SOIL SURVEY OF

Swift County, Minnesota

United States Department of Agriculture
Soil Conservation Service
In cooperation with
University of Minnesota
Agricultural Experiment Station

Issued February 1973

Major fieldwork for this soil survey was done in the period 1953–66. Soil names and descriptions were approved in 1966. Unless otherwise indicated, statements in this publication refer to conditions in the county in 1966. This survey was made cooperatively by the Soil Conservation Service and the University of Minnesota Agricultural Experiment Station. It is part of the technical assistance furnished to the Swift County Soil and Water Conservation District.

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

HOW TO USE THIS SOIL SURVEY

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

Locating Soils

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

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

Finding and Using Information

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

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

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

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

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

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

Newcomers in the county will 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," which gives additional information about the county.

Cover: Contour stripcropping on Barnes, Buse, and Sverdrup soils.

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SOIL SURVEY OF SWIFT COUNTY, MINNESOTA

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UNITED STATES DEPARTMENT OF AGRICULTURE IN COOPERATION WITH THE UNIVERSITY OF MINNESOTA AGRICULTURAL EXPERIMENT STATION

SWIFT COUNTY is in the west-central part of Minnesota (fig. 1). It has a total land area of 478,080 acres, or 747 square miles. Benson is the county seat.

About 80 percent of the county is farmed, and corn, soybeans, and small grains are the main crops. Hogs and feeder cattle are raised, and dairy herds are kept.

How This Survey Was Made

Soil scientists made this survey to learn what kinds of soil are in Swift County, where they are located, and how they can be used. The soil scientists went into the county knowing they likely would find many soils they had already seen and perhaps some they had not.

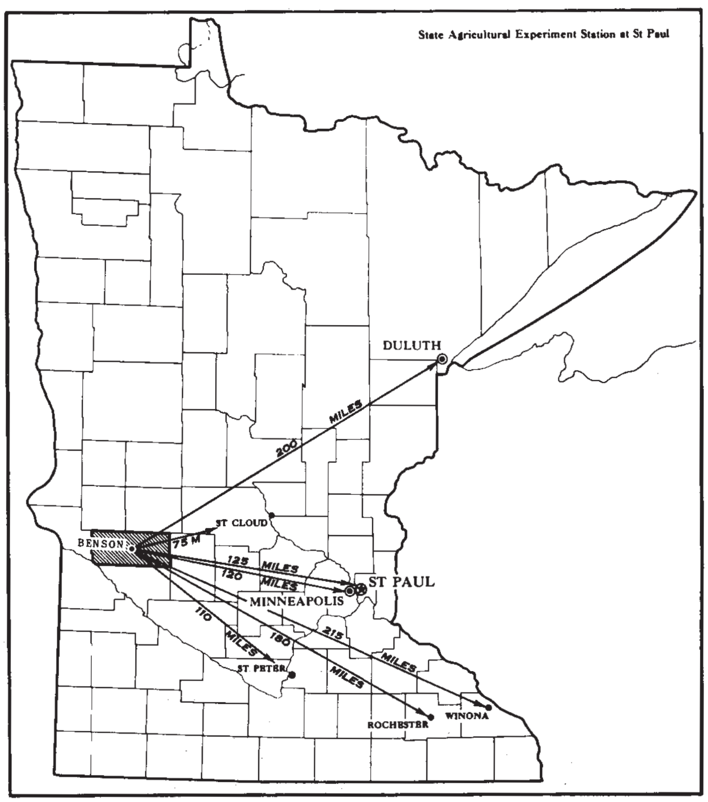

Figure 1.—Location of Swift County in Minnesota.

They observed the steepness, length, and shape of slopes, the size and speed of streams, the kinds of native plants or crops, the kinds of rock, and many facts about the soils. They dug many holes to expose soil profiles. A profile is the sequence of natural layers, or horizons, in a soil; it extends from the surface down into the parent material that has not been changed much by leaching or by the action of plant roots.

The soil scientists made comparisons among the profiles they studied, and they compared these profiles with those in counties nearby and in places more distant. They classified and named the soils according to nationwide, uniform procedures. The soil series and the soil phase (*7*) [1] are the categories of soil classification most used in a local survey.

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

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

After a guide for classifying and naming the soils had been worked out, the soil scientists drew the boundaries of the individual soils on aerial photographs. These photographs show woodlands, buildings, field borders, trees, and other details that help in drawing boundaries accurately. The soil map in the back of this publication 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 the management of farms and fields, a mapping unit is nearly equivalent to a soil phase. It is not

[1] Italic numbers in parentheses refer to Literature Cited, page 114.

exactly equivalent, because it is not practical to show on such a map all the small, scattered bits of soil of some other kind that have been seen within an area that is dominantly of a recognized soil phase.

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

A soil complex consists of areas of two or more soils, so intermingled or so small in size that they cannot be shown separately on the soil map. Each area of a complex contains some of each of the two or more dominant soils, and the pattern and relative proportions are about the same in all areas. The name of a soil complex consists of the names of the dominant soils, joined by a hyphen. Barnes-Buse loams, 2 to 6 percent slopes, eroded, is an example.

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

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

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

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

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

General Soil Map

The general soil map at the back of this survey shows, in color, the soil associations in Swift 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 land use. Such a map is a useful general guide in managing a watershed, a wooded tract, or a wildlife area, or in planning engineering works, recreational facilities, and community developments. It is not a suitable map for planning the management of a farm or field, or for selecting the exact location of a road, building, or similar structure, because the soils in any one association ordinarily differ in slope, depth, stoniness, drainage, and other characteristics that affect their management.

The twelve soil associations in Swift County are discussed in the following pages. The terms for texture used in the title for several of the associations apply to the surface layer. For example, in the title for association 1 the words "medium textured" refer to texture of the surface layer.

1. Buse-Barnes association

Deep, hilly and rolling, somewhat excessively drained and well-drained, medium-textured soils that formed in glacial till

This association is dominantly hilly and rolling, but there are some gently sloping areas and numerous depressions, potholes, and small lakes. It occupies about 6 percent of the county and is located mostly in its northeastern and northwestern parts. Buse soils make up about 45 percent of the association, Barnes soils 30 percent, and minor soils 25 percent.

The Buse are somewhat excessively drained, highly calcareous soils on steeper ridges and breaks. The Barnes are dark-colored, well-drained soils on the more gentle slopes.

The minor soils are the poorly drained Flom soils in drainageways and in small, shallow depressions; the very poorly drained Parnell soils in the deeper depressions and potholes and on flats along the Chippewa River; very poorly drained Muck and peat in marshes and potholes; somewhat excessively drained Sverdrup and Renshaw soils and excessively drained Sioux soils on slopes adjacent to or near the Chippewa River.

About 80 percent of this area is subject to erosion. On the more gentle slopes, erosion can be controlled by use of conservation cropping systems, stripcropping, contour farming, terraces, minimum tillage, and crop residue management. On the steeper slopes, erosion is controlled by use of grass or tree cover. The remaining 20 percent of the association needs drainage. Some areas near the Chippewa River lack adequate drainage outlets.

About 75 percent of this area is farmed. The main crops are corn, soybeans, small grains, and alfalfa. Hogs and feeder cattle are raised, and small dairy herds are kept. In this association are small wooded areas, the largest of which are near Camp Lake, Simon Lake, and Swift Falls.

2. *Barnes-Buse-Svea association*

Deep, dominantly rolling, somewhat excessively drained to moderately well drained, medium-textured soils that formed in glacial till

This association is dominantly rolling, but there are some level and gently sloping areas and numerous depressions, potholes, and small lakes. It occupies about 7 percent of the county and is located mostly in its northeastern part. The Barnes soils make up about 30 percent of the association, Buse soils 20 percent, Svea soils 15 percent, and minor soils 35 percent.

The Barnes are rolling, dark-colored, well-drained soils on the more gentle slopes. The Buse are highly calcareous, somewhat excessively drained soils on knobs and knolls. The Svea are dark-colored, moderately well drained, nearly level to gently sloping soils.

The minor soils are the poorly drained to very poorly drained Parnell and Flom soils and small areas of the moderately well drained Hamerly soils and the somewhat excessively drained Renshaw soils.

About 60 percent of this area is subject to erosion. Erosion can be controlled by use of conservation cropping systems, stripcropping, contour farming, terraces, minimum tillage, and crop residue management. About 20 percent of the area needs drainage.

Nearly all of this area is now cultivated. Corn and soybeans are the main crops, but small acreages of alfalfa and small grains are also grown. Hogs and feeder cattle are raised, and small dairy herds are kept.

3. *Tara-Barnes-Hamerly association*

Deep, nearly level to gently rolling, moderately well drained and well drained, medium-textured soils that formed in glacial till

This association is dominantly nearly level to gently rolling, but there are some low, level areas, drainageways, depressions, and potholes. This association occupies about 22 percent of the county and occurs mostly in the northwestern part, as well as in smaller areas in the eastern and northeastern parts. Tara soils make up 20 percent of the association, the Barnes soils 20 percent, Hamerly soils 15 percent, and the less extensive soils 45 percent.

The Tara are silty, moderately well drained, nearly level soils. The Hamerly are moderately well drained, undulating, strongly calcareous loams that have a thin, light-colored surface layer. The Barnes are well-drained, gently rolling soils that have a dark-colored surface layer.

The less extensive soils are the somewhat excessively drained Buse soils, the moderately well drained Svea soils, the poorly drained Vallers-Winger complex, Winger and Flom soils, and the very poorly drained Parnell and Oldham soils.

About 80 percent of this area is subject to erosion, which can be controlled by stripcropping, contour farming, and return of crop residue. About 20 percent of the area needs supplemental drainage. Tile and surface drains are used to drain the wet, poorly drained, and very poorly drained soils.

Most of this association is farmed. Corn, soybeans, small grains, and alfalfa are the main crops. Hogs and feeder cattle are raised, and small dairy herds are kept. Hay and pasture are the main crops grown in an 8-square mile area, southwest of Appleton, that is covered with numerous stones and boulders.

4. *Vallers-Winger-Hamerly association*

Deep, nearly level to gently undulating, poorly drained to moderately well drained, moderately fine textured and medium-textured soils that formed in glacial till

This is a level to gently undulating soil association that is marked by many drainageways, potholes, and sloughs. It is located mainly in Pillsbury and Dublin Townships in the southeastern part of the county and in Fairfield and Tara Townships in the northwestern part. This association occupies about 10 percent of the county. The Vallers-Winger complex and the Winger soils make up about 40 percent of the association, Hamerly soils 25 percent, and minor soils 35 percent.

The Vallers and Winger are poorly drained, highly calcareous soils. They both formed in clay loam glacial till, but the Winger soils are overlain by a thin mantle of silt. The Hamerly are moderately well drained, undulating, highly calcareous loams that occur on slight rises.

The minor soils are the moderately well drained McIntosh, Tara, and Svea soils, the well-drained Barnes soils, the somewhat excessively drained Buse soils, the very poorly drained Parnell soils, and the poorly drained Oldham soils.

About 50 percent of this area is limited by wetness. Tile and surface ditches are used to drain soils that can be improved by disposing of excess water. About 50 percent of the association is subject to soil blowing and erosion. Soil blowing and erosion can be controlled by use of conservation cropping systems, contour farming, stubble mulching, field windbreaks, crop residue management, and minimum tillage. There is an imbalance of plant nutrients in these soils because they are highly calcareous. The balance of plant nutrients is improved by application of phosphates and potash.

Most of this association is farmed. The main crops are corn, soybeans, small grains, and alfalfa. Sugar beets are suited to most of these soils. Hogs and feeder cattle are raised, and small dairy herds are kept.

5. *Colvin-Perella-Bearden association*

Deep, level and nearly level, very poorly drained to moderately well drained, moderately fine textured and medium-textured lacustrine soils

This association is in level or nearly level areas where soil materials were deposited in glacial lakes. It is located mainly in the south-central and east-central parts of the county and includes a 4-square mile area southwest of Appleton, adjacent to the Minnesota River. This association occupies about 18 percent of the county. The Colvin soils make up about 35 percent of the association, the Perella soils 25 percent, the Bearden soils 20 percent, and minor soils 20 percent.

The Colvin are dark-colored, poorly drained soils in the broad, level areas. The Perella are very poorly drained soils in depressions. The Bearden are dark-colored, moderately well drained soils on gentle slopes.

The minor soils are the moderately well drained Hamerly, McIntosh, and Hantho soils; the poorly drained Vallers, Winger, and Lamoure soils; the very poorly drained Rauville soils; and Alluvial land, frequently flooded. The Lamoure and Rauville soils and Alluvial land, frequently flooded, are most commonly located in the area southwest of Appleton.

About 30 percent of this area is subject to soil blowing, which is controlled by crop residue management. About 70 percent of the area needs drainage, but most of the land in the area adjacent to the Minnesota River cannot be drained because of lack of adequate outlets. Because these soils are highly calcareous, there is an imbalance of plant nutrients. The balance of plant nutrients is improved by application of phosphates and potash.

Most of this area is farmed. The main crops are corn and soybeans, but small grains, alfalfa, and sugar beets are also grown. Sugar beets are well suited to most of these soils. Hogs and feeder cattle are raised, and small dairy herds are kept.

6. *Marysland-Arveson association*

Level, poorly drained, medium-textured soils that are dominantly moderately deep to sand and gravel

This association is generally level, but there are some slight rises and many shallow depressions. The area is dissected by several deep surface ditches. It occupies about 10 percent of the county and is located mostly in its southwest-central part. Marysland soils make up about 50 percent of the association, Arveson soils 10 percent, and less extensive soils 40 percent.

The Marysland soils are poorly drained loams underlain by sand at a depth of 24 to 40 inches. South of Holloway they are underlain by both sand and gravel. The Arveson soils are poorly drained loams underlain by sand at a depth of 14 to 22 inches.

The less extensive soils include the moderately well drained Clontarf, Malachy, and Swenoda soils and the poorly drained Hamar and Mayer soils.

About 80 percent of this area needs drainage. Use of tile drainage is difficult because of the sandy underlying material. Unprotected fields are subject to soil blowing in winter and in spring.

Because these soils have a high lime content, there is an imbalance of plant nutrients that can be temporarily corrected by application of phosphates and potash.

Corn and soybeans are the main crops, but small grains and alfalfa are also grown. Hogs and feeder cattle are raised, and small dairy herds are kept. Some of the depressions in this area have not been drained, and these are marshlands that provide wildlife habitat.

7. *Hegne-Colvin-Perella association*

Deep, level, poorly drained and very poorly drained, dominantly fine textured and moderately fine textured lacustrine soils

This association is level to slightly depressional. It occupies about 4 percent of the county. The Hegne soils make up about 30 percent of the association, Colvin soils 25 percent, Perella soils 25 percent, and minor soils 20 percent.

The Hegne soils are poorly drained, calcareous clays and are level to slightly depressional. The Colvin are poorly drained, calcareous silty clay loams that occur in broad, level areas. The Perella are very poorly drained silt loams that occur in large depressions.

The minor soils are the Bearden and Vallers soils and the organic soils, Muck and peat. The Bearden are moderately well drained soils on slight rises. The Vallers soils formed in glacial till and are intermingled with the Colvin soils. Muck and peat occur in the broad, deeper depressions along Shakopee Creek and the Chippewa River.

About 95 percent of this area needs drainage. Some of the Perella soils are difficult to drain because they lack adequate outlets. Because the poorly drained soils have a high lime content, there is an imbalance of plant nutrients that can be temporarily corrected by application of phosphates and potash. Unprotected fields are subject to soil blowing in winter and in spring.

