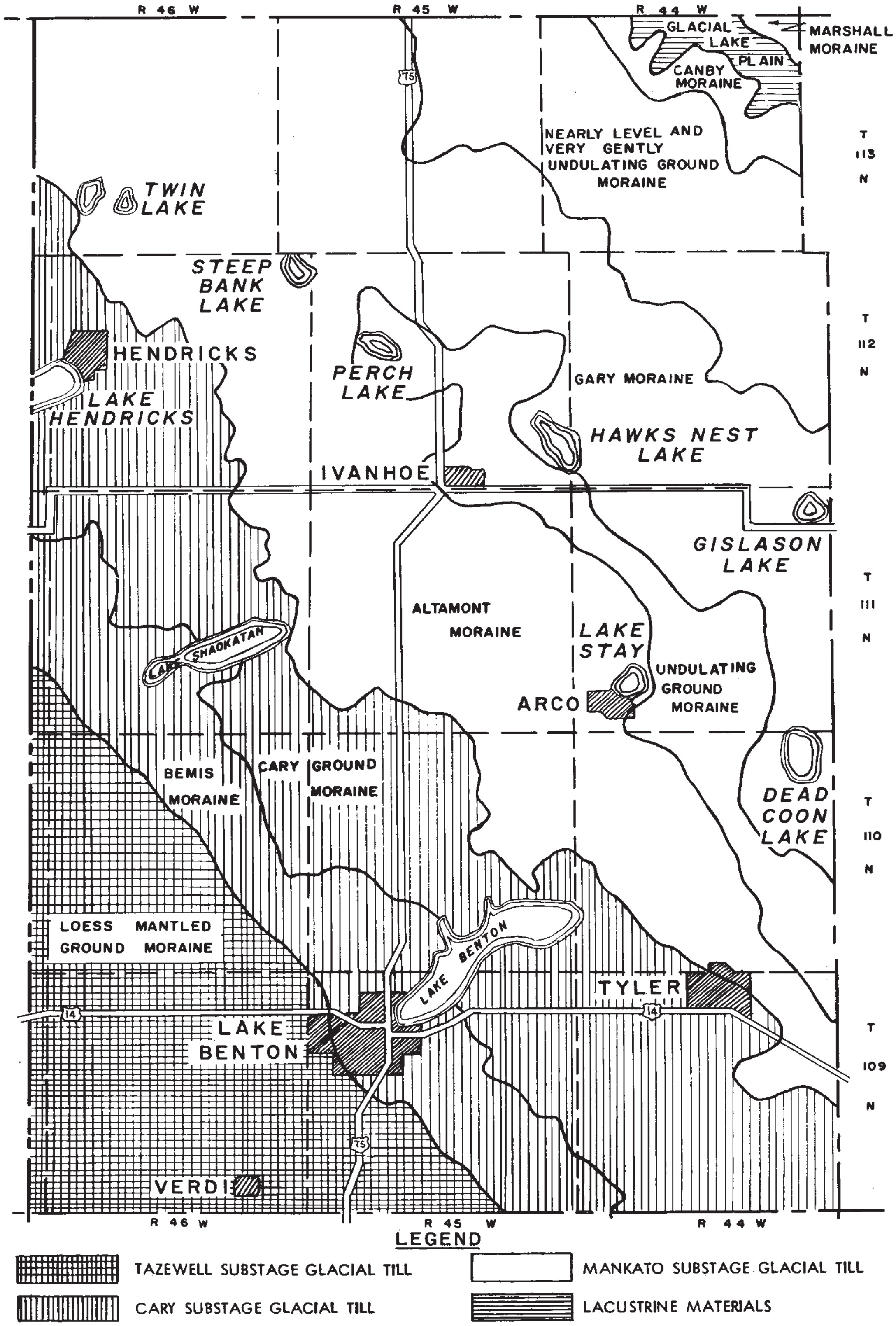

***Figure 13.*—Map of Lincoln County showing major glacial moraines and parent materials of the soils.**

Lacustrine materials of the glacial lake plain.—In the extreme northeastern corner of the county, between the Canby and Marshall end moraines, a nearly level lake plain formed during glacial time. This lake plain is narrow in Lincoln County. In adjoining Lyon and Yellow Medicine Counties and in Lac qui Parle County, it has greater breadth and is extensive. The soil materials consist of lacustrine sediments of medium or moderately fine texture. Colvin soils formed in these lacustrine sediments. In Lincoln County the lacustrine sediments have been covered or mixed in many places with alluvium that was deposited by the North Branch Yellow Medicine River.

Glacial outwash.—Outwash materials have been deposited on small, discontinuous stream terraces along most of the major streams, and in pockets or in layers over the glacial till on uplands throughout the county. The soils in these areas developed in parent material that consists of 1 to 3 feet of loam or sandy loam underlain by gravel and sand. The Fordville, Arvilla, Sioux, Sverdrup, Flandreau, and Dickey soils are the principal soils that developed in this material.

In a major acreage of the Beotia-Dickey, silty variants, soil association, the soil material consists of 2 to 5 feet of silt loam, either loess or water-laid sediments, underlain by outwash sand and gravel. Beotia, Divide, and Estelline soils developed in this material.

Alluvium and colluvium.—Alluvial material has been deposited along the streams in the county. These sediments in most places are many feet thick, dark colored, and limy. Their texture is medium or moderately fine. The Lamoure, Rauville, and LaPrairie soils consist of alluvial material.

In drainageways, on alluvial fans, and near the base of steeper slopes, colluvium has accumulated. Colluvial material is similar to alluvial material, but it is not limy. The Terril soils, in colluvium, are moderately well drained. Other, more poorly drained soils in colluvium are the Hidewood, Flom, and Parnell soils.

Organic material.—Organic material accumulated in some of the closed depressions that had a continuously high water table and luxuriant aquatic vegetation. The organic material has been decomposed to form muck, which generally is about 2 feet thick. Depressions that contain muck are scattered throughout the county, except in the parts that are covered with loess.