About 90 percent of this area is farmed. Corn and soybeans are the main crops, but small grains and alfalfa are also grown. If properly drained, most of these soils would be suited to growing sugar beets. Hogs and feeder cattle are raised, and small dairy herds are kept.

8. *Arveson-Marysland-Hecla association*

Level, poorly drained, medium-textured soils that are shallow and moderately deep to sand and gravel; and deep, nearly level, moderately well drained, coarse-textured soils

Most of this association is level, but there are some gentle swells and shallow depressions. It occupies about 9 percent of the county and is located in its north-central part. Arveson soils make up about 40 percent of the association, Marysland soils 25 percent, Hecla soils 15 percent, and minor soils 20 percent.

The Arveson are poorly drained, calcareous loams that are underlain by sand at a depth of 14 to 22 inches. The Marysland are poorly drained, calcareous loams that are underlain by sand at a depth of 24 to 40 inches. The Hecla are moderately well drained loamy sands on the slightly higher swells.

The minor soils are the poorly drained Fossum soils, the moderately well drained Clontarf, Swenoda, and Malachy soils, the poorly drained Hamar soils, and the very poorly drained, depressional Venlo soils.

This association is limited by a high water table in spring and by droughtiness late in summer. Droughtiness is a severe limitation on about 30 percent of the area, and about 75 percent needs drainage. Shallow surface ditches are commonly used, since use of tile drainage is difficult because of the sandy underlying material. About 90 percent of the area is subject to soil blowing. Soil blowing can be controlled by use of crop residue, stubble mulching, wind stripcropping, and minimum tillage.

Nearly all of this area has been farmed. The main crops are corn, soybeans, and oats. This area also has potential for grassland farming. Hogs and feeder cattle are raised, and small dairy herds are kept.

9. Maddock-Shible association

Deep, nearly level to gently sloping, well-drained, coarse textured and moderately coarse textured soils

This association is dissected by the Pomme de Terre River and by several large waterways that flow in a southeasterly direction. The soils adjacent to these waterways are generally more sloping than those in the rest of the association. The association occupies about 5 percent of the county and is located in its southwestern and northeastern parts. Maddock soils make up about 50 percent of the association, Shible soils 30 percent, and minor soils 20 percent.

The Maddock are well-drained, sandy soils. The Shible are dark-colored, well-drained fine sandy loams that have a sandy loam to loam subsoil and sandy underlying material.

The minor soils of the association are the somewhat excessively drained Renshaw soils; the well-drained Flandreau and Estelline soils; the moderately well drained Swenoda and Clontarf soils; the poorly drained Hamar and Arveson soils; and the very poorly drained Venlo soils.

Droughtiness is a limitation in 75 percent of this area, and about 15 percent needs drainage. About 90 percent of the area is subject to soil blowing. Soil blowing can be controlled by use of crop residue management, stubble mulching, wind stripcropping, and field windbreaks.

All of this association is farmed, except for a few potholes and sloughs. The main crops grown are corn and soybeans, but small amounts of small grains and alfalfa are also grown. Hogs and feeder cattle are raised, and small dairy herds are kept.

10. Edison-Clontarf-Hantho association

Deep, nearly level to sloping, well drained and moderately well drained, moderately coarse textured and medium-textured soils

This association is mostly in the southwestern part of the county southeast of the city of Appleton. The soils occur in a complex pattern of silt, sand, sand over silt, and silt over sand. The association occupies about 1 percent of the county. Edison soils make up about 50 percent of the association, Clontarf soils 10 percent, Hantho soils 10 percent, and less extensive soils 30 percent.

Edison soils are well-drained fine sandy loams that have a loamy subsoil underlain by very fine sand at a depth of 24 to 40 inches. Clontarf soils are moderately well drained sandy loams underlain by sand at a depth of 24 inches. Hantho soils are moderately well drained silt loams.

The less extensive soils of this association include the excessively drained Torning soils, the well-drained Maddock soils, the moderately well drained Swenoda soils, and the poorly drained Perella soils.

About 90 percent of the acreage is subject to soil blowing. Soil blowing is controlled by use of crop residue management, stubble mulching, wind stripcropping, field windbreaks, and minimum tillage. About 20 percent of the area needs drainage.

All of these soils are farmed, except for a few potholes. The main crops are corn and soybeans, but small grains and alfalfa are also grown. Hogs and feeder cattle are raised, and small dairy herds are kept.

11. Renshaw-Fordville-Sioux association

Nearly level to sloping, dominantly excessively drained to well-drained, medium-textured and moderately coarse textured soils that are shallow and moderately deep to sand and gravel

This association is located mainly north of Appleton and along the Pomme de Terre River. There are also areas of these soils northwest of Danvers and south of Swift Falls. The soils are mainly level to gently sloping except south of Swift Falls, where they are undulating to sloping. Gravel pits are common in this association.

This association occupies about 6 percent of the county. Renshaw soils make up about 50 percent of the association, Fordville soils and soils of the Spottswood-Fordville complex, 20 percent, Sioux soils 15 percent, and minor soils 15 percent.

The Renshaw are shallow, loamy soils that are underlain by sand and gravel. Fordville and Spottswood soils are moderately deep to gravel. The Sioux soils are excessively drained and gravelly.

The minor soils of this association are the poorly drained Marysland and Benoit soils and the poorly drained and very poorly drained Mayer soils. In addition, Alluvial land, frequently flooded, occurs on the bottom land along the Pomme de Terre and Chippewa Rivers.

About 90 percent of this area is subject to soil blowing and droughtiness. Soil blowing is controlled by use of crop residue management, stripcropping, field windbreaks, and minimum tillage. About 10 percent of the association needs drainage, and most of these areas are drained by surface ditches. Some places, particularly near the river, lack adequate outlets and are therefore marshland.

Nearly all of this area is farmed. The main crops are corn and soybeans, but some small grains and alfalfa are also grown. Hogs and feeder cattle are raised, and small dairy herds are commonly kept.

12. Shakopee-Fulda-Nutley association

Level, poorly drained, fine-textured soils that are moderately deep to sand; and deep, nearly level, poorly drained to moderately well drained, fine-textured soils

This association is located around Drywood Lakes and adjacent to Judicial Ditch 8 in West Bank Township. It occupies about 2 percent of the county. Shakopee soils make up 40 percent of the association, Fulda soils 35 percent, Nutley soils 10 percent, and minor soils 15 percent.

Shakopee soils are in flat areas in the southwestern part of Marysland Township. They are poorly drained, calcareous, clayey soils that are underlain by sand at a depth of 24 to 40 inches. Fulda are deep, poorly drained, clayey soils. Fulda soils that occur along Judicial Ditch 8 in West Bank Township are somewhat poorly drained clayey soils that are underlain by sand at a depth of 24 to 40 inches. The Nutley soils occur on nearly level to sloping areas around Drywood Lakes. These are deep, moderately well drained, clayey soils.

The minor soils include the somewhat excessively drained Renshaw soils; the well-drained Maddock and

Flandreau soils; the moderately well drained Tara, Svea, and McIntosh soils; and the poorly drained Colvin, Hegne, and Marysland soils.

About 70 percent of this area needs additional drainage. Surface ditches are common, and they usually provide adequate drainage. Use of tile drainage is difficult in the soils that are underlain by sand. Management of the soils to keep good tilth is important on these fine-textured soils. Good tilth is kept by rotating crops, adding organic matter, using minimum tillage, and properly timing work in the field.

The main crops grown on these soils are corn and soybeans, but small grains and alfalfa are also grown. Hogs and feeder cattle are raised, and small dairy herds are kept.

Descriptions of the Soils

This section describes the soil series and mapping units of Swift County. The approximate acreage and proportionate extent of each mapping unit are given in table 1.

In the pages that follow, a general description of each soil series is given. Each series description has a detailed description of a profile typical of the series and a brief statement of the range in characteristics of the soils in the series, as mapped in this county. Following the series description, each mapping unit in the series is described individually. For full information on any one mapping unit, it is necessary to read the description of the soil series as well as the description of the mapping unit. Miscellaneous land types, such as Alluvial land, frequently flooded, are described in alphabetic order along with soil series.

Following the name of each mapping unit is a symbol in parentheses. This symbol identifies the mapping unit on the detailed soil map. At the end of the description of each mapping unit are listed the capability unit and the windbreak group in which the mapping unit has been placed. The page where each of these groups is described can be found readily by referring to the "Guide to Mapping Units."

Descriptions, names, and delineations of soils in this soil survey do not fully agree with soil maps in adjacent counties published at a different date. Differences are the result of better knowledge of soils, modifications in series concepts, intensity of mapping, and the extent of soils within the survey area. In some places it is more feasible to combine small acreages of similar soils that respond to use and management in much the same way than it is to separate these soils and give them names.

For more general information about the soils, the reader can refer to the section "General Soil Map," in which the broad patterns of soils are described. Many of the terms used in the soil descriptions and other parts of the survey are defined in the Glossary.

Alluvial Land, Frequently Flooded

Alluvial land, frequently flooded (Af) consists of nearly level, dark-colored soils recently deposited by rivers and smaller streams. It occurs near streams and 1 to 3 feet higher than normal stream level. The areas are highly dissected by old stream channels.

The surface layer ranges from coarse sand to loam, and its texture varies considerably within short distances. The underlying material normally is sand. In the old stream channels, a layer of peat 8 to 18 inches thick occurs in some places.

These areas are chiefly poorly drained and very poorly drained, but small areas are moderately well drained. Flooding occurs frequently in spring and during periods of excessive rainfall. During the major part of the growing season, the water table is at a depth of 1 to 3 feet.

Draining this land is not practical, because the level of the streams and of the water table are nearly the same. Water often stands in the lower lying channels for long periods. Alluvial land, frequently flooded, is suitable for use as pasture or wildlife habitat. Pastured areas commonly become hummocky. Capability unit VIw-1; windbreak suitability group 9.

Arveson Series

The Arveson series consists of nearly level or slightly depressional, poorly drained soils. These soils formed in calcareous loamy material 13 to 20 inches thick over calcareous outwash sand. They are in the lake-plain area in the north-central part of the county.

In a representative profile, the surface layer is about 17 inches thick. The upper 7 inches is calcareous black loam. The next 10 inches is strongly calcareous black and very dark gray loam and sandy loam. The upper part of the underlying material is strongly calcareous, friable, olive-gray sandy loam that has many light olive-brown mottles. This is underlain by olive, very friable, strongly calcareous loamy sand that has a few light olive-brown mottles and some manganese concretions. This loamy sand grades to a loose, light olive-gray, strongly calcareous fine sand that becomes less mottled and less calcareous as depth increases. At a depth of about 48 inches, the sands are medium and coarse.

The organic-matter content is high. The natural fertility is low. The available water capacity is low. Permeability is moderately rapid in the loam and rapid in the sand. The high content of lime causes an imbalance of plant nutrients. These soils have a high water table, which limits root growth.

Wetness, soil blowing, and low fertility are the major problems. Most areas of these soils are cropped where additional drainage has been provided.

Representative profile of Arveson loam, having a slope of 0 to 2 percent, located 45 feet south and 30 feet west of cornerpost in the NE. corner of sec. 13, T. 122 N., R. 41 W.

Ap—0 to 7 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.

A1ca—7 to 12 inches, black (10YR 2/1) to very dark gray (10YR 3/1) loam; dark gray (2.5Y 4/1) when dry; weak, fine, granular structure; friable; sands bleached by wind shifting; strongly calcareous; gradual, wavy boundary.

A3ca—12 to 17 inches, very dark gray (10YR 3/1) sandy loam; gray (2.5Y 5/1) when dry; few, fine, distinct grayish-brown mottles; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

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

Soil	Acres	Percent	Soil	Acres	Percent
Alluvial land, frequently flooded	2,660	0.6	Maddock loamy fine sand, 6 to 12 percent slopes	670	0.1
Arveson loam	16,960	3.5	Maddock sandy loam, 0 to 4 percent slopes	3,440	.7
Barnes loam, 0 to 2 percent slopes	1,830	.4	Maddock-Dune land complex	220	(1)
Barnes-Buse loams, 2 to 6 percent slopes, eroded	44,240	9.3	Malachy sandy loam, 0 to 2 percent slopes	2,310	.5
Barnes-Buse loams, 6 to 12 percent slopes, eroded	3,120	.7	Malachy sandy loam, loamy subsoil variant, 0 to 2 percent slopes	640	.1
Barnes-Buse very stony loams, 2 to 12 percent slopes	720	.2	Marsh	7,000	1.4
Bearden silty clay loam, 0 to 2 percent slopes	16,095	3.4	Marysland loam	24,670	5.1
Benoit loam	880	.2	Mayer loam	3,020	.6
Blue Earth silt loam	920	.2	Mayer loam, depressional	6,430	1.3
Borup silt loam	1,200	.3	McIntosh silt loam, 0 to 3 percent slopes	4,730	1.0
Buse loam, 18 to 25 percent slopes	1,520	.3	Muck and peat	850	.2
Buse loam, 25 to 35 percent slopes	720	.2	Muck and peat, calcareous	1,800	.4
Buse very stony loam, 12 to 30 percent slopes	160	(1)	Muck and peat, calcareous, shallow	3,000	.7
Buse-Barnes loams, 2 to 6 percent slopes, eroded	7,920	1.7	Muck and peat, shallow over loam	1,450	.3
Buse-Barnes loams, 6 to 12 percent slopes, eroded	7,690	1.6	Muck and peat, shallow over sand	150	(1)
Buse-Barnes loams, 12 to 18 percent slopes, eroded	4,270	.9	Nutley-Hattie clays, 0 to 2 percent slopes	660	.1
Clontarf sandy loam, 0 to 2 percent slopes	3,270	.7	Oldham silty clay loam	3,480	.7
Colvin silty clay loam	40,995	8.5	Parnell silty clay loam	12,000	2.4
Colvin silty clay loam, depressional	1,150	.2	Parnell and Flom soils	17,940	3.7
Darnen loam, 0 to 4 percent slopes	1,210	.3	Perella silt loam	3,110	.6
Doland silt loam, 0 to 2 percent slopes	2,240	.5	Perella silty clay loam, depressional	12,260	2.6
Doland silt loam, 2 to 6 percent slopes	2,430	.5	Rauville silty clay loam	2,220	.5
Edison very fine sandy loam, 0 to 2 percent slopes	750	.2	Renshaw loam, 0 to 2 percent slopes	15,230	3.2
Edison very fine sandy loam, 2 to 6 percent slopes	470	.1	Renshaw loam, 2 to 6 percent slopes	2,620	.5
Embden fine sandy loam	550	.1	Renshaw loam, 6 to 12 percent slopes, eroded	470	.1
Estelline silt loam, 0 to 2 percent slopes	1,400	.3	Renshaw stony loam, 0 to 6 percent slopes	210	(1)
Flandreau silt loam, 0 to 2 percent slopes	1,850	.4	Renshaw and Fordville very stony loams	250	(1)
Flandreau silt loam, 2 to 6 percent slopes	1,550	.3	Rockwell loam	1,480	.3
Flom-Parnell stony silty clay loams	330	.1	Rockwell fine sandy loam	1,420	.3
Flom-Parnell very stony silty clay loams	1,680	.4	Rothsay silt loam, 0 to 2 percent slopes	980	.2
Fordville loam, 2 to 6 percent slopes	680	.1	Rothsay silt loam, 2 to 6 percent slopes	1,830	.4
Fordville stony loam, 0 to 2 percent slopes	340	.1	Sandy lake beaches	500	.1
Fossum sandy loam	3,560	.8	Shakopee clay	2,620	.5
Fulda loam, sand subsoil variant, 0 to 2 percent slopes	730	.2	Shible fine sandy loam, 0 to 2 percent slopes	4,160	.9
Fulda silty clay, 0 to 2 percent slopes	1,510	.3	Shible fine sandy loam, 2 to 6 percent slopes	1,890	.4
Fulda silty clay, sand subsoil variant, 0 to 2 percent slopes	1,020	.2	Sioux sandy loam, 0 to 2 percent slopes	1,070	.2
Glyndon silt loam, 0 to 2 percent slopes	1,730	.4	Sioux sandy loam, 2 to 6 percent slopes	1,360	.3
Hamar loamy sand	900	.2	Sioux sandy loam, 6 to 12 percent slopes	700	.1
Hamar sandy loam	2,020	.4	Sioux sandy loam, 12 to 25 percent slopes	470	.1
Hamerly loam, 0 to 3 percent slopes	28,940	6.0	Spottswood-Fordville loams, 0 to 2 percent slopes	5,110	1.1
Hantho silt loam, 0 to 2 percent slopes	5,040	1.1	Svea loam, 0 to 2 percent slopes	15,080	3.1
Hattie clay, 6 to 12 percent slopes, eroded	80	(1)	Svea loam, 2 to 4 percent slopes	5,440	1.2
Hattie-Nutley clays, 2 to 6 percent slopes	600	.1	Svea stony loam, 0 to 2 percent slopes	330	.1
Hecla loamy sand, 0 to 3 percent slopes	8,190	1.7	Svea very stony loam	1,150	.2
Hegne clay	5,860	1.2	Sverdrup sandy loam, 0 to 2 percent slopes	490	.1
Lamoure silty clay loam	3,380	.7	Sverdrup sandy loam, 2 to 6 percent slopes	910	.2
Lamoure-Rauville complex	1,340	.3	Swenoda sandy loam, 0 to 2 percent slopes	1,810	.4
La Prairie silty clay loam	320	.1	Tara silt loam, 0 to 2 percent slopes	13,540	2.1
Maddock loamy sand, loamy subsoil variant, 0 to 3 percent slopes	880	.2	Torning loamy fine sand, 0 to 6 percent slopes	540	.8
Maddock loamy fine sand, 0 to 2 percent slopes	760	.2	Vallers-Winger silty clay loams	25,950	5.4
Maddock loamy fine sand, 2 to 6 percent slopes	2,050	.4	Venlo fine sandy loam	2,950	.6
			Winger silty clay loam	5,770	1.2
			Zell-Rothsay silt loams, 2 to 6 percent slopes	320	.1
			Zell-Rothsay silt loams, 6 to 12 percent slopes	550	.1
			Gravel pits	880	.2
			Urban areas	2,060	.4
			Water areas	5,180	1.1
			Total	478,080	100.0

[1] Less than 0.1 percent.

C1ca—**17 to 20 inches, olive-gray (5Y 4/2) and dark grayish-brown** (2.5Y 4/2) sandy loam; many, fine, distinct, light olive-brown mottles; weak, fine, subangular blocky structure; friable; dark-brown manganese concretions; strongly calcareous; gradual, wavy boundary.

IIC2ca—**20 to 23 inches**, olive (5Y 5/3) loamy sand; few, fine, faint, light olive-brown mottles; weak, coarse, angular blocky structure; very friable; few manganese concretions; strongly calcareous; gradual, wavy boundary.

IIC3ca—23 to 32 inches, light olive-gray (5Y 6/2) fine sand; common, medium, prominent, yellowish-brown mottles; single grain; loose; few manganese concretions; weak cementation; strongly calcareous; gradual, wavy boundary.

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IIC4—32 to 48 inches, light olive-gray (5Y 6/2) fine sand; few, fine, faint, yellowish-brown mottles; single grain; loose; calcareous; gradual, wavy boundary.

IIC5—48 to 60 inches, light olive-gray (5Y 6/2), medium and coarse sands; single grain; loose; calcareous.

The Ap and A1 horizons are 9 to 14 inches thick and are loam in texture but border on sandy clay loam and sandy loam. The Ap and A1 horizons generally are calcareous to strongly calcareous. The zone of maximum lime accumulation is 9 to 15 inches thick and lies just below the Ap horizon. Depth to the underlying loamy sand or sand is 13 to 20 inches. The underlying sand is fine at a depth of less than 48 inches but includes some medium and coarse grains.

The Arveson soils have a coarse-textured C horizon at a depth of 20 inches or less, but the Marysland soils have a coarse-textured C horizon at a depth of more than 20 inches. Arveson soils are more calcareous than Hamar soils. They have a finer textured A horizon than the Fossum soils.

Arveson loam (0 to 2 percent slopes) (Av).—This soil occurs in areas that are generally broad and lie in a southeast-northwest direction. These areas border the gently sloping Hecla and Malachy soils and the wet, very poorly drained Venlo and Mayer, depressional, soils; they inter-finger with the poorly drained Fossum and Hamar soils.

Included in mapping were small areas of Fossum, Hamar, and Venlo soils. In some places the upper few inches of the surface layer is noncalcareous. Occasionally pebbles occur in the profile. Also included were small areas of somewhat poorly drained soils.

This soil is wet early in summer when the water table is at a depth of about 2 feet. By late in July, however, the water table drops to about 5 feet. Most of the area has been drained by surface ditches, but wetness persists. Soil blowing is a serious problem in unprotected fields.

All common crops are grown on this soil. Applications of phosphorus and potassium are needed to offset the high content of lime. Capability unit IIIw-5; windbreak suitability group 7.

Barnes Series

The Barnes series consists of deep, well-drained soils that developed in calcareous loam glacial till. These are nearly level to rolling soils in the northeastern and western parts of the county.

In a representative profile, the surface layer is neutral, black loam about 10 inches thick. The subsoil is dark-brown, neutral, friable loam about 10 inches thick. The underlying material is light olive-brown, friable, strongly calcareous loam to a depth of about 40 inches. This is underlain by calcareous, light olive-brown, friable loam that has grayish-brown and yellowish-brown mottles.

Organic-matter content, available water capacity, and natural fertility are high. Permeability is moderate.

Most areas of Barnes soils are cultivated. Erosion is a hazard in the sloping areas. Erosion control and soil management are the main needs.

Representative profile of a Barnes loam from an area of Barnes-Buse loams, 2 to 6 percent slopes, eroded, 50 feet north of grove and 155 feet east of field boundary, SW¼SW¼SW¼ sec. 10, T. 121 N., R. 37 W.

Ap—0 to 10 inches, black (10YR 2/1) loam; weak, fine, angular blocky structure; friable; neutral; abrupt, smooth boundary.

B21—10 to 16 inches, very dark grayish-brown (10YR 3/2) loam; peds have dark-brown (10YR 4/3) interiors; weak, fine and medium, prismatic structure breaking to weak, medium subangular blocky structure; friable; neutral; abrupt, smooth boundary.

B22—16 to 20 inches, dark-brown (10YR 3/3) loam; weak, medium, prismatic structure breaking to weak, fine, angular blocky structure; friable; neutral; abrupt, wavy boundary.

C1ca—20 to 34 inches, light olive-brown (2.5Y 5/4) loam; light gray (2.5Y 7/2) when dry; weak, fine, subangular blocky structure; horizontal fracture; friable; larger gravel has limy accumulations on lower surface; strongly calcareous; clear, smooth boundary.

C2ca—34 to 40 inches, light olive-brown (2.5Y 5/4) loam; light gray (2.5Y 7/2) when dry; weak, fine, subangular blocky structure; friable; strongly calcareous; clear, smooth boundary.

C3—40 to 50 inches, light olive-brown (2.5Y 5/4) loam; few grayish-brown and yellowish-brown mottles; massive; friable; calcareous.

The A horizon is 8 to 12 inches thick and is loam, clay loam, or silt loam in texture. The B horizon is 6 to 14 inches thick and is loam or clay loam in texture. The C horizon is calcareous loam or clay loam. Lime is leached to a depth of 12 to 24 inches. A layer of lime accumulation 10 to 30 inches thick occurs beneath the B horizon. In a few places a continuous pebble line is found in the profile.

The Barnes soils have a thicker solum than Buse soils. They have a solum that developed in till, whereas the Doland soils have an upper part that developed in loess.

Barnes loam, 0 to 2 percent slopes (BaA).—This is a nearly level soil that occurs mainly in the western part of the county. The Barnes soil is in the uniform, convex part of the area and represents 85 percent of the area.

Included in mapping were Buse soils that occur as small, gray bumps. The soil in this unit is next to the Svea, Parnell, Flom, Doland, and Tara soils, and often includes small areas of them.

This soil is used intensively for corn and soybeans. Soil blowing is a problem in fields left bare in winter and spring. Soil management is needed that keeps good soil tilth, controls erosion, and maintains high fertility. Capability unit I-1; windbreak suitability group 1.

Barnes-Buse loams, 2 to 6 percent slopes, eroded (BbB2).—The Buse and Barnes soils occur in such a complex pattern that the separation of each soil is impractical. These are undulating soils that occur mostly in the northeastern part of the county. The slopes are 75 to 200 feet in length.

The Barnes soil represents about 75 percent of the area and has the more uniform slopes. It has the profile described as representative for the Barnes series. On the upper part of the slopes, much of the original surface layer has been removed by erosion. Here the soil is brownish in color because of the mixing of the dark-brown subsoil with the remaining surface layer. Near the bottom of the slopes the surface layer is thicker than typical because of the accumulation of soil from higher slopes.

The Buse soil is on the very top of the slight rises, and it comprises about 20 percent of this mapping unit. Buse soil is grayish in color because of the mixing of the thin surface layer with the grayish-brown, strongly calcareous underlying material.

Included in mapping were small areas of Doland, Darnen, Flom, Parnell and Vallers soils. They are generally in the lower positions in the soil area. A small acreage of clay loam soils south of Monson Lake also was included.

All crops common to the county are well suited to these soils. The Buse soil is less suitable to crops than the Barnes soil, because the Buse soil has a nutrient imbalance caused by a high lime content. Soil blowing is a slight hazard in fields left bare in winter and spring. Erosion is a moderate problem and has lowered the organic-matter content and infiltration rate of these soils.

Soil management is needed that increases organic-matter content, maintains a high nutrient level, and controls erosion. Both soils in capability unit IIe–1; Barnes part in windbreak suitability group 1, and Buse part in windbreak suitability group 5.

Barnes-Buse loams, 6 to 12 percent slopes, eroded (BbC2).—The Barnes and Buse soils occur in such a complex pattern that the separation of each is impractical. The Barnes soil comprises about 60 percent of this complex, and Buse soil about 35 percent. The Buse soil has developed on the crest of the hills and on slight rises or bumps. It appears grayish in color because of the mixing of the underlying material with the plow layer. The Barnes soil occurs on the more uniform slopes. On a large part of the slopes, particularly in the upper part, the plow layer is mixed with the dark-brown subsoil. This gives these slopes a brownish surface layer. At the base of the slopes and in waterways, the surface layer is thicker than typical because of the accumulation of soil washed in from above.

These are rolling soils that occur mostly in the northeastern part of the county. The topography is complex and slopes in several directions. Slopes are irregular and range from 75 to 250 feet in length. These soils have lost up to two-thirds of the original surface layer.

These soils occur close to the Doland and Svea soils and include small areas of them. Also included in this unit were some areas in which the Barnes soil has lost less than one-third of the original surface layer. Small pockets of sand or gravel were included in places in mapping this unit.

All crops common to the county are grown on these soils but the use of row crops creates a serious erosion hazard. The organic-matter content and infiltration rate have been reduced by erosion. Management practices to control erosion and increase the fertility level are needed. Both soils in capability unit IIIe–1; Barnes part in windbreak suitability group 1, and Buse part in windbreak suitability group 5.

Barnes-Buse very stony loams, 2 to 12 percent slopes (BcC).—These rolling to undulating soils are southwest of the city of Appleton. Barnes soil makes up about 60 percent of the complex, and Buse soil 40 percent. These soils are so stony that it is not economically feasible to clear them for cropland. Their use is limited to hayland or pasture. On about one-third of the acreage, the stones are so numerous and protrude above the ground to such an extent that the use of haying equipment is not practicable. These soils can provide good grazing. The value of the hayland decreases when it is used for grazing, because the soils become compacted and more stones are exposed and protrude above the ground. Capability unit VIe–2; windbreak suitability group 10.

Bearden Series

The Bearden series consists of deep, moderately well drained to somewhat poorly drained, calcareous soils that have been formed in moderately fine textured, water-laid material. These soils are nearly level. They occur in the south-central part of the county.

In a representative profile, the surface layer is calcareous, black silty clay loam about 9 inches thick. The underlying material is friable silty clay loam. The upper part is about 9 inches thick and is dark gray to grayish brown and strongly calcareous. The lower part is light olive brown and calcareous. Grayish-brown and light olive-brown mottles are common at a depth of about 24 inches.

The organic-matter content and available water capacity are high. Natural fertility is only moderate because the high lime content reduces the availability of some nutrients. Permeability is moderately slow. Normally, the water table is not a limitation, but in extremely wet periods it rises high enough to limit the root zone.

Most areas of Bearden soils are cultivated intensively. The fertility imbalance is the main problem, but crops grow well with proper fertilization and soil management.

Representative profile of Bearden silty clay loam, 0 to 2 percent slopes, in a cultivated field, 400 feet south and 175 feet east of NW. corner of NW¼NW¼ sec. 24, T. 120 N., R. 40 W.

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

C1ca—9 to 12 inches, dark-gray (2.5Y 4/1) silty clay loam; weak, coarse, prismatic structure breaking to weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, smooth boundary.

C2ca—12 to 18 inches, grayish-brown (2.5Y 5/2) silty clay loam; weak, coarse, prismatic structure breaking to moderate, medium, subangular blocky structure; friable; some dark grayish-brown (2.5Y 4/2) coatings on peds; tongues of material from the A horizon extend through this horizon; strongly calcareous; gradual, smooth boundary.

C3—18 to 24 inches, light olive-brown (2.5Y 5/4) silty clay loam; weak, fine, subangular blocky structure; friable; a few lime specks and dark grayish-brown coatings on peds; calcareous; gradual, smooth boundary.

C4—24 to 60 inches, light olive-brown (2.5Y 5/4) silty clay loam; common, fine, faint mottles of grayish brown and light olive brown; mottling increases with depth; massive; friable; calcareous.

The texture throughout the profile ranges from silty clay loam to silt loam. The profile is generally calcareous throughout, but in some places the lime is leached to a depth of 8 to 14 inches. In places gypsum crystals are in the C horizon.

Bearden soils have a more brownish color in the Cca horizon than the poorly drained Colvin soils. Bearden soils formed in lacustrine material, while the McIntosh soils formed in lacustrine material and glacial till. Bearden soils are more calcareous than the Hantho soils.

Bearden silty clay loam, 0 to 2 percent slopes (BdA).—This nearly level soil occurs on the lake plain in the south-central part of the county. It generally occurs in irregular, broad areas that in many places are oriented in a north-south direction.

Included in mapping were small areas of Colvin, Perella, depressional, Hantho, McIntosh, and Hamerly soils. Colvin soils are in small, shallow depressions. Also included is an area of about 200 acres in southeastern Cashel Township where the texture is heavy silty clay loam or silty clay throughout the profile. Some small areas having slopes up to 4 percent were included. Some fields contain a few dark-gray spots in which the surface layer is more calcareous than typical. Pebbles and small stones are occasionally found on the surface. In some areas the underlying glacial till occurs at a depth of less than 40 inches.