Climate

The climate has had pronounced effects on soil development. The frozen soil during winter slows the soil-forming processes. The alternate thawing and freezing, especially in spring, play a part in development of soil structure. The rainfall of the area has affected the leaching of lime. Thickness of the soil from which free lime has been leached has largely determined the thickness of the solum. Climate was responsible to a large degree for the vegetation of grass instead of forests. The grass vegetation has produced soils that have a dark-colored surface layer. Details about the climate are given in the section "General Nature of the County."

Plant and animal life

The native vegetation in Lincoln County consisted of short, medium, and tall grasses, depending on the soil, the drainage, and other site factors. Some of the common grasses were big bluestem, little bluestem, Canada wildrye, prairie cordgrass, indiangrass, blue grama, sideoats grama, needle-and-thread grass, porcupine grass, and rice cutgrass. A variety of flowers flourished on the native prairies, including species of aster, goldenrod, sunflower, blazingstar, rose, lily, harebell, phlox, fringed gentian, and many others. In the marshes, cattails and sedges provided luxuriant vegetation. Soils under grass develop a surface layer that has high content of organic matter. Most uneroded, gently sloping soils have a dark surface layer that is more than 12 inches thick. The steeper soils have a thinner surface layer as a result of greater runoff, sparse vegetation, and natural erosion.

Some mixing of surface soil, subsoil, and parent material by earthworms has occurred in nearly all the soils. The Singsaas and the Oak Lake soils on the Cary ground moraine are examples of worm-worked soils. It is believed that they once had profiles similar to those of the Barnes and the Svea soils. In the present Singsaas and Oak Lake soils, the original subsoil has been thoroughly mixed with the surface soil and the underlying material.

Man has had a great influence on the soils. Farming has affected most of the soil-forming processes, and increased the action of some of them. Accelerated erosion of the surface layer has occurred on some of the sloping soils. Some of the lower lying soils have gained deposits of eroded material. The strong granular structure has been weakened or destroyed in the surface layer of many soils. The color of the surface layer of most of the soils has become lighter as a result of mixing with subsoil and reduction of the amount of organic matter. Leaching of many soils has been slowed as a result of increased runoff and reduced infiltration.

Relief and drainage

Lincoln County has relief ranging from nearly level to very steep. Relief is the most important factor in the development of different soils in uniform parent material. Soils that have fairly mature soil profiles, in which the horizons are distinct, developed wherever soil drainage is good and the slope is gentle. Steep soils show little soil development, mostly because runoff is excessive. Runoff is likely to cause soil erosion. Runoff also reduces the amount of water that can leach the soil and the amount that plants can use. Many steep soils, therefore, are droughty, have indistinct horizons, and support a poor cover of plants.

Topographic position is a partial key to the kind of soil and the soil drainage class at any place in the landscape. For example, the location of Buse, Barnes, Svea, Flom, and Parnell soils, which make up the Barnes drainage sequence, can be predicted in a general way. Each of these soils is on a particular part of the landscape. The excessively drained Buse soils are on steep side slopes; the well-drained Barnes soils are on undulating, mild slopes and on hilltops; the moderately well drained Svea soils are on nearly level and very gently undulating slopes below the Barnes soils or in slightly depressed, nearly level areas surrounded by Barnes soils; the poorly drained Flom soils are in drainageways and on nearly level wet flats; and the very poorly drained Parnell soils are in closed depressions and very wet drainageways.

The glacial ground moraines have predominantly undulating relief, and the glacial end moraines have rolling relief. Soils on the ground moraines are affected by erosion and drainage problems of about equal intensity. Soils on the end moraines are affected by a greater problem of erosion and a lesser problem of drainage.

Time

The time required for soil development depends, to a large extent, on the other factors of soil formation. Wherever favorable relief and drainage exist in Lincoln County, there has been enough time for soils to develop mature profiles. The steep soils have immature or thin profiles because the soil-forming processes there have not been effective. Soils in alluvium along the streams are immature or weakly developed because the material is young. Fresh deposits are added to the alluvium almost annually, and distinct, mature horizons have not had time to form.

In the geological sense, all the soil materials in the county are very young. The oldest soil materials are in the loess-covered parts of the county, and they are at least 15,000 years old. In the rest of the county, except on the alluvial plains that have been mentioned, soil-forming processes have been active for probably only about 8,000 to 15,000 years.

Classification of Soils

Soils are classified so that we can more easily remember their significant characteristics. Classification enables us to assemble knowledge about the soils, to see their relationships to one another and to the whole environment, and to develop principles that help us to understand their behavior and their response to manipulation. First, through classification, and then through use of soil maps, we can apply our knowledge to specific fields and other tracts of land.

Thus, in classification, soils are placed in narrow classes that are used in detailed soil surveys so that knowledge about the soils can be organized and applied in managing farms, fields, and woodlands; in developing rural areas; in engineering work; and in many other ways. They are placed in broad classes in successively higher categories to facilitate study and comparison in large areas, such as countries and continents.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*9*) and revised later (*8*). The system currently used was adopted for general use by the National Cooperative Soil Survey in 1965. The current system is under continual study (*6*, *10*). Therefore, readers interested in developments of the system should refer to the latest literature available.

Under the current system of classification, six categories are recognized. Beginning with the broadest and most inclusive, these are the order, the suborder, the great group, the subgroup, the family, and the series. Table 7 gives the family, subgroup, and order for each series in the county under the current classification, as well as the great soil group of the 1938 classification.

General Nature of the County

This section is primarily for readers not familiar with Lincoln County. It tells about the physiography, relief, drainage, and climate. Then, it gives a short discussion of history and development and of transportation and markets. The agriculture of the county is summarized mainly by use of information from the U.S. Census of Agriculture. A short discussion of recreational facilities is also given.

Physiography, Relief, and Drainage

Lincoln County includes some of the highest land in Minnesota. The elevation ranges between 1,900 and 2,000 feet on the Bemis moraine, which is a ridge that crosses the southwestern part of the county from northwest to southeast. On the till plains that border each side of the moraine, much of the area in this county is above 1,800 feet. Streams northeast of this moraine drain to the Minnesota River, which is a tributary of the upper Mississippi River; and those southwest of it drain to the Big Sioux and thence to the Missouri River. The elevation in the southwestern corner of the county is about 1,740 feet, and in the northeastern corner about 1,180 feet.