This soil is used intensively for corn and soybeans, and it is well suited to sugar beets. Soil blowing is a hazard in fields that are left bare in winter and spring.

Management is needed to control erosion and maintain a high fertility level. Applications of nitrogen, phosphorus, and potassium are needed. Capability unit IIe-4; windbreak suitability group 5.

Benoit Series

In the Benoit series are nearly level, poorly drained soils that formed in outwash consisting of calcareous loam overlying calcareous sand and gravel.

In a representative profile, the surface layer is about 13 inches of calcareous black loam and about 5 inches of calcareous very dark gray loam. The upper part of the underlying material is strongly calcareous and calcareous, gray to very dark grayish-brown sandy loam about 5 inches thick. It is slightly sticky and contains grayish-brown, yellowish-brown, and light olive-brown mottles. Below this is calcareous, light yellowish-brown, loose sand and gravel in which brown and gray mottles become more common with depth.

The organic-matter content is high. The natural fertility is low because of the high lime content. The available water capacity also is low. Permeability is moderate in the surface layer and very rapid in the sand and gravel. The water table is high during the early part of the growing season and restricts the root zone.

Wetness and low fertility are the principal limitations. Droughtiness is a limitation when rainfall is inadequate.

Representative profile of Benoit loam, 600 feet north and 280 feet east of SW. corner of NW¼ sec. 2, T. 120 N., R. 42 W.

Ap—0 to 7 inches, black (10YR 2/1) loam; moderate, medium, subangular blocky structure; slightly sticky; calcareous; abrupt, smooth boundary.

A11—7 to 13 inches, black (10YR 2/1) loam; weak, medium, subangular blocky structure; slightly sticky; calcareous; clear, gradual boundary.

A12ca—13 to 18 inches, very dark gray (2.5Y 3/1) loam; gray (2.5Y 5/0) when dry; weak, medium, angular blocky structure; slightly sticky; strongly calcareous; clear boundary.

C1ca—18 to 20 inches, gray (2.5Y 5/1) sandy loam; few, fine, faint, light olive-brown mottles; weak, fine, subangular blocky structure; slightly sticky; strongly calcareous; clear, gradual boundary.

C2—20 to 23 inches, very dark grayish-brown (2.5Y 3/2) sandy loam; dark gray (2.5Y 4/1) when dry; common, fine, distinct, grayish-brown and yellowish-brown mottles; weak, coarse, angular blocky structure; slightly sticky; calcareous; clear, gradual boundary.

IIC3—23 to 60 inches, light yellowish-brown (2.5Y 6/3) sand and gravel; common, fine to medium, distinct, brown and gray mottles; single grain; loose; calcareous.

The A horizon generally is loam, but in places it is sandy loam. This horizon is calcareous to strongly calcareous. Depth to sand and gravel ranges from 16 to 24 inches but is normally about 20 inches.

Benoit soils are underlain by sand and gravel within 24 inches of the surface, whereas the Marysland soils are underlain by sand and gravel at depths of more than 24 inches. The Benoit soils have a horizon of lime accumulation, but Mayer soils do not.

Benoit loam (Be).—This nearly level soil occurs in the outwash areas throughout the county, mainly in Edison and West Bank Townships.

Included in mapping were small areas of Marysland loam, Mayer loam, and Renshaw loam. Also included were areas in which the surface layer is very strongly calcareous and areas where it is noncalcareous.

All crops common to the area are grown on this soil. Most areas have been drained to some degree, but further drainage is needed. Because the water table is high, the soil is slow to warm up in spring. Fields are often wet and difficult to work. Applications of nitrogen, phosphorus, and potassium are needed to offset the high lime content of the soil. Soil blowing is a hazard in fields left bare in winter and spring.

Management is needed that provides adequate drainage, controls erosion, and maintains a balance of plant nutrients. Capability unit IIIw-5; windbreak suitability group 7.

Blue Earth Series

The Blue Earth series consists of deep, very poorly drained soils that formed in calcareous, highly organic silty sediments. These soils occur as large circular or elongated depressions throughout the county.

In a representative profile, the surface layer is calcareous mucky silt loam about 24 inches thick. Snail shells are common in this layer. Its upper part is black, but it grades to very dark gray in the lower 10 inches. The underlying material is calcareous, friable silty clay loam. The upper part is very dark gray and contains snail shells and large, faint, olive mottles. As the depth increases the color becomes dark gray and olive.

The organic-matter content is very high. The natural fertility is moderate because of the high lime content. The available water capacity is high. Permeability is moderately slow. Surface water is generally ponded in these areas for long periods.

Wetness and fertility are the principal limitations. With adequate drainage and proper soil management, these soils are suited to all commonly grown crops.

Representative profile of Blue Earth silt loam, cultivated, 950 feet south and 375 feet west of NE. corner of NW¼ sec. 2, T. 122 N., R. 37 W.

Ap—0 to 7 inches, black (2.5Y 2/0) silt loam; moderate, fine, granular structure; friable; snail shells common; calcareous; abrupt, smooth boundary.

A11—7 to 14 inches, black (5Y 2/1) mucky silt loam; moderate, very fine, granular structure; friable; snail shells common; calcareous; clear, smooth boundary.

A12g—14 to 24 inches, very dark gray (5Y 3/1) silt loam; moderate, fine, angular blocky structure; friable; snail shells common; calcareous; gradual, wavy boundary.

C1g—24 to 40 inches, very dark gray (5Y 3/1) silty clay loam; common, large, faint, olive mottles; massive; friable; snail shells common; calcareous; gradual, wavy boundary.

C2—40 to 60 inches, dark-gray (5Y 4/1) and olive (5Y 4/4) silty clay loam; massive; friable; calcareous.

The Ap horizon includes both mucky silt loam and mucky silty clay loam. A layer of peat or muck less than 12 inches thick is on this soil in some areas. Snail shells are common throughout the profile, and the entire profile is calcareous.

In Swift County soils of this series occur mainly in glaciated uplands, where the underlying material is a loam, clay loam, or silty clay loam. A small acreage is on the lacustrine lake plain, where the underlying material is ordinarily silt loam but where sand is encountered in some places at depths below 4 feet.

Blue Earth soils have a lower organic-matter content than the Muck and peat soils. They are more calcareous and higher in organic-matter content than the Parnell soils. They are siltier and contain more organic matter than the Oldham soils.

Blue Earth silt loam (Bh).—This nearly level soil occurs in large depressions and old lake beds throughout the county.

Included with this soil in mapping were small areas of Oldham silty clay loam and of Vallers silty clay loam. These soils are near the edge of the tract in which Blue Earth silt loam occurs.

Many areas of this soil are not drained and contain water for most of the year. These areas have high value for waterfowl because they provide nesting, mating, or resting areas. When properly drained, they are suited to all common crops. Small grains tend to lodge, however, and corn and soybeans are often damaged by early frost. Silage corn is well suited. Soil blowing is a problem in fields left bare during winter and spring.

Management is needed that provides adequate drainage and maintains a high nutrient level. Applications of phosphorus and potash are needed for maximum production. Capability unit IIIw–6; windbreak suitability group 9.

Borup Series

The Borup series consists of poorly drained soils that formed in calcareous lacustrine sediments. These nearly level soils occur on the lake plain east of Benson, in Kildare Township.

In a representative profile, the surface layer is calcareous black silt loam in the upper 15 inches and strongly calcareous very dark-gray silt loam in the lower 4 inches. The lower part is friable and has few, faint, olive-yellow mottles. The upper 12 inches of the underlying material is calcareous and strongly calcareous, friable, gray and olive silt loam. Below this is a calcareous, olive very fine sandy loam that grades to very fine sand. Yellowish-brown and gray mottles are common in this underlying material.

The organic-matter content is high. The natural fertility is moderate because of the high lime content. The available water capacity is moderate. Permeability is moderate in the silt loam and in the very fine sand. The high content of lime in the soil causes an imbalance of plant nutrients. Early in summer, root growth is restricted by a high water table.

Wetness and low fertility are the principal hazards. This soil is well suited to all crops when it is properly managed.

Representative profile of Borup silt loam, under native grass, 700 feet north and 50 feet west of SE. corner of sec. 5, T. 121 N., R. 38 W.

A11—0 to 15 inches, black (10YR 2/1) silt loam; weak, fine, angular blocky structure; very friable; calcareous; abrupt, smooth boundary.

A12ca—15 to 19 inches, very dark gray (2.5Y 3/1) silt loam; gray (2.5Y 5/1) when dry; few, fine, faint, olive-yellow mottles; weak, fine, angular blocky structure; friable; strongly calcareous; gradual, smooth boundary.

C1ca—19 to 24 inches, gray (2.5Y 5/1) silt loam; weak, fine, angular blocky structure; friable; strongly calcareous, gradual, smooth boundary.

C2—24 to 28 inches, gray (5Y 5/1) silty clay loam; few, fine, faint, olive mottles; weak, very fine, angular blocky structure; friable; few black root stains; calcareous; gradual, wavy boundary.

C3—28 to 31 inches, olive (5Y 5/3) silt loam; weak, fine, angular blocky structure; friable; calcareous; clear, wavy boundary.

IIC4—31 to 36 inches, olive (5Y 5/3) very fine sandy loam; single grain; very friable; calcareous; gradual, wavy boundary.

IIC5—36 to 60 inches, olive (5Y 5/3) very fine sand; common, medium, prominent, gray, brown, and yellowish-brown mottles; single grain; loose; calcareous.

The texture of the A horizon includes silt loam, very fine sandy loam, and loam. The A horizon ranges from slightly calcareous to strongly calcareous. The zone of lime accumulation is within 16 inches of the surface and is very dark gray to gray in color. Depth to sands ranges from 24 to 40 inches. The texture of this underlying layer is very fine sand or loamy very fine sand.

Borup soils are coarser textured in the lower part of the C horizon than the Colvin soils. They are finer textured than the Marysland soils.

Borup silt loam (Bm).—This is a nearly level soil that generally occurs in broad irregular areas. It is associated with Marysland, Malachy, Arveson, and Glyndon soils. It occurs in northern Kildare Township east of Benson.

This soil is wet in the early part of the growing season when the water table is about 2 feet from the surface. By the middle of June the water table has dropped to about 4 feet from the surface.

Some small areas of Glyndon and Arveson soils were included with this soil in mapping. Also included were areas where the underlying material is fine sands that contain a high percentage of very fine sands.

This soil requires drainage. Most areas already have been drained by surface ditches, which are adequate in most years.

This soil is well suited to corn, soybeans, and sugar beets. Soil blowing is a problem in fields left bare during winter and spring. Applications of nitrogen, phosphorus, and potassium are needed. Capability unit IIw–4; windbreak suitability group 7.

Buse Series

In the Buse series are deep, somewhat excessively drained soils that formed in calcareous loam glacial till. These soils are gently undulating to hilly.

In a representative profile, the surface layer is calcareous, very dark gray to very dark grayish-brown loam about 7 inches thick. The upper part of the underlying material is friable, strongly calcareous, grayish-brown loam about 7 inches thick. Below this is strongly calcareous, light olive-brown loam, about 26 inches thick, that contains lime concretions. Underlying this layer is calcareous, light olive-brown loam containing many yellowish-brown and light brownish-gray mottles and some dark reddish-brown concretions.

The organic-matter content in these soils is moderate. The natural fertility is only moderate because of the excessive amount of lime. The available water capacity is high. The permeability is moderate.

Water erosion, fertility management, and droughtiness are the principal concerns. Where the slopes are not too steep, most of the acreage of these soils is cultivated. The steeper slopes are commonly in grass.

Representative profile of a Buse loam from an area of Buse-Barnes loams, 2 to 6 percent slopes, eroded, in a cultivated area 50 feet south and 910 feet east of NW. corner of SW¼NW¼ of sec. 7, T. 122 N., R. 37 W.

Ap—0 to 7 inches, very dark gray (10YR 3/1) to very dark grayish-brown (10YR 3/2) loam; some brown (10YR 5/3) material from the B horizon mixed in; weak, fine, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.

C1ca—7 to 14 inches, grayish-brown (2.5Y 5/2) loam; weak, thick, platy structure; friable; strongly calcareous; gradual, wavy boundary.

C2ca—14 to 40 inches, light olive-brown (2.5Y 5/5) loam; weak, fine, subangular blocky structure; friable; lime concretions; strongly calcareous; gradual, wavy boundary.

C3—40 to 60 inches, light olive-brown (2.5Y 5/4) loam; common, medium, faint, yellowish-brown and light brownish-gray mottles; weak, fine, subangular blocky structure; friable; dark reddish-brown iron concretions; calcareous.

The A horizon ranges from black to very dark grayish brown, from loam to clay loam, and from 4 to 12 inches in thickness. The C1ca horizon is loam or clay loam in texture. In places a weakly defined brownish layer less than 3 inches thick is present below the A horizon. A layer of lime accumulation 10 to 33 inches thick occurs beneath the A horizon.

Buse soils have a thinner solum and are more calcareous than the Barnes soils. They formed in glacial till, but the Zell soils formed in well-sorted silts. Buse soils generally are more brownish in the C1 horizon than Hamerly soils. They are coarser textured than the Hattie soils.

Buse loam, 18 to 25 percent slopes (BnE).—This soil occurs mostly in the northeastern part of the county. Waterways commonly cross it and make it irregular. Slopes range from 150 to 300 feet in length. The surface layer is 4 to 8 inches thick.

Included with this soil in mapping, and making up about 10 percent of its acreage, were Buse-Barnes loams, eroded, on slopes of 12 to 18 percent.

Also included, in draws and on lower parts of slopes, were small areas of Barnes soil, which has a black or very dark grayish-brown surface layer. In places this layer is thicker than is typical for Barnes soil because it has received soil material from nearby slopes.

This soil generally is on crests of hills and upper parts of slopes adjacent to streams, waterways, sloughs or lakes. Most of this soil is under grass, but some areas that have been cultivated and subjected to erosion were included. Vegetation on this soil is ordinarily sparse and in many places is stunted.

Included with this soil in mapping were small areas of Buse-Barnes complex on the upper slopes and of Darnen or Parnell and Flom soils on lower slopes. In some areas small sand or gravel pockets were included.

This soil is well suited to pasture. If it is overgrazed erosion will start. Capability unit VIe–1; windbreak suitability group 5.

Buse loam, 25 to 35 percent slopes (BnF).—This soil generally is near streams, waterways, sloughs, or lakes. Slopes are 150 to 300 feet long and are complex because numerous waterways dissect them. Some small pockets of sand or gravel commonly were included in mapping. The soil is very erodible.

This soil is under grass or trees. If it is used as pasture, grazing should be limited to control erosion. Capability unit VIIe–1; windbreak suitability group 5.

Buse very stony loam, 12 to 30 percent slopes (BoE).—This steep soil occupies areas southwest of Appleton that break toward the bottom lands along the Minnesota River and the Pomme de Terre River. Stones greatly limit use, but this soil is well suited to pasture or as habitat for wildlife. The steep slopes and stoniness limit grazing. Erosion is a serious hazard if pasture is overgrazed. Capability unit VIe–1; windbreak suitability group 10.

Buse-Barnes loams, 2 to 6 percent slopes, eroded (BuB2).—This complex consists of gently undulating soils that are mostly in the northeastern part of the county. The Buse soil generally is on the crests of the slopes and has a very dark grayish-brown surface layer. It has the profile described as representative of the Buse series. The Barnes soil has a darker surface layer and is more nearly level than the Buse soil. The two kinds of soil are in about equal proportion but occur in such an intricate pattern that separating them on the map is not practical. These soils occur near the Svea and Hamerly soils, and in some places small areas of those soils were included in mapping.

Buse and Barnes soils are well suited to corn and soybeans. Crops on the Buse soil do not grow so well as those on the Barnes soil because the excessive amount of lime in the Buse soil causes an imbalance of plant nutrients.

Management that controls erosion and maintains fertility is needed. Both soils in capability unit IIe–2; Buse part in windbreak suitability group 5, and Barnes part in windbreak suitability group 1.

Buse-Barnes loams, 6 to 12 percent slopes, eroded (BuC2).—The soils in this complex are rolling and have irregular slopes, 75 to 300 feet long, that face in several directions. Buse soil makes up about 60 percent of this complex, and Barnes soil, 35 percent. The Buse soil is on the crowns or knobs. It is grayish because its very dark gray surface layer has been mixed with the grayish-brown underlying material. The Barnes soil is in the sags and downslope from the knobs of Buse soil. Barnes soil generally has a black surface layer, but in places its brown subsoil has been turned up by plowing.

This complex occurs with the Barnes-Buse, Flom, Parnell, Vallers, Winger, and Doland soils. In many places small areas of these were included in mapping. Also included is an area in northern Kerkhoven Township that contains a high proportion of silt or very fine sand.

All crops common in the county are grown on the soils of this complex. The natural fertility of the Buse soil is low because the calcareous parent material is exposed. The content of organic matter and the infiltration of moisture have been lowered for both soils by past erosion.

Management that controls erosion, increases the supply of organic matter, and improves fertility is needed. Both soils in capability unit IIIe–1; Buse part in windbreak suitability group 5, and Barnes part in windbreak suitability group 1.

Buse-Barnes loams, 12 to 18 percent slopes, eroded (BuD2).—This complex of hilly soils occurs mostly in the northeastern part of the county. The slopes are steep, are complex, ordinarily face in several directions, and are dissected by many waterways. Length of slope ranges from 75 to 100 feet.

Buse soil makes up about 80 percent of this soil complex. It is on the crests of the hills and the upper parts of slopes. It is grayish brown because it has been eroded and the lighter colored underlying material has been exposed.

The Barnes soil, which makes up about 15 percent of this complex, is in the draws and sags and areas downslope from the Buse soil. It has a black surface layer, which is thick in the draws because soil from nearby slopes has accumulated on it. In some places where the Barnes and Buse soils join, the brownish subsoil of the Barnes soil is exposed.

Included in mapping this complex were areas of Doland soils on the upper slopes and Darnen or Parnell and Flom soils on lower slopes. Also included were some small areas of sand and gravel. In northern Kerkhoven Township some soils were included in mapping that have a high percentage of silt or very fine sandy loam in the surface layer.

About one-fourth of this complex is under grass or trees and has been protected from erosion. The rest has been cultivated, and as a result of erosion, the supply of organic matter and the infiltration of moisture have been lowered. Management is needed that controls erosion on these steep soils. Both soils in capability unit IVe–1; Buse part in windbreak suitability group 5, and Barnes part in windbreak suitability group 1.

Clontarf Series

The Clontarf series consists of deep, moderately well drained soils that formed in outwash sands. These soils are in nearly level to slightly depressed areas in the north-central and southwestern parts of the county.

In a representative profile, the surface layer is neutral, black sandy loam about 15 inches thick. The subsoil is friable, very dark grayish-brown, neutral sandy loam and loamy sand about 10 inches thick. Faint, brownish-gray and olive-brown mottles are common in the lower 3 inches. The underlying material begins at a depth of about 25 inches. In the upper part it is neutral, olive-brown loamy sand in which there are common, distinct, grayish-brown and yellowish-brown mottles. At a depth of 29 inches, this loamy sand grades to light olive-brown medium sand that has a few, faint, yellowish-brown, light brownish-gray, and pale-brown mottles.

The organic-matter content is high, but natural fertility and available water capacity are low. Permeability is moderately rapid in the sandy loam, but rapid in the loamy sand and sand.

Soil blowing and droughtiness are the major problems of these soils. Most areas of Clontarf soils are now cultivated. Moderate response can be expected when rainfall is adequate and management is good.

Representative profile of Clontarf sandy loam, 0 to 2 percent slopes, in a cultivated area, 600 feet south and 150 feet west of NE. corner of sec. 25, T. 122 N., R. 41 W.

Ap—0 to 7 inches, black (10YR 2/1) sandy loam; weak, fine, angular blocky structure; friable; neutral; abrupt, smooth boundary.

A1—7 to 15 inches, black (10YR 2/1) sandy loam; weak, fine, angular blocky structure; friable; neutral; clear, smooth boundary.

B21—15 to 18 inches, very dark grayish-brown (2.5Y 3/2) sandy loam; weak, fine, angular blocky structure; friable; neutral; gradual, wavy boundary.

B22—18 to 22 inches, very dark grayish-brown (2.5Y 3/2) sandy loam; dark brown (10YR 3/3) when crushed; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

IIB23—22 to 25 inches, very dark grayish-brown (2.5Y 3/2) loamy sand; common, fine, faint, brownish-gray and olive-brown mottles; single grain; loose; neutral; gradual, wavy boundary.

IIC1—25 to 29 inches, olive-brown (2.5Y 4/4) loamy sand; common, fine, distinct, grayish-brown and yellowish-brown mottles; single grain; loose; neutral; gradual, wavy boundary.

IIC2—29 to 40 inches, light olive-brown (2.5Y 5/4) medium sand; few, fine, faint, yellowish-brown and light brownish-gray mottles; single grain; loose; neutral; gradual, wavy boundary.

IIC3—40 to 60 inches, light olive-brown (2.5Y 5/6) medium sand; few, fine, faint, yellowish-brown and pale-brown mottles; single grain; loose; neutral.

The A horizon ranges from 12 to 20 inches in thickness, from black to very dark gray in color, and from sandy loam to loam in texture. The B horizon is 8 to 14 inches thick and is sandy loam to loamy sand. The C horizon is loamy sand to medium and fine sand. Carbonates are leached to depths below 40 inches.

Clontarf soils have finer textures in the A and B2 horizons than do Maddock soils. They are finer textured in the solum than Hecla soils.

Clontarf sandy loam, 0 to 2 percent slopes (ClA).—This nearly level to slightly depressional soil is in the north-central and southwestern parts of the county. The soil areas are usually elongated and oriented in a southeast-northwest direction. Soil material drifted along fence rows and small areas of soil accumulation are evidence of past soil blowing.

Included with this soil in mapping were small areas of Malachy sandy loam, of Hecla loamy sand, and of the poorly drained Arveson and Hamar soils. Some small moderately eroded spots that have a brownish surface layer were included in some areas at slightly higher elevations. In the area around Clontarf village, coarse sands commonly occur in the underlying material. There is also a small area 2 miles west of Clontarf that has a thin loam surface layer and an area 1 mile east of Appleton that contains a buried profile. In the southwestern part of the county, this Clontarf soil has formed in fine and medium sands.

Corn, soybeans, and small grains are the main crops grown on this soil. Soil blowing is a hazard in unprotected fields. Drought is a problem late in summer. Capability unit IIIs–3; windbreak suitability group 8.

Colvin Series

The Colvin series consists of deep, calcareous, poorly drained soils that formed in moderately fine textured, water-deposited silty material. These nearly level soils are in the south-central part of the county.

In a representative profile, the surface layer is a calcareous, black silty clay loam, about 6 inches thick, over about 6 inches of strongly calcareous, very dark gray silty clay loam. The underlying material is friable silty clay loam. It is strongly calcareous and dark grayish brown in the upper 4 inches. The lower part is calcareous, olive or olive-gray silty clay loam mottled with light brownish gray, light olive brown, and yellowish brown.

The organic-matter content and available water capacity are high. Permeability is moderately slow. The high content of lime causes an imbalance of available plant nutrients; the natural fertility is therefore moderate. Colvin soils have a high water table during the early part of the growing season, which limits the root zone.

Most areas of the Colvin soils are cultivated. When they are adequately drained, these soils are well suited to all crops if good management is applied.

Representative profile of Colvin silty clay loam in a cultivated field 100 feet east and 1,300 feet north of crossroads, SW. corner of sec. 11, T. 120 N., R. 39 W.

Ap—0 to 6 inches, black (10YR 2/1) silty clay loam; weak, fine, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.

A1ca—6 to 12 inches, very dark gray (2.5Y 3/1) silty clay loam; weak, fine, subangular blocky structure; friable; strongly calcareous; clear, wavy boundary.

C1ca—12 to 16 inches, dark grayish-brown (2.5Y 4/2) silty clay loam; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

C2—16 to 28 inches, olive (5Y 5/3) silty clay loam; common, medium, distinct, light brownish-gray, light olive-brown, and yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C3—28 to 60 inches, olive-gray (5Y 5/2) silty clay loam; common, medium, prominent, yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous.

The texture of the A horizon ranges from silt loam to silty clay loam. The C1 horizon is a silty clay loam that in places grades to a silt loam in the lower part. The C2 and C3 horizons in some places contain an abundance of gypsum crystals.

Colvin soils are calcareous, but the Perella soils are not. Colvin soils are finer textured than the Borup or Marysland soils. Their profile is more olive colored than that of the Bearden soils.

Colvin silty clay loam (Co).—This soil is the level areas or slight depressions in the south-central part of the county. It has the profile described as representative for the series. It is wet to the surface early in the growing season, when the water table is at a depth of about 2 feet. Early in June the surface layer has dried.

This soil occurs near the higher lying Bearden or McIntosh soils and near the Perella soils of the depressions. Included with it in mapping were small areas of Bearden and Perella soils. Also included were small areas that are noncalcareous to a depth of 14 inches; areas where pebbles and small stones are on the surface; and areas where glacial till occurs at a depth of less than 40 inches.

This poorly drained soil needs additional drainage. Most of it has been drained by surface ditches that are adequate for most years. Tile systems are needed, however, to obtain complete drainage.

This soil is used intensively for corn and soybeans and is well suited to sugar beets. Capability unit IIw–3; windbreak suitability group 4.

Colvin silty clay loam, depressional (Cv).—This soil is mainly in shallow potholes and sloughs. A few areas occur as rims around the deeper potholes. This soil is flooded early in the growing season but ordinarily dries out by mid-July.

This soil is adjacent to Winger, Bearden, Perella, and other Colvin soils. Included with it in mapping were small areas of Colvin or Winger soils on the edge of depressions and of Perella, depressional, soils in the center parts of the depressions.

Additional drainage is required if this soil is to be farmed. Most areas already have surface ditches, but these do not provide adequate drainage. For complete drainage, tile should be installed. When this soil is drained, all crops common to the county can be grown. At times, however, small grain lodges and corn and soybeans do not mature. Nitrogen, phosphorus, and potassium are needed to offset the high lime content of this soil. Capability unit IIIw–2; windbreak suitability group 4.

Darnen Series

In the Darnen series are deep, moderately well drained soils that formed in material washed down from nearby soils that developed in calcareous glacial till of loam texture. Darnen soils are nearly level to gently sloping. They are in drainageways or at the base of slopes in the rolling glacial moraine parts of the county.

In a representative profile, the surface layer is black loam about 24 inches thick and neutral in reaction. The subsoil is friable, very dark grayish-brown and dark grayish-brown loam about 14 inches thick. The underlying material is calcareous, friable loam that grades from a dark grayish brown to grayish brown with depth.

The organic-matter content is high. Available water capacity is high, and the permeability is moderate. The natural fertility is high. These soils lie in positions that receive considerable runoff. They are often a little wetter than other sloping soils nearby.

These soils are well suited to all crops, but they are in small areas in waterways or at the base of slopes, and are farmed with the adjoining soils.

Representative profile of Darnen loam, 0 to 4 percent slopes, 150 feet north of field approach, in SW¼SE¼ sec. 29, T. 122 N., R. 42 W.

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

A1—8 to 24 inches, black (10YR 2/1) loam; weak, medium, subangular blocky structure; friable; neutral; clear, smooth boundary.

B1—24 to 29 inches, very dark grayish-brown (10YR 3/2) loam; weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

B21—29 to 34 inches, dark grayish-brown (10YR 4/2) loam; weak, fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

B22—34 to 38 inches, dark grayish-brown (2.5Y 4/2) loam; weak, fine, subangular blocky structure; friable; calcareous; gradual, smooth boundary.

C1—38 to 58 inches, dark grayish-brown (2.5Y 4/2) loam; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C2—58 to 64 inches, grayish-brown (2.5Y 5/3) loam; weak, fine, subangular blocky structure; friable; calcareous.

The A horizon ranges from 18 to 28 inches in thickness. It is loam or silt loam and ranges from neutral to moderately alkaline. In places it is calcareous. Depth to free lime ranges from 14 to 36 inches. Sand grains and pebbles are common, and in some profiles there are thin lenses of sand.

Darnen soils have a thicker A horizon than Svea or Tara soils. They are better drained and have a thicker B2 horizon than the Flom soils.

Darnen loam, 0 to 4 percent slopes (DaB).—This nearly level to gently sloping soil occurs in waterways and at the base of slopes. The areas are generally long and narrow, at the mouth of waterways. Some are shaped like a delta.

In the Pomme de Terre River valley, the Darnen soil lies between the nearly level, droughty Renshaw soils and the steeper Buse-Barnes soils. Where this soil is in the morainic upland, it lies between the poorly drained Vallers soils and Parnell and Flom soils and the well-drained Barnes and Buse soils. Small areas of Flom, Svea, or Barnes soils were included with this soil in mapping.

This soil is generally farmed with the adjoining soils. It is well suited to all of the common crops. Water erosion can be a problem in some places. Capability unit I-1; windbreak suitability group 1.

Doland Series

The Doland series consists of deep, well-drained soils that formed in shallow windblown silty material overlying calcareous loam glacial till. These soils are nearly level to gently sloping and occur throughout the county.

In a representative profile, the surface layer is neutral, black and very dark gray silt loam about 11 inches thick. The subsoil is neutral, very dark grayish-brown, dark grayish-brown, and dark-brown friable silt loam and loam about 15 inches thick. The underlying material is a friable, calcareous, light olive-brown and brown loam. Light brownish-gray and yellowish-brown mottles are common in the underlying material.

The organic-matter content is high. Available water capacity is high, and permeability is moderate. The natural fertility is high.

With good soil management, soils of this series are well suited to all crops. Erosion is a slight hazard on long slopes.

Representative profile of Doland silt loam, 0 to 2 percent slopes, in a cultivated area halfway between the 3rd and 4th light poles east of driveway and 30 feet south, in NE¼NE¼NW¼ sec. 23, T. 122 N., R. 42 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam; weak, fine, angular blocky structure; friable; neutral; abrupt, smooth boundary.

A1—8 to 11 inches, very dark gray (10YR 3/1) silt loam; weak, medium, angular blocky structure; friable; neutral; clear, irregular boundary.

B21—11 to 15 inches, very dark grayish-brown (10YR 3/2) to dark-brown (10YR 3/3) silt loam; weak, fine, subangular blocky structure; friable; tongues of A1 reach to depth of 14 inches; neutral; clear, wavy boundary.

B22—15 to 20 inches, dark grayish-brown (10YR 4/2) silt loam; weak, medium, prismatic structure breaking to weak, fine, subangular blocky; friable; neutral; gradual, wavy boundary.

IIB23—20 to 26 inches, dark grayish-brown (10YR 4/2) to dark-brown (10YR 4/3) loam; weak, fine, subangular blocky structure; friable; stone line at depth of 23 inches; neutral; gradual, wavy boundary.