The relief of the Bemis moraine is predominantly hilly, and the slopes are rolling to steep. A glacial valley, 150 to 200 feet deep, cuts through the moraine in a south-southwest direction from Lake Benton. It is bounded on each side by picturesque bluffs. A similar valley, which has been eroded through the massive ridge of this moraine and through the smooth sheet of drift that slopes downward from its west side, begins at the southwestern end of Lake Shaokatan.

South and west of the Bemis moraine, the relief is marked predominantly by long, smooth, gentle slopes. The wind-deposited loess has filled in the irregularities of the glacial till plain. The relief northeast of this moraine is largely morainic and consists of narrow, gently undulating till plains between conspicuous smaller moraines. These moraines lie successively lower as the land slopes toward the northeast.

The North Branch Yellow Medicine River and the South Branch Lac qui Parle River drain most of the northern two-thirds of Lincoln County. Branches of the Redwood River drain the southeastern one-third. The land south and west of the Bemis moraine is drained by tributaries of the Big Sioux River.

Related information about the physiography, relief, and drainage in Lincoln County is given under the heading "Parent Material" in the section "Formation and Classification of the Soils." That section contains a map that shows the location of the major kinds of parent material and the glacial moraines.

Bedrock crops out in only one area in Lincoln County. Sandstone is exposed in the valley of the North Branch Yellow Medicine River in the extreme northeastern part of the county (*7*). The southwestern part of the county is underlain by Sioux quartzite at a depth of 200 feet or more.

Climate[4]

Lincoln County is located near the center of the great land mass of the North American continent and has a climate of the continental type. This means that summers are warm, winters are cold, and precipitation is greatest

[4] By JOSEPH H. STRUB, JR., State climatologist, U.S. Weather Bureau.

TABLE 7.—*Soil series classified according to the current system of classification and the 1938 system with its later revisions*

Series	Current classification [1]			Great soil groups of the 1938 classification
	Family	Subgroup	Order	
Aastad	Fine-loamy, mixed, frigid	Pachic Udic Haploborolls	Mollisols	Chernozems.
Arvilla	Coarse-loamy, mixed, frigid	Udic Haploborolls	Mollisols	Chernozems.
Barnes	Fine-loamy, mixed, frigid	Udic Haploborolls	Mollisols	Chernozems.
Beotia	Fine-silty, mixed, frigid	Pachic Haploborolls	Mollisols	Chernozems.
Blue Earth	Fine-silty, mixed, calcareous, mesic	Cumulic Haplaquolls	Mollisols	Humic Gley soils.
Brookings	Fine-silty, mixed, frigid	Pachic Udic Haploborolls	Mollisols	Chernozems.
Buse	Fine-loamy, mixed, frigid	Entic Udic Haploborolls	Mollisols	Regosols.
Colvin	Fine-silty, mixed, frigid	Typic Calciaquolls	Mollisols	Solonchak soils (calcium carbonate).
Crofton	Fine-silty, mixed, calcareous, mesic	Typic Ustorthents	Entisols	Regosols.
Dickey, silty variants.	Sandy over fine-silty, mixed, frigid	Udic Haploborolls	Mollisols	Chernozems.
Divide	Fine-loamy over sand or sandy-skeletal, mixed, frigid.	Aeric Calciaquolls	Mollisols	Solonchak soils (calcium carbonate).
Estelline	Fine-silty over sand or sandy-skeletal, mixed, frigid.	Pachic Udic Haploborolls	Mollisols	Chernozems.
Flandreau	Fine-loamy, mixed, mesic	Typic Haplustolls	Mollisols	Chernozems.
Flom	Fine-loamy, mixed, noncalcareous, frigid.	Typic Haplaquolls	Mollisols	Humic Gley soils.
Fordville	Fine-loamy over sand or sandy-skeletal, mixed, frigid.	Udic Haploborolls	Mollisols	Chernozems.
Forman	Fine-loamy, mixed, frigid	Udic Argiborolls	Mollisols	Chernozems.
Fulda	Fine-montmorillonitic, noncalcareous, frigid.	Typic Haplaquolls	Mollisols	Humic Gley soils.
Hamerly	Fine-loamy, mixed, frigid	Aeric Calciaquolls	Mollisols	Solonchak soils (calcium carbonate).
Hidewood	Fine-silty, mixed, noncalcareous, frigid	Typic Haplaquolls	Mollisols	Humic Gley soils intergrading toward Chernozems.
Kranzburg	Fine-silty, mixed, frigid	Typic Haploborolls	Mollisols	Chernozems.
Lamoure	Fine-silty, mixed, calcareous, frigid	Cumulic Haplaquolls	Mollisols	Alluvial soils intergrading toward Humic Gley soils.
LaPrairie	Fine-loamy, mixed, frigid	Cumulic Udic Haploborolls	Mollisols	Alluvial soils.
Lismore	Fine-loamy, mixed, frigid	Pachic Udic Haploborolls	Mollisols	Chernozems.
Oak Lake	Fine-loamy, mixed, frigid	Hapludic Vermiborolls	Mollisols	Chernozems.
Oldham	Fine, montmorillonitic, calcareous, frigid.	Cumulic Haplaquolls	Mollisols	Humic Gley soils.
Parnell	Fine, montmorillonitic, noncalcareous, frigid.	Cumulic Argiaquolls	Mollisols	Humic Gley soils.
Poinsett	Fine-silty, mixed, frigid	Udic Haploborolls	Mollisols	Chernozems.
Rauville	Fine, mixed, calcareous, frigid	Cumulic Haplaquolls	Mollisols	Alluvial soils intergrading toward Humic Gley soils.
Sinai	Fine, mixed, frigid	Pachic Udic Haploborolls	Mollisols	Chernozems.
Singsaas	Fine-loamy, mixed, frigid	Hapludic Vermiborolls	Mollisols	Chernozems.
Sioux	Sandy-skeletal, mixed, frigid	Entic Udic Haploborolls	Mollisols	Regosols.
Svea	Fine-loamy, mixed, frigid	Pachic Udic Haploborolls	Mollisols	Chernozems.
Sverdrup	Coarse-loamy, mixed, frigid	Udic Haploborolls	Mollisols	Chernozems.
Terril	Fine-loamy, mixed, mesic	Cumulic Hapludolls	Mollisols	Chernozems.
Vallers	Fine-loamy, mixed, frigid	Typic Calciaquolls	Mollisols	Solonchak soils (calcium carbonate) intergrading toward Humic Gley soils.
Vienna	Fine-loamy, mixed, frigid	Typic Udic Haploborolls	Mollisols	Chernozems.
Waubay	Fine-silty, mixed, frigid	Pachic Udic Haploborolls	Mollisols	Chernozems.