IIC1ca—26 to 30 inches, light olive-brown (2.5Y 5/4) loam; common, fine, faint, light brownish-gray mottles and few, fine, faint, yellowish-brown mottles; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

IIC2—30 to 54 inches, brown (10YR 5/3) to light olive-brown (2.5Y 5/3) loam; common, fine, faint, light brownish-gray mottles and few, fine, faint, yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous.

The thickness of the silt cap ranges from 18 to 40 inches but in most places is near 24 inches. Pebbles and small stones are on the surface in many places. Free lime is leached to a depth of 16 to 30 inches and ordinarily is in the glacial till. In many places there is a loam or sandy loam texture at the contact between the loess and till.

Doland soils differ from Barnes soils in having a silt loam A horizon rather than an A horizon of loam or clay loam. Doland soils are underlain by glacial till, but Rothsay soils formed in deep silts.

Doland silt loam, 0 to 2 percent slopes (DlA).—This is a nearly level soil in irregular areas slightly elevated from the surrounding landscape and in places oriented in a northwest-southeast direction. The profile of this soil is the one described as typical for the series.

Mapped with this soil were small areas of Tara and McIntosh soils. Also included were small spots where the silt cap is so thin that pebbly glacial till is exposed, and small areas having a highly calcareous surface layer.

All crops common to the county are well suited to this soil. Soil blowing is a problem if fields are left bare during winter and spring. Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Capability unit I-1; windbreak suitability group 1.

Doland silt loam, 2 to 6 percent slopes (DlB).—This nearly level to gently sloping soil occurs throughout the county but is mainly in the northwestern part. Slopes are smooth and 100 to 250 feet in length. The greatest amount of erosion has taken place on the upper part of the slopes and on the crests of the hills. On the lower parts of the slopes the soil is generally uneroded, and in places the surface layer is thicker than normal. Nearly half of this soil has been subject to moderate erosion and has lost more than a third of the original surface soil. Mixing of the surface layer with the upper part of the subsoil has given the eroded areas a brownish cast.

Included with this soil in mapping were small areas of Rothsay silt loam and Darnen loam. Also included were small areas that are limy at the surface.

All crops common to the county are well suited to this soil. Water erosion is a problem on the longer slopes. Soil blowing is a hazard in unprotected fields during winter and spring. Eroded areas have a lower organic-matter content and lower nutrient-supplying capacity than those not eroded.

Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients in the soil. Capability unit IIe–1; windbreak suitability group 1.

Edison Series

The Edison series is made up of deep, well-drained soils that formed in moderately coarse textured outwash. These soils are nearly level to gently sloping and occur southeast of the city of Appleton.

In a representative profile, the surface layer is a neutral, very dark brown very fine sandy loam about 10 inches thick. The subsoil is neutral and about 24 inches thick. The upper part of the subsoil is a friable, dark grayish-brown very fine sandy loam that grades to loamy fine sand. The lower part is a friable, dark-brown loam. The underlying material is loose, yellowish-brown, slightly calcareous fine sandy loam. This fine sandy loam grades with depth to light olive-brown, strongly calcareous loamy very fine sand.

Free lime is generally at 24 to 40 inches. The organic-matter content is high. The natural fertility is moderate. The available water capacity is medium. The permeability is moderate in the very fine sandy loam and rapid in the loamy very fine sand.

Nearly all areas of these soils are cultivated. They are well suited to corn and soybeans if moisture is adequate and good management is applied.

Representative profile of Edison very fine sandy loam, 0 to 2 percent slopes, in a cultivated field, 75 feet south of first power pole west of field approach, in NE¼NW¼NW¼ sec. 31, T. 120 N., R. 42 W.

Ap—0 to 10 inches, very dark brown (10YR 2/2) very fine sandy loam; weak, fine, angular blocky structure; friable; very dark grayish-brown (10YR 3/2) and black (10YR 2/1) root channels; neutral; abrupt, smooth boundary.

B21—10 to 14 inches, dark grayish-brown (10YR 4/2) very fine sandy loam; weak, medium, angular blocky structure; friable; black worm channels; neutral; abrupt, smooth boundary.

B22—14 to 21 inches, dark grayish-brown (10YR 4/2) loamy fine sand; weak, coarse, angular blocky structure breaking to single grain; loose; neutral; abrupt, smooth boundary.

IIB23b—21 to 29 inches, dark-brown (10YR 3/3) loam having a high content of very fine and fine sands; weak to moderate, medium to coarse, prismatic structure breaking to moderate, fine, angular blocky structure; friable; thin patchy clay films and in places occasional continuous clay films; neutral; abrupt, smooth boundary.

IIB24tb—29 to 34 inches, dark-brown (10YR 3/3, 4/3) loam having high content of very fine and fine sands; weak, coarse, prismatic structure breaking to weak, fine, angular blocky structure; friable; neutral; abrupt, smooth boundary.

IIIC1b—34 to 38 inches, yellowish-brown (10YR 5/4) and light olive-brown (2.5Y 5/4) fine sandy loam; massive; loose; slightly calcareous; abrupt, smooth boundary.

IIIC2cab—38 to 54 inches, light olive-brown (2.5Y 5/3) loamy very fine sand; massive; loose; strongly calcareous; few calcium concretions; abrupt, smooth boundary.

IIIC3b—54 to 60 inches, light olive-brown (2.5Y 5/3) loamy very fine sand; massive; loose; calcareous.

The A horizon is fine sandy loam having a high content of very fine sand or very fine sandy loam. The thickness ranges from 8 to 14 inches. The B21 and B22 horizons are 8 to 20 inches thick and very fine sandy loam, loamy fine sand, or loamy very fine sand in texture. The IIB23 and IIB24 horizons are 10 to 20 inches thick, loam or very fine sandy loam in texture, and of weak prismatic and moderate blocky structure. The C horizon is fine sandy loam, loamy very fine sand, or a loamy fine sand having a high content of very fine sand. The entire profile contains a high percentage of fine and very fine sand.

The Edison soils contain a larger amount of very fine sand than the Shible or Maddock soils.

Edison very fine sandy loam, 0 to 2 percent slopes (EdA).—This is a level to nearly level soil in the sandy outwash area southeast of Appleton. Most of the soil areas are broad and irregularly shaped, but some are elongated and oriented in a northwest-southeast direction.

Included with this soil in mapping were some areas that are silty. Also included were small areas of Shible, Clontarf, Maddock, and Swenoda soils, all of which occur near this soil.

Soil blowing is a problem in unprotected fields during winter and spring. Some small areas have been moderately eroded, and in these the dark grayish-brown subsoil is exposed at the surface. Droughtiness is a hazard in some seasons.

All crops common to the county are well suited to this soil. Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Capability unit IIs–1; windbreak suitability group 8.

Edison very fine sandy loam, 2 to 6 percent slopes (EdB).—Areas of this gently sloping soil are generally elongated and are oriented from northwest to southeast. Some areas slope toward waterways or potholes.

Included with this soil in mapping were a few areas having a silty profile. Also included were small areas of Maddock, Torning, and Flandreau soils, all of which occur near this soil.

Soil blowing is a hazard in fields left unprotected during winter and spring. Water erosion has caused moderate soil loss on some slopes, and as a result the brown subsoil is exposed. Droughtiness is a problem in some seasons.

All crops common to the county are grown on this soil. Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Capability unit IIe–3; windbreak suitability group 8.

Embden Series

In the Embden series are deep, moderately well drained soils that formed in moderately coarse textured alluvium. These nearly level soils are 10 to 15 feet above the Chippewa River, so they are subject to flooding only during periods of extremely high water, or once in 7 years. A few old stream channels dissect some areas of these soils.

In a representative profile, the surface layer is a neutral, black and very dark gray fine sandy loam and sandy loam about 32 inches thick. The subsoil is calcareous, very dark grayish-brown, friable sandy loam about 15 inches thick. The underlying material is calcareous, very dark grayish-brown, loose loamy sand.

The organic-matter content is high. Natural fertility is moderate. The available water capacity is moderate, and permeability is moderately rapid.

These soils are well suited to all crops, but they generally occur in small areas and are therefore managed with adjoining soils.

Representative profile of nearly level Embden fine sandy loam, in a cultivated field, 1,650 feet south and 15 feet west of NE. corner of sec. 35, T. 120 N., R. 41 W.

Ap—0 to 6 inches, black (10YR 2/1) fine sandy loam; weak, medium, angular blocky structure; friable; neutral; abrupt, smooth boundary.

A11—6 to 16 inches, black (10YR 2/1) fine sandy loam; weak, medium, angular blocky structure; friable; neutral; gradual, wavy boundary.

A12—16 to 32 inches, very dark gray (10YR 3/1) sandy loam; weak, medium, angular blocky structure; very friable; neutral; gradual, wavy boundary.

B2—32 to 47 inches, very dark grayish-brown (10YR 3/2) sandy loam; few, fine, very dark grayish-brown mottles; weak, medium, angular blocky structure; friable; calcareous; gradual, wavy boundary.

IIC—47 to 60 inches, very dark grayish-brown (2.5Y 3/2) loamy sand; single grain; loose; calcareous; some small pebbles throughout.

The texture of the A horizon is fine sandy loam or sandy loam. The A and B horizons are neutral in most places. Free lime generally is at a depth below 30 inches. Depth to sand ranges from 40 to 60 inches. Thickness of horizons is variable, and sand lenses occur in the soil profile in many places.

Embden soils have a thicker, darker A horizon than the Maddock or Clontarf soils. They differ from Malachy soils by being noncalcareous in the A horizon.

Embden fine sandy loam (Em).—This nearly level soil is on terraces along the Chippewa River, mainly in Swenoda and West Bank Townships. The soil areas are generally elongated and parallel to the river. They are 10 to 15 feet above the normal water level and are flooded only during extremely wet seasons.

Included with this soil in mapping were some small areas that have sand or gravel in the underlying material. Also included were small areas where lime is less than 30 inches from the surface.

All crops common to the county are grown on this soil. Droughtiness is a hazard in some seasons. Capability unit IIs–1; windbreak suitability group 8.

Estelline Series

The Estelline series consists of well drained and moderately well drained soils that formed in sorted silts overlying calcareous sands and gravels. These nearly level soils occur in the western two-thirds of this county but are most extensive in Marysland and Swenoda Townships.

In a representative profile, the surface layer is neutral, black to very dark gray silt loam about 15 inches thick. The subsoil, about 7 inches thick, is neutral, very dark grayish-brown silt loam. The upper part of the underlying material is a grayish-brown and light olive-brown, strongly calcareous and calcareous silt loam. This part has some faint grayish-brown and light yellowish-brown mottles. The lower part, beginning at about 36 inches, is strongly calcareous, light olive-brown, mottled fine sand.

The organic-matter content is high. The natural fertility is moderate because depth to sand and gravel is moderate. The available water capacity is moderate. Permeability is moderate in the silts and very rapid in the sands and gravels.

Most areas of these soils are cultivated intensively to corn and soybeans. Soil blowing and droughtiness are hazards. Crops grow well, when rainfall is adequate and good soil management is practiced.

Representative profile of Estelline silt loam, 0 to 2 percent slopes, in a cultivated field 1,300 feet east and 20 feet south of NW. corner of SW¼ sec. 12, T. 120 N., R. 42 W.

Ap—0 to 8 inches, black (10YR 2/1) silt loam; moderate, medium, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A1—8 to 13 inches, black (10YR 2/1) silt loam; moderate, medium, subangular blocky structure; friable; neutral; clear, smooth boundary.

A3—13 to 15 inches, very dark gray (10YR 3/1) silt loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B2—15 to 22 inches, very dark grayish-brown (2.5Y 3/2) silt loam; weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

C1ca—22 to 26 inches, grayish-brown (2.5Y 5/2) silt loam; few, fine, faint, light yellowish-brown mottles; weak, fine, subangular blocky structure; friable; strongly calcareous; clear, smooth boundary.

C2—26 to 36 inches, light olive-brown (2.5Y 5/4) silt loam; common, fine, faint, grayish-brown and light yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

IIC3—36 to 60 inches, light olive-brown (2.5Y 5/4) fine sand; common, medium, distinct, yellowish-brown and grayish-brown mottles; single grain; loose; strongly calcareous.

The A horizon is 8 to 16 inches thick, and the B horizon is 6 to 18 inches thick and silt loam or loam. The depth to sand or to sand and gravel ranges from 24 to 36 inches. Free lime is near the contact between the silts and the sand and gravel in most places.

The Estelline soils have a thicker A horizon than the Flandreau soils. They differ from Rothsay soils by being underlain by sand and gravel.

Estelline silt loam, 0 to 2 percent slopes (EsA).—This nearly level to gently sloping soil is on terraces along the Pomme de Terre River. This soil is associated with Spottswood, Fordville, Renshaw, and Sioux soils, and in places small areas of those soils were included in mapping this soil. This soil is on the more nearly level part of the terraces, and Renshaw and Sioux are on the ridges nearby. Where this soil is near the breaks in the Pomme de Terre valley, it is deeper than it is farther away. In section 2 of Tara township, where this soil occurs in association with the Marysland soils, its surface is free of stones but there are some pebbles. Also included in mapping were a few small areas where the surface layer is a loam.

All crops common to the area can be grown on this soil, but they occasionally are damaged by lack of moisture during long dry periods. Soil blowing is a hazard in fields left bare in winter and early in spring. Soil management is needed that controls erosion and maintains good soil tilth and a high level of fertility. Capability unit IIs–1; windbreak suitability group 2.

Flandreau Series

The Flandreau series consists of well-drained soils that formed in sorted silt overlying calcareous sand. These soils are nearly level to gently sloping and occur throughout the county.

In a representative profile, the surface layer is neutral, black and very dark gray silt loam about 10 inches thick. The subsoil is neutral, friable, very dark grayish-brown and dark grayish-brown silt loam about 10 inches thick. The upper 8 inches of the underlying material is brown, friable silt loam that grades to a calcareous, friable, pale-brown loam. Under this is calcareous, friable fine sandy loam that contains a few light-gray lime segregations. This grades to calcareous, pale-brown and brown fine sand that contains some medium and coarse sand.

The organic-matter content is high. The natural fertility is moderate because of the moderate depth to sand. The available water capacity is moderate. Permeability is moderate in the surface layer and subsoil and rapid in the underlying sand.

Most areas of these soils are cultivated. Soil blowing and droughtiness are the major hazards. When rainfall is adequate, crops grow well if good soil management is applied.

Representative profile of Flandreau silt loam, 0 to 2 percent slopes, in a cultivated field, 300 feet south and 75 feet west of NE. corner of sec. 2, T. 120 N., R. 42 W.

Ap—0 to 7 inches, black (10YR 2/1) silt loam; weak, fine, subangular blocky structure; friable; contains worm casts; neutral; abrupt, smooth boundary.

A1—7 to 10 inches, very dark gray (10YR 3/1) silt loam; weak, coarse, prismatic structure breaking to weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

B21—10 to 15 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, coarse, prismatic structure breaking to weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

B22—15 to 20 inches, dark grayish-brown (10YR 4/2) silt loam; weak, coarse, prismatic structure breaking to weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

C1—20 to 23 inches, brown (10YR 5/3) silt loam; weak, coarse, prismatic structure breaking to weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

C2ca—23 to 28 inches, pale-brown (10YR 6/3) loam; weak, fine, subangular blocky structure; friable; calcareous; clear, smooth boundary.

C3ca—28 to 31 inches, pale-brown (10YR 6/3) fine sandy loam; weak, fine, subangular blocky structure; friable; few light-gray lime segregations; calcareous; clear, smooth boundary.

IIC4ca—31 to 40 inches, pale-brown (10YR 6/3) fine sand containing some medium and coarse sand; single grain; loose; calcareous; clear, smooth boundary.