[1] Placement of some soil series in the current system of classification, especially families, may change as more precise information becomes available.

during the warm season. Because the county lies in a belt where there is considerable interaction between cold, dry air masses from the north and warm, moist air masses from the south, marked changes in both temperature and precipitation occur from day to day. Because the county has no large bodies of water or marked differences in topography, the climate in different parts is nearly uniform.

The mean temperature in the winter months of December, January, and February is near 16° F. Extremely cold continental air masses cause the temperature to drop to 20° below zero or lower at least once during most winters.

The first snowfall of 1 inch or more usually occurs by November 22, and the last of the season occurs early in April. Average annual snowfall is 34 inches.

The summers are warm and pleasant, with long days and prevailing southerly winds. The mean temperature for the three months of June, July, and August is 71°. Days when the temperature reaches 100° or higher have occurred 74 times in the last 30 years and 15 times in the last 20 years.

The wide range of temperature to be expected is shown in table 8. For example, during July it can be expected that 2 years in 10 will have at least 4 days with a temperature of 99° or higher. At the other extreme, during January, 2 years in 10 will have at least 4 days with a temperature of 19° or more below zero. Precipitation data are also given in table 8. All data in this table are from records kept at the Pipestone Weather Station, in adjoining Pipestone County.

A little more than 19 inches of precipitation, or about 78 percent of the annual total, falls during the period April through September. Precipitation of 0.01 inch or more can be expected on about 95 days per year, and on 5 days there is 1 inch or more. Rainfall of 1.25 inches or more in 1 hour can be expected once in 2 years. There has been considerable variation in the annual precipitation. The least on record was 14.28 inches in 1910, and the most was 35.45 inches in 1942. The heaviest rains occur as thunderstorms, of which there are on the average about 45 each year. Some thunderstorms are accompanied by hail and damaging winds. During the period 1916–1962 there were eight reported tornadoes in the county.

The freeze-free period is long enough that the staple crops of the county reach maturity without much danger of damage by frost. The probability of certain temperatures occurring in spring and in fall is shown in table 9. For example, in 5 years out of 10, or 50 percent of the time, a temperature of 32° or lower can be expected to occur in spring after May 10. In fall, the probability is 50 percent that a temperature of 32° will occur before September 30.

TABLE 8.—*Temperature and precipitation*

[All data from Pipestone, Pipestone County, Minn.]

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	2 years in 10 will have at least 4 days with—		1 year in 10 will have—			Days with snow cover of 1.0 inch or more	Average depth of snow on days with snow cover
			Maximum temperature equal to or higher than—	Minimum temperature equal to or lower than—	Average total	Less than—	More than—		
	°F.	°F.	°F.	°F.	*Inches*	*Inches*	*Inches*	*Number*	*Inches*
January	23	3	44	−19	0.5	0.1	0.9	25	5
February	28	6	50	−15	.7	.4	1.2	23	6
March	38	18	61	−5	1.3	.4	2.4	20	8
April	56	33	76	20	2.1	.7	4.2	3	2
May	69	45	86	31	3.2	.9	5.1	0	----------
June	79	56	92	44	4.7	2.7	6.2	0	----------
July	86	61	99	49	2.9	.9	6.2	0	----------
August	84	59	95	48	3.4	1.2	5.6	0	----------
September	74	48	91	32	2.9	.6	5.1	0	----------
October	61	37	80	22	1.4	.2	3.0	(1)	----------
November	41	21	65	1	.9	.1	1.8	5	2
December	29	10	46	−11	.6	.1	1.2	20	4
Year	56	33	[2] 108	[3] −40	24.5	19.1	30.7	96	6

[1] Less than 0.5 day.
[2] Average annual highest temperature for period of record.
[3] Average annual lowest temperature for period of record.

TABLE 9.—*Probabilities of last freezing temperatures in spring and first in fall*

Probability	Dates for given probability and temperature							
	16° F. or lower	20° F. or lower	24° F. or lower	28° F. or lower	32° F. or lower	36° F. or lower	40° F. or lower	50° F. or lower
Spring:								
1 year in 10 later than	Apr. 12	Apr. 22	May 2	May 18	May 23	June 2	June 13	--------
2 years in 10 later than	Apr. 7	Apr. 17	Apr. 27	May 12	May 19	May 29	June 9	--------
5 years in 10 later than	Mar. 28	Apr. 8	Apr. 20	May 2	May 10	May 21	May 31	June 21
Fall:								
1 year in 10 earlier than	Oct. 25	Oct. 15	Oct. 1	Sept. 21	Sept. 14	Sept. 4	Aug. 17	--------
2 years in 10 earlier than	Oct. 30	Oct. 20	Oct. 6	Sept. 27	Sept. 19	Sept. 9	Aug. 25	--------
5 years in 10 earlier than	Nov. 9	Oct. 29	Oct. 18	Oct. 8	Sept. 30	Sept. 18	Sept. 9	July 20

In farming it is helpful to know the best time to perform certain tasks to take advantage of wet or dry periods. Table 10 lists the percentage possibility of receiving selected amounts of precipitation during one-week periods.

Wind, humidity, and cloud observations are not made in Lincoln County but are made at the Weather Bureau Airport Station at Sioux Falls, S. Dak. The following information, based on the Sioux Falls records, can be considered as representative of Lincoln County. The mean annual windspeed is 11 miles per hour, and the highest monthly mean, 13.6 miles per hour, occurs in April. From November through May, the prevailing direction of the wind is northwesterly. During the remaining months it is southerly. The humidity at noon averages 56 percent and ranges from 52 percent in July to 66 percent in March. During a typical year, there are 104 clear days, 105 partly cloudy days, and 156 cloudy days.

History and Development

The area that is now Lincoln County was successively part of Wabasha, Dakota, Blue Earth, Brown, Redwood, and Lyon Counties. Lincoln County was named for Abraham Lincoln and was created by legislative act in 1873.