IIC5—40 to 50 inches, brown (10YR 5/3) fine sand containing some medium and coarse sand; single grain; loose; calcareous.

The A horizon ranges from 7 to 12 inches in thickness and from silt loam to a loam having a high content of very fine sand. The B horizon is 8 to 16 inches thick. Free lime is generally leached down to the underlying sand, which is at depths of 24 to 40 inches.

Flandreau soils have a thinner, dark A horizon than the Estelline soils. They differ from Rothsay by being underlain by fine sand.

Flandreau silt loam, 0 to 2 percent slopes (FlA).—This nearly level soil occurs throughout the county. It has the profile described as representative for the series. Most of this soil is close to rivers or streams, where it is adjacent to the droughty Maddock and Renshaw soils. Some small areas are in the upland adjoining Barnes or Sverdrup soils.

Included with this soil in mapping were some small areas of Maddock sandy loam, Renshaw loam, and Sverdrup sandy loam. A few small grayish areas, limy at the surface, were also included.

This soil is well suited to all of the common crops. Soil blowing is a hazard in fields left bare during winter and spring. Droughtiness is a hazard during long dry periods. Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Capability unit IIs-1; windbreak suitability group 2.

Flandreau silt loam, 2 to 6 percent slopes (FlB).—This nearly level to gently sloping soil occurs mainly in areas of local outwash within the glacial moraine, but some areas are on terraces near rivers and streams.

Included with this soil in mapping were small areas of Renshaw loam, Maddock sandy loam, Sverdrup sandy loam, and Barnes-Buse loams. Also included were small areas that are limy at the surface. Some moderately eroded areas also were included. These areas have a brownish cast because the surface layer has been mixed with the subsoil. These eroded areas generally are on the upper part of slopes.

All crops common in the county are grown on this soil. Droughtiness is a moderate hazard during long dry periods. Soil blowing is a hazard in fields left bare during winter and spring. Water erosion on the stronger slopes has already caused some damage.

Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Capability unit IIe-3; windbreak suitability group 2.

Flom Series

The Flom series consists of nearly level, deep, poorly drained soils that formed in medium-textured or moderately fine textured glacial till. These soils are in broad, slightly depressed areas and drainageways in the ground moraine.

In a representative profile, the surface layer is neutral, black and very dark gray silty clay loam about 19 inches thick. The subsoil is slightly calcareous, very dark grayish-brown, friable silty clay loam about 3 inches thick. The underlying material is calcareous, friable, olive-gray loam with yellowish-brown mottles. This grades at a depth of about 30 inches to a strongly calcareous, friable, light olive-gray clay loam that contains a few, faint, olive mottles. Below this is calcareous, olive-gray clay loam mottled with yellowish brown.

The organic-matter content is high. The available water capacity is high, and permeability is moderately slow. The natural fertility is high. These soils tend to be wet. The water table is 2 to 3 feet from the surface in the early part of the growing season, and because of this, the zone for root growth is restricted.

These are highly productive soils when drained and otherwise well managed.

Representative profile of Flom silty clay loam from an area of Parnell and Flom soils, in a cultivated area 75 feet south and 100 feet east of the NW. corner of SW¼ sec. 13, T. 121 N., R. 43 W.

Ap—0 to 8 inches, black (10YR 2/1) silty clay loam; weak, fine, angular blocky structure; friable; neutral; abrupt, smooth boundary.

A1g—8 to 19 inches, very dark gray (2.5Y 3/1) silty clay loam; weak, fine, angular blocky structure; friable; neutral; clear, smooth boundary.

B2—19 to 22 inches, very dark grayish-brown (2.5Y 3/2) silty clay loam; weak, fine, angular blocky structure; friable; slightly calcareous; clear, smooth boundary.

C1—22 to 30 inches, olive-gray (5Y 5/2) loam; few, fine, distinct, yellowish-brown mottles; weak, very fine, angular blocky structure; friable; calcareous; gradual, wavy boundary.

C2ca—30 to 34 inches, light olive-gray (5Y 6/2) clay loam; few, fine, faint, olive mottles; massive; friable; strongly calcareous; clear, smooth boundary.

C3—34 to 54 inches, olive-gray (5Y 5/2) clay loam; common, fine, distinct, yellowish-brown mottles; massive; friable; calcareous.

The A horizon ranges from loam through silt loam to silty clay loam and is 18 to 24 inches thick. Free lime is at a depth of 18 to 28 inches. In some places the drainage is somewhat poor rather than poor.

The Flom soils differ from Vallers in having a B horizon. They lack the B2t horizon of the Parnell soils. They differ from Perella in having developed from glacial till.

Flom-Parnell stony silty clay loams (Fm).—This complex occupies the broad nearly level areas, drainageways, and depressions southwest of Appleton. In sections 7 and 8 and parts of 17 and 18, Appleton Township, they are in broad flat areas. In the rest of the county they occur in drainageways oriented northwest to southeast.

Flom stony silty clay loam makes up about 75 percent of the complex, and Parnell stony silty clay loam, which is in depressions, makes up about 25 percent. The Parnell soil generally is more stony than the Flom soil and contains water most of the summer.

These soils can be economically cleared of stones for crops. Most of the acreage is used for hay or wildlife. For use as cropland, additional drainage would be needed. Capability unit Vw–1; windbreak suitability group 10.

Flom-Parnell very stony silty clay loams (Fn).—This complex consists of nearly level soils that occupy broad areas, drainageways, and depressions southwest of Appleton. In sections 7 and 8 and parts of 17 and 18, Appleton Township, these soils are in broad areas. In other places they occur in drainageways oriented in a northwest-southeast direction.

Flom very stony silty clay loam makes up about 75 percent of the complex, and Parnell very stony silty clay loam, which is in depressions, makes up the remaining 25 percent. The Parnell soil generally contains more stones than the Flom soil, and it holds water most of the summer.

These soils are so stony that their use is greatly limited. It is not economically feasible to clear them for crops, and they are best suited to hay or wildlife. Some of the drainageways are too wet for hay. If the soils of this complex are grazed, they become compacted and more stones are exposed. This greatly reduces value of the soils for hay. Capability unit Vw–1; windbreak suitability group 10.

Fordville Series

The Fordville series consists of well-drained soils that formed in loam-textured outwash that is moderately deep over calcareous sand and gravel. These nearly level to gently sloping soils occur throughout the county.

In a representative profile, the surface layer is neutral, black and very dark gray loam about 14 inches thick. The subsoil is neutral, dark yellowish-brown, friable loam about 7 inches thick. The upper 11 inches of the underlying material is a light olive-brown loam that is strongly calcareous in the upper part and calcareous in the lower part. Below this is light olive-brown, calcareous sand and gravel.

The organic-matter content is high. Natural fertility is medium because of the underlying sand and gravel, and available water capacity is low to moderate. Permeability is moderate in the surface layer and subsoil, but rapid in the sand and gravel.

These are slightly droughty soils. They are a source of sand and gravel for road construction.

Representative profile of Fordville loam from an area of Spottswood-Fordville loams, 0 to 2 percent slopes, in a cultivated field in SE. corner of NW¼SE¼ sec. 27, T. 121 N., R. 43 W.

Ap—0 to 6 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A1—6 to 14 inches, very dark gray (10YR 3/1) loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B2—14 to 21 inches, dark yellowish-brown (10YR 3/4) loam; weak, medium, prismatic structure breaking to moderate, medium, subangular blocky structure; friable; black tongues of the A1 extend to a depth of 19 inches; neutral; gradual, wavy boundary.

C1ca—21 to 27 inches, light olive-brown (2.5Y 5/4) loam; weak, fine, subangular blocky structure; friable; tongues of B horizon extend through this layer; strongly calcareous; gradual, wavy boundary.

C2—27 to 32 inches, light olive-brown (2.5Y 5/4) loam; weak, fine, subangular blocky structure; friable; tongues of the B horizon extend to a depth of 30 inches; calcareous; gradual, wavy boundary.

C3—32 to 54 inches, light olive-brown (2.5Y 5/4, 5/6) sand and gravel; single grain; loose; calcareous.

The A horizon ranges from 8 to 16 inches in thickness, and the B horizon from 6 to 10 inches. Free lime is 15 to 27 inches from the surface. Depth to sand and gravel ranges from 24 to 40 inches but generally is near 27 inches. In many places there is an increase in clay content in the layer just above the sand and gravel.

Fordville soils are deeper to gravel than the Renshaw soils. They have a coarser textured C3 horizon than the Sverdrup soils.

Fordville loam, 2 to 6 percent slopes (FoB).—This gently sloping soil occurs throughout the county. Most of it is adjacent to streams and waterways in the glacial upland, where it lies near Barnes and Sverdrup soils. A small part is on terraces and glacial outwash, where it occupies slight ridges or breaks toward waterways and is near the droughty Renshaw or Sioux soils.

Included with this soil in mapping were small areas of Spottswood loam, Renshaw loam, Barnes loam, Sverdrup sandy loam, and Flandreau silt loam. Also included were some areas that are moderately eroded, and some small areas that have slopes greater than 6 percent.

This soil is suited to all crops common in the county.

Soil blowing is a hazard in fields left bare in winter and spring. Water erosion is a hazard on the steeper slopes.

Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Applications of nitrogen and phosphorus are needed for maximum production. Capability unit IIe-3; windbreak suitability group 2.

Fordville stony loam, 0 to 2 percent slopes (FrA).—This soil is mainly southwest of the city of Appleton. It is nearly level but is so stony that it is used mainly for hay or pasture. Nevertheless, it is economically feasible to clear the stones.

Even in areas cleared of stones for cultivation, some stones still interfere with tillage. Management is needed to maintain the supply of organic matter and plant nutrients. Soil blowing is a problem in fields left bare during winter and spring. Capability unit VIe-2; windbreak suitability group 10.

Fossum Series

In the Fossum series are deep, poorly drained soils that formed in coarse-textured water-laid sands. These nearly level soils are in the lake plain in the north-central part of the county.

In a representative profile, the surface layer is about 8 inches of black, highly organic sandy loam over about 13 inches of very dark gray and very dark grayish-brown, strongly calcareous loamy medium and fine sand. Faint brown and gray mottles are common in the lower part. The underlying material is an olive-gray and light olive-gray fine sand that is strongly calcareous and is mottled with light olive brown and brownish yellow.

The organic-matter content is high. The natural fertility is low because the high content of lime causes an imbalance of plant nutrients. The available water capacity is low. The permeability is rapid.

Wetness and low fertility are the main limitations of the Fossum soils. Most areas are cultivated, but crop yields are low.

Representative profile in a nearly level Fossum sandy loam in a cultivated field, 1,100 feet east and 160 feet south of NW. corner of sec. 25, T. 122 N., R. 40 W.

Ap—0 to 8 inches, black (10YR 2/1) sandy loam; cloddy but breaks to weak, fine, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.

A11ca—8 to 13 inches, very dark gray (2.5Y 3/1) loamy medium sand; dark gray (5Y 4/1) when dry; single grain; loose; strongly calcareous; clear, smooth boundary.

A12ca—13 to 21 inches, very dark grayish-brown (2.5Y 3/2) medium and fine sand; gray (5Y 5/1) when dry; common, fine, faint, gray and brown mottles; single grain; loose; strongly calcareous; clear, smooth boundary.

C1ca—21 to 26 inches, olive-gray (5Y 5/2) fine sand; common, medium, distinct, light olive-brown mottles; single grain; loose; strongly calcareous; clear, smooth boundary.

C2ca—26 to 34 inches, light olive-gray (5Y 6/2) fine sand; common, strong, prominent, brownish-yellow mottles; single grain; loose; strongly calcareous; clear, wavy boundary.

C3—34 to 60 inches, light olive-gray (5Y 6/2) fine sand; few, medium, prominent, brownish-yellow mottles; single grain; loose; strongly calcareous.

The Ap horizon ranges from 6 to 10 inches in thickness and from sandy loam to loamy sand in texture. It is calcareous to strongly calcareous. The underlying sand is generally fine and medium in size, but coarse sands occur in many places. Some small pebbles occur in the profile in some areas.

Fossum soils are more calcareous than the Hamar soils, and the upper part of their A horizon is finer textured. Fossum soils are coarser textured than the Arveson soils.

Fossum sandy loam (Fs).—This nearly level soil is in the lake-plain area in the north-central part of the county. The soil areas are slightly depressed, are broad and flat, and are generally oriented in a northwest-southeast direction.

Included with this soil in mapping were small areas of Arveson loam, Hamar loamy sand, and Hecla loamy sand. Also included were some small gray spots that are very strongly calcareous on the surface and some small areas that are underlain by loamy material.

This soil is used intensively for corn and soybeans but is not well suited to these crops. It is often difficult to work this soil in spring because the water table is high. Soil blowing is a serious problem in unprotected fields. In midsummer, the soil is droughty because the water table has dropped.

Management is needed that controls erosion, provides adequate drainage, and maintains a high content of plant nutrients. Capability unit IVw-1; windbreak suitability group 7.

Fulda Series

In the Fulda series are deep, poorly drained soils that formed in fine-textured, calcareous, water-laid silts. These nearly level to slightly depressional soils are in the south-central, southwestern, and northeastern parts of the county.

In a representative profile, the surface layer is neutral and calcareous, black silty clay about 22 inches thick. The subsoil is calcareous, olive-gray, friable to firm silty clay about 9 inches thick. This layer contains gypsum crystals and a few, faint, olive mottles. The underlying material is calcareous, olive-gray, friable silty clay containing gypsum crystals.

The organic-matter content, the natural fertility, and the available water capacity are high. The permeability is very slow. These soils have a high water table that restricts root growth.

Most areas of these soils are cultivated. Wetness and soil compaction are limitations.

Representative profile of Fulda silty clay, 0 to 2 percent slopes, in a cultivated area, 800 feet east and 90 feet north of the SW. corner of sec. 22, T. 121 N., R. 43 W.

Ap—0 to 7 inches, black (N 2/0) silty clay; moderate, very fine, subangular blocky structure; firm; few white sugar-size sulfate crystals and threads; neutral; abrupt, smooth boundary.

A1—7 to 15 inches, black (2.5Y 2/1) silty clay; moderate, very fine, subangular blocky structure; firm; few, white, sugar-size sulfate crystals and threads; neutral; gradual, smooth boundary.

A3—15 to 22 inches, black (5Y 2/1) grading to very dark gray (5Y 3/1) silty clay; moderate, very fine, subangular blocky structure; firm; gypsum crystals in pockets; calcareous; gradual, smooth boundary.

B2g—22 to 31 inches, olive-gray (5Y 4/2, 5/2) silty clay; has some mixture of dark gray (5Y 4/1) and a few, fine, faint, olive mottles; moderate, very fine, subangular blocky structure; friable to firm; tongues of A1 horizon up to 1 inch in width extend into this horizon; contains gypsum crystals; calcareous; clear wavy boundary.

Cg—31 to 60 inches, olive-gray (5Y 4/2) silty clay; moderate, very fine, subangular blocky structure; friable; gypsum crystals in pockets; calcareous.

The Ap horizon is neutral to moderately alkaline and in places is calcareous. Its texture is silty clay or silty clay loam. The A1 and A3 horizons are silty clay or clay. The C horizon is silty clay, but in some places silty clay loam occurs below a depth of 36 inches.

The Fulda soils are finer textured than Flom or Perella soils. They differ from the Hegne soils in not having a horizon of lime accumulation.