The first settlement in the county, near Lake Benton in 1862, was unsuccessful. Scattered pioneer homes were built in the late 1860's and early 1870's. In 1875 the population was 413. No significant increase in population occurred until Icelandic and Danish settlements became firmly established in the 1880's. At present the people are largely of Scandinavian, Polish, and German descent.

The population was 5,691 in 1890, 9,874 in 1910, and 11,303 in 1930. By 1960 it had decreased to 9,651.

There are five incorporated villages—Ivanhoe, Tyler, Lake Benton, Hendricks, and Arco. Ivanhoe, population 719, is the county seat. Tyler, the largest village, has a population of 1,138. Lake Benton was formerly the county seat.

Transportation and Markets

One railway crosses the county from east to west and serves Tyler, Lake Benton, and Verdi. A branch line from Tyler serves Arco, Ivanhoe, and Hendricks. Another railway crosses the extreme southeastern part of the county.

The major highways are either paved or blacktopped. U.S. Highway No. 75 crosses the county from north to south, U.S. Highway No. 14 crosses from east to west, and Minnesota Highway No. 19 crosses the county from east to west. Minnesota Highways No. 23, No. 68, and No. 271 serve parts of the county. Gravelled county and township roads serve every farm. More than 75 miles of county roads have been blacktopped, and more miles are being completed each year.

Grain elevators are located in each of the villages. Livestock generally are taken by truck to Sioux Falls, Sioux City, or South St. Paul. Most of the milk is marketed as whole milk and is picked up daily by trucks.

Agriculture

Wheat, oats, barley, potatoes, and wild hay cut from prairie land were the principal crops produced by the first settlers.

Corn for sale and for feed is now the principal crop. The acreage of corn has nearly doubled since 1939. Wheat

TABLE 10.—*Amounts and probability* [1] *of weekly precipitation* [2]

Date	Amount of precipitation in inches							
	None or a trace	0.20	0.40	0.60	0.80	1.00	1.40	2.00
April 26 to May 2	11	69	52	38	28	20	10	4
May 3 to May 9	4	68	51	39	30	23	15	7
May 10 to May 16	9	62	44	32	23	16	9	3
May 17 to May 23	11	72	56	43	32	24	14	6
May 24 to May 30	9	67	51	39	30	24	14	7
May 31 to June 6	9	75	61	50	40	33	21	11
June 7 to June 13	6	80	66	54	44	36	24	12
June 14 to June 20	11	77	64	53	43	34	22	11
June 21 to June 27	9	79	67	55	45	37	24	12
June 28 to July 4	8	80	65	51	40	31	18	8
July 5 to July 11	11	63	43	30	20	13	6	2
July 12 to July 18	11	60	41	28	19	13	6	2
July 19 to July 25	13	67	51	39	30	23	13	6
July 26 to August 1	11	65	49	37	28	21	12	5
August 2 to August 8	13	64	49	38	29	23	14	7
August 9 to August 15	22	69	57	47	38	30	19	9
August 16 to August 22	19	59	41	29	21	15	7	3
August 23 to August 29	22	59	45	35	27	21	12	6
August 30 to September 5	17	55	38	27	19	14	8	3
September 6 to September 12	11	69	54	43	34	27	17	9
September 13 to September 19	24	53	39	30	23	18	11	5
September 20 to September 26	24	53	39	28	21	15	8	3
September 27 to October 3	33	38	26	18	13	9	5	2

[1] Probability, expressed as a percentage or number of times out of 100 that the event can be expected to occur.

[2] Tabulation based on records for Brookings, S. Dak., from bulletin, "Chances of Receiving Selected Amounts of Precipitation in the North Central Region of the U.S." (*2*).

was grown on 105,147 acres in 1899 but is now a minor crop. The acreage of soybeans has increased significantly in recent years. Acreages of oats and flax, the second and third most important crops, have remained fairly stable. Barley and rye were grown on a considerable acreage in 1939 but are now minor crops.

The acreage of alfalfa has more than doubled since 1949. The acreage of wild hay is becoming smaller each year. The wet hayland is being drained and used for cultivated crops.

According to the U.S. census, there were, in 1964, 88,285 acres of corn; 33,090 acres of oats; 33,495 acres of flax; 17,244 acres of soybeans; 26,334 acres of alfalfa; and 6,354 acres of other hay crops.

The number of hogs and pigs has increased greatly since 1950, and so has the number of cattle and calves. The number of sheep has remained fairly constant. Horses were still much in use in 1939, but shortages of labor during World War II accelerated the use of tractors, and the number of horses declined. Most of the horses in the county now are riding horses.

Almost all the farms had milk cows in 1949, but less than half the farms reported milk cows in 1964. The size of herds has increased to offset the decrease in number of farms keeping milk cows.

According to the 1964 census there were in the county 55,816 cattle and calves; 9,109 milk cows; 81,351 hogs and pigs; and 8,792 sheep and lambs.

There were 1,414 farms in the county in 1959, and 1,230 in 1964. Most of the land, however, was bought or rented by farmers and is still in use. The average size of farms was 233 acres in 1959 and 263 acres in 1964.

Recreational Facilities [5]

Lincoln County has many recreational facilities. Five large lakes, Benton, Shaokatan, Stay, Dead Coon, and Hendricks, and several smaller lakes, provide facilities for fishing, swimming, and water skiing. Perch, walleyes, northern pike, and bullheads are caught in the large lakes, and perch and bullheads are caught in most of the smaller lakes. About 25 farm ponds have been stocked with sunfish and bass, and spawning areas are planned to improve the fishing in Lakes Shaokatan, Benton, and Hendricks. Boats are available at the resorts along these three lakes. The wooded lakeshores provide good sites for cottages and summer homes.

Facilities for hunting are good. The county has many ring-necked pheasants and Hungarian partridges. Also, a total of 430 stockwater pits and ponds provide good feeding and nesting sites for waterfowl (fig. 14). The population of white-tailed deer is increasing, and deer, squirrels, and foxes are hunted in some parts of the county. Twenty-five wildlife management areas, owned by the State, occupy more than 3,000 acres in the county. These areas are open to the public for hunting waterfowl and upland game birds.

An airport and a nine-hole golf course at Tyler provide other recreational facilities. Community parks have been developed in or near all of the towns. Picnic shelters, fireplaces, ball diamonds, and parking facilities are available in most of the parks.

[5] Prepared with the assistance of HANS G. UHLIG, biologist, Soil Conservation Service.

Figure 14.—**Areas of Marsh make excellent habitats for wildlife. This area was acquired by the State of Minnesota as a habitat for waterfowl.**

U.S. Highway No. 75, a main north-south artery that connects the Midwestern and Southern States with the northern part of Minnesota and with Winnipeg, Canada, bisects the county and brings many people into the area. U.S. Highway No. 14, running east and west, provides a convenient route from the Eastern States to the Black Hills in South Dakota and to Yellowstone Park. The county has potential for the development of camping areas along these highways, and also potential for hiking or riding trails, dude ranches, and private hunting farms. Landowners interested in developing recreational enterprises should contact a local representative of the Soil Conservation Service for assistance in planning such facilities.

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Glossary

Alluvium (alluvial deposits). Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Calcareous soil. An alkaline soil that contains enough calcium carbonate to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Carbonate. A compound that is a salt or ester of carbonic acid. An example is calcium carbonate.

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 clay on the surface of a soil aggregate. Synonyms: Clay coat, clay skin.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

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; will not hold together in a mass.

Friable. When moist, crushes easily under gentle to moderate 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; tends to stretch somewhat and pull apart rather than pull free from other material.

Hard. When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft. When dry, breaks into powder or individual grains under very slight pressure.

Cemented. Hard and brittle; little affected by moistening.

Drainage, soil. The rapidity and extent of the removal of water from the soil by runoff, by flow through the soil to underground spaces, or by a combination of both processes.

Drift (geology). Material of any sort deposited by geological processes in one place after having been removed from another. *Glacial drift* consists of earth, sand, gravel, and boulders deposited by glaciers and by the streams and lakes associated with glaciers. It includes *glacial till*, which is not stratified, and *glacial outwash*, which is stratified.

Fertility, soil. The quality of a soil that enables it to provide compounds, in adequate amounts and in proper balance, for the growth of specified plants, when other growth factors, such as light, moisture, temperature, and physical condition (or tilth) of the soil, are favorable.

Gravel. Rounded or angular rock fragments that are not prominently flattened and are between 1 millimeter (0.039 inch) and 3 inches in diameter. A gravelly soil consists of 15 to 50 percent gravel, by volume, and a very gravelly soil, of 50 to 90 percent.

Green manure. A crop grown for the purpose of being turned under in an early stage of maturity or soon after maturity for soil improvement.

Horizon, soil. A layer of soil, approximately parallel to the soil surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon. The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residue.

A horizon. The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active, and it is therefore marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides (iron and aluminum oxides).

B horizon. The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has (1) distinctive characteristics caused by accumulation of clay, sesquioxides, humus, or some combination of these; (2) prismatic or blocky structure; (3) redder or stronger colors; or (4) some combination of these. The combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon. The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

R layer. Consolidated rock beneath the soil. In most places the rock underlies a C horizon but may be immediately beneath an A or B horizon.

Lacustrine deposit (geology). Material deposited in lake water and exposed by lowering of the water level or elevation of the land.

Liquid limit (soil engineering). The moisture content at which the soil passes from a plastic to a liquid state. In engineering, a high liquid limit indicates that the soil has a high content of clay and a low capacity for supporting loads.

Loess. A fine-grained eolian deposit consisting dominantly of silt-sized particles.

Maximum density. The greatest density obtained when soil is compacted by a standard procedure. Expressed as pounds of oven-dry soil per cubic foot.

Medium-textured soil. Soil of very fine sandy loam, loam, silt loam, or silt texture.

Moraine. An accumulation of glacial drift having a topographic expression that is independent of the surface of the ground underneath it, and having been built by the direct action of glacier ice. End moraines and ground moraines are two types.

Mottled. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Nurse crop. A crop, often a small grain, that is planted with another crop to shelter it or to provide good conditions for its growth.

Optimum moisture content. The moisture content at which a soil material yields the highest density in the standard or modified test for optimum moisture and maximum density.

Outwash, glacial. Soil material carried by running water from the melting ice of a glacier and laid down in stratified deposits.

Parent material. The disintegrated and partly weathered rock from which soil has formed.

Permeability. The quality of a soil horizon that enables water or air to move through it. Terms used to describe permeability are as follows: *Very slow, slow, moderately slow, moderate, moderately rapid, rapid,* and *very rapid.*

Plastic limit. The moisture content at which a soil material passes from a semisolid to a plastic state.

Plasticity index. The numerical difference between the liquid limit and the plastic limit. It indicates the range of moisture content within which a soil material is in a plastic condition.

Plow planting. Planting a crop at the time the soil is plowed, or soon after, without additional tillage operations to prepare a seedbed. Also called wheel-track planting.

Profile, soil. A vertical section of the soil through all its horizons and extending into the parent material.

Reaction, soil. The degree of acidity or alkalinity of a soil expressed in pH values. A soil that tests pH 7.0 is precisely neutral in reaction, because it is neither acid nor alkaline. In words the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	Neutral	6.6 to 7.3
Very strongly acid	4.5 to 5.0	Mildly alkaline	7.4 to 7.8
Strongly acid	5.1 to 5.5	Moderately alkaline	7.9 to 8.4
Medium acid	5.6 to 6.0	Strongly alkaline	8.5 to 9.0
Slightly acid	6.1 to 6.5	Very strongly alkaline.	9.1 and higher

Sand. Individual rock or mineral fragments in soils having a diameter ranging from 0.05 millimeter to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more of sand and not more than 10 percent clay. See also Texture, soil.

Shear strength. The ability of material to resist applied forces that cause contiguous parts to slide relatively to each other in a plane parallel to their plane of contact. Measured by one or more of several standard tests.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay. See also Texture, soil.

Slope classes. Slope classes used in mapping and describing soils in this survey are as follows:

	Percent of slope
Nearly level	0 to 2
Undulating or gently sloping	2 to 6
Rolling or sloping	6 to 12
Moderately steep	12 to 18
Steep	18 to 25
Very steep	25 to 40

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effects of climate and living matter acting upon parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soils includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying parent material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular) and *granular*. *Structureless* soils are (1) *single grain* (each grain by itself, as in dune sand) or (2) *massive* (the particles adhering together without any regular cleavage, as in many claypans and hardpans).

Subsoil. Technically, the B horizon; roughly, the part of the profile below plow depth.

Substratum. Any layer beneath the solum, or true soil. It may refer to the parent material or to layers below the B horizon.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

Terrace, agricultural. An embankment or ridge constructed across a slope, on the contour or at a slight angle to the contour. The terrace intercepts and slows surface runoff so that it may soak into the soil or flow slowly and harmlessly to a prepared outlet. Terraces in fields are generally built so they can be farmed. Terraces intended mainly for drainage have a deep channel that is maintained in permanent sod. A *broad-base* terrace is one built on slopes gentle enough to be farmed; it is used on permeable soils. A *level* terrace is one built across a slope on the contour, as contrasted to a *graded* terrace built at a slight angle to the contour. A *level* terrace is used only on soils that are permeable enough to permit all of the storm water to soak into the soil, so that none will break over the terrace to cause gullies.

Terrace, geological. An old alluvial plain, ordinarily flat or undulating, bordering a river, lake, or the sea. Stream terraces are frequently called second bottoms, as contrasted to flood plains, and are seldom subject to overflow. Marine terraces were deposited by the sea and are generally wide.

Texture, soil. The relative proportions of sand, silt, and clay particles in a mass of soil. The basic textural classes, in order of increasing proportion of fine particles, are *sand*, *loamy sand*, *sandy loam*, *loam*, *silt loam*, *silt*, *sandy clay loam*, *clay loam*, *silty clay loam*, *sandy clay*, *silty clay*, and *clay*. The sand, loamy sand, and sandy loam classes may be further divided by specifying "coarse," "fine," or "very fine."

Till, glacial. An unstratified deposit of earth, sand, gravel, and boulders transported by glaciers.

Tilth, soil. The condition of the soil in relation to the growth of plants, especially soil structure. Good tilth refers to the friable state and is associated with high noncapillary porosity and stable, granular structure. A soil in poor tilth is nonfriable, hard, nonaggregated, and difficult to till.

Topsoil. A presumably fertile soil or soil material, ordinarily rich in organic matter, used to topdress roadbanks, lawns, and gardens.

Variant, soil. A soil that has properties sufficiently different from those of other known soils to justify a new series name, but whose geographic area is so limited that creation of a new series is not believed to be justified.

Water table. The highest part of the soil or underlying rock material that is wholly saturated with water. In some places an upper, or perched, water table may be separated from a lower one by a dry zone.

Wheel-track planting. See Plow planting.

GUIDE TO MAPPING UNITS

For a full description of a mapping unit, read both the description of the mapping unit and the soil series to which the mapping unit belongs. Other information is given in tables as follows:

Acreage and extent, table 1, p. 7
Predicted yields, table 2, p. 48

Engineering uses of soils, tables 4, 5, 6, pp. 54 through 74.

Map symbol	Mapping unit	Described on page	Capability unit		Windbreak suitability group	
			Symbol	Page	Number	Page
AaA	Aastad clay loam, 0 to 2 percent slopes----------	6	I-1	39	1	50
ArA	Arvilla sandy loam, 0 to 2 percent slopes--------	8	IIIs-1	44	4	51
ArB	Arvilla sandy loam, 2 to 6 percent slopes--------	8	IIIe-2	43	4	51
ArC2	Arvilla sandy loam, 6 to 12 percent slopes, eroded--	8	IVe-2	45	4	51
ArD2	Arvilla sandy loam, 12 to 18 percent slopes, eroded--	9	VIe-2	46	8	52
BaA	Barnes loam, 0 to 2 percent slopes---------------	9	I-1	39	1	50
BaB	Barnes loam, 2 to 6 percent slopes---------------	9	IIe-2	40	1	50
BaB2	Barnes loam, 2 to 6 percent slopes, eroded-------	10	IIe-2	40	1	50
BbB2	Barnes and Buse loams, 2 to 6 percent slopes, eroded--	10	IIe-2	40	--	--
	Barnes soil----------------------------------	--	-----	--	1	50
	Buse soil------------------------------------	--	-----	--	5	51
BbC	Barnes and Buse loams, 6 to 12 percent slopes----	10	IIIe-1	43	--	--
	Barnes soil----------------------------------	--	------	--	1	50
	Buse soil------------------------------------	--	-----	--	5	51
BbC2	Barnes and Buse loams, 6 to 12 percent slopes, eroded--	10	IIIe-1	43	--	--
	Barnes soil----------------------------------	--	-----	--	1	50
	Buse soil------------------------------------	--	-----	--	5	51
BcB	Barnes-Buse-Arvilla complex, 2 to 6 percent slopes--	11	IIIe-2	43	---	--
	Barnes soil----------------------------------	--	-----	--	1	50
	Buse soil------------------------------------	--	-----	--	5	51
	Arvilla soil---------------------------------	--	-----	--	4	51
BcB2	Barnes-Buse-Arvilla complex, 2 to 6 percent slopes, eroded--------------------------------	11	IIIe-2	43	--	--
	Barnes soil----------------------------------	--	-----	--	1	50
	Buse soil------------------------------------	--	-----	--	5	51
	Arvilla soil---------------------------------	--	-----	--	4	51
BcC2	Barnes-Buse-Arvilla complex, 6 to 12 percent slopes, eroded--------------------------------	11	IVe-2	45	---	--
	Barnes soil----------------------------------	--	-----	--	1	50
	Buse soil------------------------------------	--	-----	--	5	51
	Arvilla soil---------------------------------	--	-----	--	4	51
BeA	Beotia silt loam, 0 to 2 percent slopes----------	12	I-1	39	1	50
BeB	Beotia silt loam, 2 to 4 percent slopes----------	12	IIe-2	40	1	50
Bh	Blue Earth silt loam-----------------------------	12	IIIw-2	45	3	51
BkA	Brookings silty clay loam, 0 to 2 percent slopes-	13	I-1	39	1	50
BkB	Brookings silty clay loam, 2 to 4 percent slopes-	14	IIe-1	40	1	50
BlE	Buse loam, 18 to 25 percent slopes---------------	14	VIe-1	46	6	51
BlF	Buse loam, 25 to 40 percent slopes---------------	15	VIIe-1	46	6	51
BnF	Buse stony loam, 5 to 40 percent slopes----------	15	VIIs-1	47	8	52

Map symbol	Mapping unit	Described on page	Capability unit Symbol	Capability unit Page	Windbreak suitability group Number	Windbreak suitability group Page
BoD	Buse-Barnes loams, 12 to 18 percent slopes	15	IVe-1	45	6	51
BoD2	Buse-Barnes loams, 12 to 18 percent slopes, eroded	15	IVe-1	45	6	51
BrD2	Buse-Arvilla complex, 12 to 18 percent slopes, eroded	15	VIe-2	46	--	--
	Buse soil	--	-----	--	6	51
	Arvilla soil	--	-----	--	8	52
BrF	Buse-Arvilla complex, 18 to 40 percent slopes	15	VIIe-1	46	--	--
	Buse soil	--	-----	--	6	51
	Arvilla soil	--	-----	--	8	52
Co	Colvin silty clay loam	16	IIw-2	42	3	51
CrC	Crofton silty clay loam, 4 to 12 percent slopes	16	IIIe-1	43	5	51
DcA	Dickey sandy loam, silty variant, 0 to 2 percent slopes	17	IIIs-1	44	4	51
DcB	Dickey sandy loam, silty variant, 2 to 6 percent slopes	17	IIIe-2	43	4	51
Dv	Divide silt loam	18	IIw-6	43	3	51
EsA	Estelline silt loam, 0 to 2 percent slopes	19	IIs-1	41	7	51
FaA	Flandreau loam, 0 to 2 percent slopes	19	IIs-1	41	7	51
FaB	Flandreau loam, 2 to 6 percent slopes	19	IIe-3	40	7	51
Fc	Flom clay loam	20	IIw-1	42	2	50
FdA	Fordville loam, 0 to 2 percent slopes	21	IIs-1	41	7	51
FdB	Fordville loam, 2 to 6 percent slopes	21	IIe-3	40	7	51
FdB2	Fordville loam, 2 to 6 percent slopes, eroded	21	IIe-3	40	7	51
FmA	Forman clay loam, 0 to 2 percent slopes	22	I-1	39	1	50
FrB	Forman and Barnes soils, 2 to 6 percent slopes	22	IIe-2	40	1	50
FrB2	Forman and Barnes soils, 2 to 6 percent slopes, eroded	22	IIe-2	40	1	50
Fu	Fulda silty clay loam	23	IIw-3	42	2	50
Gp	Gravel pit	23	-----	--	--	--
HaA	Hamerly loam, 0 to 3 percent slopes	24	IIs-3	41	5	51
Hd	Hidewood silty clay loam	24	IIw-1	42	2	50
KrA	Kranzburg silt loam, 0 to 2 percent slopes	25	I-1	39	1	50
KrB	Kranzburg silt loam, 2 to 6 percent slopes	25	IIe-2	40	1	50
KrB2	Kranzburg silt loam, 2 to 6 percent slopes, eroded	26	IIe-2	40	1	50
La	Lake beaches	26	IVw-1	45	8	52
Lm	Lamoure silty clay loam	26	IIw-5	43	3	51
Lo	Lamoure and LaPrairie soils, frequently flooded	26	VIw-1	46	8	52
Lp	LaPrairie loam	27	IIw-4	42	1	50
LsA	Lismore silty clay loam, 0 to 3 percent slopes	27	I-1	39	1	50
Ma	Marsh	28	VIIIw-1	47	9	52
Mu	Muck	28	IIIw-1	44	2	50
OlA	Oak Lake silty clay loam, 0 to 2 percent slopes	29	I-1	39	1	50
OlB	Oak Lake silty clay loam, 2 to 4 percent slopes	29	IIe-1	40	1	50
Om	Oldham silty clay loam	29	IIIw-2	45	3	51
Pa	Parnell silty clay loam	30	IIIw-1	44	2	50
PoB	Poinsett silty clay loam, 2 to 6 percent slopes	31	IIe-2	40	1	50
PoB2	Poinsett silty clay loam, 2 to 6 percent slopes, eroded	31	IIe-2	40	1	50

Map symbol	Mapping unit	Described on page	Capability unit		Windbreak suitability group	
			Symbol	Page	Number	Page
Ra	Rauville silty clay loam	31	VIw-2	46	9	52
ScA	Sinai silty clay loam, 0 to 2 percent slopes	32	IIs-2	41	1	50
ScB	Sinai silty clay loam, 2 to 4 percent slopes	32	IIe-1	40	1	50
SgB	Singsaas silty clay loam, 2 to 6 percent slopes	33	IIe-2	40	1	50
SgB2	Singsaas silty clay loam, 2 to 6 percent slopes, eroded	33	IIe-2	40	1	50
SoF	Sioux gravelly sandy loam, 5 to 40 percent slopes	34	VIIs-1	47	8	52
SvA	Svea clay loam, 0 to 2 percent slopes	34	I-1	39	1	50
SvB	Svea clay loam, 2 to 4 percent slopes	34	IIe-1	40	1	50
SwB	Sverdrup sandy loam, 2 to 6 percent slopes	35	IIIe-2	43	4	51
SwC	Sverdrup sandy loam, 6 to 12 percent slopes	35	IVe-2	45	4	51
TeB	Terril silt loam, 2 to 6 percent slopes	36	IIe-1	40	1	50
Va	Vallers silty clay loam	36	IIw-2	42	3	51
VeB	Vienna silt loam, 2 to 6 percent slopes	37	IIe-2	40	1	50
VeB2	Vienna silt loam, 2 to 6 percent slopes, eroded	37	IIe-2	40	1	50
VeC2	Vienna silt loam, 6 to 12 percent slopes, eroded	37	IIIe-1	43	1	50
WaA	Waubay silty clay loam, 0 to 2 percent slopes	38	I-1	39	1	50
WaB	Waubay silty clay loam, 2 to 4 percent slopes	38	IIe-1	40	1	50

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