Fulda silty clay, 0 to 2 percent slopes (FvA).—This nearly level to slightly depressional soil is in the lake-plain areas of the county. It occurs in West Bank Township near the Chippewa River and near Judicial Ditch 8, in Shible Township near Lake Shible, and in Hegbert Township near Drywood Lakes. The soil areas are broad and irregular.

Included with this soil in mapping were small areas of Hegne clay, Hattie clay, Parnell silty clay loam, and Colvin silty clay loam.

This poorly drained soil needs additional drainage. Most areas have been drained by surface ditches, which are adequate in most years. All common crops, including sugar beets, are well suited. Soil blowing is a hazard in bare fields during winter and spring. Compaction is a hazard if the soil is worked when wet.

Management is needed that provides drainage, controls erosion, and maintains good tilth. Capability unit IIw-1; windbreak suitability group 3.

Fulda Series, Sand Subsoil Variant

These are moderately well drained to poorly drained soils that formed in water-laid clays overlying calcareous outwash sand. These nearly level soils occur mainly in areas adjacent to Judicial Ditch 8 in West Bank Township.

In a representative profile, the surface layer is neutral, black silty clay and clay about 14 inches thick. The upper part of the subsoil is neutral, firm, very dark gray clay about 8 inches thick. The lower part of the subsoil is neutral, firm, very dark grayish-brown clay about 9 inches thick. The underlying material is neutral, dark grayish-brown sandy loam that grades to neutral, loose, light olive-brown sand. Grayish-brown and yellowish-brown mottles are common.

The organic-matter content is high. The natural fertility is moderate because of the underlying sand. The available water capacity is moderate. Permeability is very slow in the subsoil but rapid in the underlying sand.

These clayey soils are difficult to work. Good management is needed to maintain tilth and permeability. Wetness is a problem in spring, and droughtiness often is a hazard late in summer.

Representative profile of Fulda silty clay, sand subsoil variant, 0 to 2 percent slopes, 100 feet south and 300 feet west of NE. corner of SE¼ sec. 33, T. 120 N., R. 41 W.

Ap—0 to 8 inches, black (10YR 2/1) silty clay; weak, very fine, angular blocky structure; friable; neutral; abrupt, smooth boundary.

A1—8 to 14 inches, black (10YR 2/1) clay; strong, very fine, angular blocky structure; friable; neutral; clear, wavy boundary.

B21—14 to 22 inches, very dark gray (2.5Y 3/1) clay; strong, fine, angular blocky structure; firm; patchy clay films on faces of the peds; tongues of the A horizon extend through this horizon; neutral; clear, wavy boundary.

B22—22 to 31 inches, very dark grayish-brown (2.5Y 3/2) clay; strong, fine, angular blocky structure with some evidence of fine prismatic structure; firm; continuous clay films on all faces of the peds; tongues of A horizon extend through this horizon; neutral; clear, smooth boundary.

C1—31 to 34 inches, dark grayish-brown (2.5Y 4/2) sandy loam; common, fine, distinct, grayish-brown and yellowish-brown mottles; massive; friable; weakly cemented; neutral; clear, smooth boundary.

C2—34 to 50 inches, light olive-brown (2.5Y 5/3) sand; fine, distinct, yellowish-brown mottles; single grained; loose; neutral.

The A horizon ranges from neutral to slightly acid in reaction and from loam or silty clay loam to silty clay or clay in texture. The texture of the B horizon ranges from clay to silty clay or clay loam. The underlying sand is normally medium but in some places includes fine sand and fine gravel. Depth to sand ranges from 24 to 42 inches but is normally near 30 inches.

Fulda soils, sand subsoil variant, differ from Shakopee soils in being noncalcareous. They have a finer textured solum than the Fordville or Flandreau soils.

Fulda loam, sand subsoil variant, 0 to 2 percent slopes (FuA).—This nearly level soil occurs in Swenoda Township, along Judicial Ditch 8 in West Bank Township, and along the Chippewa River. The soil areas are irregular in shape but tend to parallel streams. This soil has a profile similar to that described for the variants of the Fulda series, but its surface layer is loam and its subsoil is brighter colored.

Included with this soil in mapping were small areas of poorly drained Fulda silty clay, sand subsoil variant. Also included were small areas where underlying sand is less than 24 inches from the surface, as well as some places where lime is as little as 24 inches from the surface, as compared to an ordinary depth of about 40 inches.

Droughtiness is a hazard by midsummer because of the underlying sand and the high capacity of the soil to hold moisture in a form not available to plants. During long dry periods, cracks 2 inches wide and 18 inches deep are common. These cracks permit air to move deep into the soil, which in turn, speeds drying of the soil. Soil blowing is a hazard in areas left bare during winter and spring.

All crops common to the county are grown on this soil. Management is needed that controls erosion and maintains good tilth. Capability unit IIs-1; windbreak suitability group 2.

Fulda silty clay, sand subsoil variant, 0 to 2 percent slopes (FwA).—This nearly level to slightly depressional soil is in the southwestern part of the county, mainly in West Bank Township, along Judicial Ditch 8. Where this Fulda silty clay adjoins the uplands, the surface layer is silt loam or silty clay loam.

Included with this soil in mapping were small areas of Shakopee clay and of Fulda loam, sand subsoil variant. Also included were some small areas where the sand is deeper than 42 inches or shallower than 24 inches. In a few places the underlying material contains some gravel-sized particles. There are also some shallow depressions where water is ponded for a short time.

This soil is used intensively for corn and soybeans. Wetness is a hazard in spring because the surface layer and subsoil are slowly permeable. Droughtiness is often a serious hazard by midsummer because of the underlying sand and the high capacity of the soil to hold moisture in a form not available to plants. During long dry periods, a considerable amount of shrinkage takes place in the soil. Cracks 2 inches wide and 18 inches deep are common. These cracks permit air movement deep into the soil, which in turn, allows rapid drying of the soil. Soil blowing is a hazard in fields left bare during winter and spring.

Management is needed that prevents compaction and protects the soil against blowing by wind. The surface layer should be kept in good tilth to permit water to enter easily, but to prevent cracks from forming. Capability unit IIw–1; windbreak suitability group 3.

Glyndon Series

The Glyndon series consists of moderately well drained soils that formed in calcareous water-laid silts overlying calcareous sands. These soils are on slight rises in the nearly level lake-plain area in the central part of the county.

In a representative profile, the surface layer is about 7 inches of calcareous, black, friable silt loam overlying about 7 inches of strongly calcareous, very dark gray silt loam. The upper part of the underlying material is strongly calcareous, dark-gray, dark grayish-brown, and grayish-brown, friable silt loam about 18 inches thick. It has a few gray and olive-brown mottles. This material grades to calcareous, loose, grayish-brown loamy very fine sand and very fine sand that has a few, faint, gray and olive-brown mottles.

The organic-matter content is high. The natural fertility is moderate because of underlying sand and the high content of lime, which causes an imbalance of plant nutrients. The available water capacity is moderate to high. Permeability is moderate in the surface layer and subsoil and rapid in the sand.

Most areas of these soils are cropped. Fertility imbalance, soil blowing, and slight droughtiness are the main hazards.

Representative profile of Glyndon silt loam, 0 to 2 percent slopes, in a cultivated field, 1,100 feet west and 100 feet north of the SE. corner of NE¼ sec. 5, T. 121 N., R. 38 W.

Ap—0 to 7 inches, black (10YR 2/1) silt loam; weak, fine, angular blocky structure; friable; calcareous; abrupt, smooth boundary.

A1ca—7 to 14 inches, very dark gray (10YR 3/1) silt loam; weak, very fine, angular blocky structure; friable; strongly calcareous; clear, smooth boundary.

C1ca—14 to 19 inches, dark-gray (2.5Y 4/1) silt loam; weak, very fine, angular blocky structure; friable; strongly calcareous; gradual, smooth boundary.

C2ca—19 to 25 inches, dark grayish-brown (2.5Y 4/2) silt loam; weak, very fine, angular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

C3ca—25 to 32 inches, grayish-brown (2.5Y 5/2) silt loam; few, fine, faint, gray and olive-brown mottles; weak, fine, angular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

IIC4—32 to 37 inches, grayish-brown (2.5Y 5/2) loamy very fine sand; few, fine, faint, gray and olive-brown mottles; single grained; loose; calcareous; gradual, wavy boundary.

IIC5—37 to 60 inches, grayish-brown (2.5Y 5/2) very fine sand; single grained; loose; calcareous.

The Ap horizon is 6 to 12 inches thick, is loam or silt loam, and is calcareous to strongly calcareous. The A1ca horizon is 6 to 10 inches thick and is a loam or silt loam in texture. The depth to the underlying sands ranges from 24 to 40 inches. These sands include both fine and very fine sand.

Glyndon soils differ from Flandreau soils in having a horizon of lime accumulation in the upper part of the profile and in lacking a B2 horizon. They differ from Bearden soils in being coarse textured in the lower part of the C horizon.

Glyndon silt loam, 0 to 2 percent slopes (GdA).—This nearly level soil occupies slight rises in the lake-plain area in the central part of the county. The soil areas are irregular and elongated, and many are oriented in a northwest-southeast direction.

Included with this soil in mapping were small areas of Marysland loam, Mayer loam, Bearden silty clay loam, and Malachy sandy loam. In some places the underlying sands are at depths below 40 inches. Also included were a few areas that are very strongly calcareous at the surface.

This soil is used intensively for corn and soybeans. Soil blowing is a hazard in fields left bare during winter and spring. The high content of lime causes an imbalance of plant nutrients. Applications of nitrogen, phosphorus, and potassium are needed.

Management that controls erosion and maintains a balance of plant nutrients is needed. Capability unit IIe–4; windbreak suitability group 8.

Hamar Series

In the Hamar series are deep, poorly drained soils that formed in outwash sand. These nearly level soils are in the north-central and southwestern parts of the county.

In a representative profile, the surface layer is neutral, black and very dark gray loamy sand about 16 inches thick. The subsoil is neutral, dark grayish-brown sand, about 14 inches thick, that is mottled with olive brown. The underlying material is calcareous and strongly calcareous, olive-gray and light olive-gray, friable loamy sand having a few, faint, light olive-brown and olive-yellow mottles.

The organic-matter content is high. The natural fertility is low because these soils are sandy. The available water capacity is very low. Permeability is rapid. The high water table limits growth of roots.

These soils are often too wet in spring and too dry in summer. Low fertility is also a hazard. These soils are well suited to grass.

Representative profile of Hamar loamy sand, 200 feet south and 200 feet west of NE. corner of sec. 26, T. 122 N., R. 40 W.

A11—0 to 9 inches, black (10YR 2/1) loamy sand; weak, fine, subangular blocky structure; loose; neutral; gradual, wavy boundary.

A12—9 to 13 inches, very dark gray (10YR 3/1) loamy sand; single grained; loose; neutral; gradual, wavy boundary.

A13—13 to 16 inches, very dark gray (10YR 3/1) sand; very dark grayish brown (2.5Y 3/2) when dry; fine, faint, olive-brown mottles; single grained; loose; neutral; gradual, wavy boundary.

B21—16 to 24 inches, dark grayish-brown (2.5Y 4/2) sand; olive gray (5Y 5/2) when dry; few, fine, faint, olive-brown mottles; single grained; loose; neutral; gradual, wavy boundary.

B22—24 to 30 inches, dark grayish-brown (2.5Y 4/2) sand; gray (5Y 5/1) when dry; few, fine, faint, olive-brown mottles; single grained; loose; neutral; gradual, smooth boundary.

C1ca—30 to 35 inches, olive-gray (5Y 5/2) loamy sand; light olive gray (5Y 6/2) when dry; few, fine, distinct, light olive-brown mottles; friable; single grained; calcareous; gradual, wavy boundary.

C2ca—35 to 50 inches, light olive-gray (5Y 6/2) loamy sand; light gray (5Y 7/1) when dry; few, fine, distinct, olive-yellow mottles; single grained; friable; water table at depth of 42 inches; strongly calcareous.

The A horizon ranges from 12 to 20 inches in thickness and from sand or loamy sand to sandy loam in texture. The C horizon is loamy medium or loamy fine sand. Depth to free lime is 24 to 54 inches. In the southwestern part of the county, the sands are generally fine.

Hamar soils differ from Fossum in being noncalcareous in the solum.

Hamar loamy sand (Ha).—This is a nearly level soil in the lake-plain area in the north-central part of the county and in the wind-shifted outwash area in the southwestern part. The soil areas are generally elongated and oriented in a northwest-southeast direction. This soil adjoins areas of Hecla and Fossum soils. It has the profile described as representative for the series.

Included with this soil in mapping were small areas of Venlo and Fossum soils. Also included were some areas underlain by layers finer textured than those underlying this soil. In some places free lime is within 24 inches of the surface.

Soil blowing is serious in unprotected fields. Fencerow drifts are common on most field boundaries. Early in summer, the water table is within 2 feet of the surface and it is difficult to work the fields. By late summer, the water table has dropped to a depth of about 5 feet and the soil has become droughty.

All crops common in the county are grown on this soil. Management is needed that provides drainage, controls erosion, and maintains good tilth. Capability unit IVw-2; windbreak suitability group 7.

Hamar sandy loam (Hc).—This nearly level to slightly depressional soil is in the lake-plain area in the central part of the county and in the wind-shifted outwash areas in the southwestern part. The areas are irregular in shape.

Included with this soil in mapping were small areas of Clontarf sandy loam and of Hecla loamy sand. Also, in some small spots, lime is less than 30 inches from the surface.

This soil needs additional drainage. Many areas have been drained by surface ditches, which are adequate in most years. The water table is at a depth of about 2 feet early in summer. Soil blowing is a hazard in unprotected fields.

All crops common to the county are grown. Management is needed that improves drainage, controls soil blowing, and maintains a high content of plant nutrients. Capability unit IIIw-5; windbreak suitability group 7.

Hamerly Series

In the Hamerly series are deep, moderately well drained and somewhat poorly drained soils that formed in calcareous glacial till of loam texture. These nearly level to gently undulating soils occur throughout the county but are mostly in the southeastern and northwestern parts.

In a representative profile, the surface layer is calcareous, black loam about 8 inches thick. The underlying material is friable. The upper part of this material is about 24 inches of strongly calcareous, grayish-brown to light olive-brown loam. The lower part is calcareous, light olive-brown loam with faint, light brownish-gray mottles.

The organic-matter content is high. The available water capacity is high, and permeability is moderate. The natural fertility is moderate because the high content of lime causes an imbalance of plant nutrients.

Most areas of these soils are cultivated.

Representative profile of Hamerly loam, 0 to 3 percent slopes, in a cultivated field, 500 feet west and 160 feet south of the NE. corner of NW¼ sec. 1, T. 120 N., R. 38 W.

Ap—0 to 8 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.

C1ca—8 to 19 inches, grayish-brown (2.5Y 5/2) loam; weak, thick, platy structure breaking to weak, very fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

C2ca—19 to 32 inches, grayish-brown to light olive-brown (2.5Y 5/2, 5/4) loam; weak, thick, platy structure breaking to weak, medium, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

C3—32 to 60 inches, light olive-brown (2.5Y 5/4) loam; common, fine, faint, light brownish-gray mottles; weak, fine, subangular blocky structure; friable; calcareous.

The A horizon is 6 to 12 inches thick and a loam, clay loam, or silt loam in texture. The C1ca is 8 to 13 inches thick and a loam or clay loam in texture. The C2ca and C3 horizons are loams or clay loams. The lime content of the surface soil is variable. Commonly there are small, gray areas having high lime content in these soils. Gypsum crystals are present in some of the wetter areas.

Hamerly soils are not so well drained as Buse soils and are less sloping. They differ from McIntosh soils in having a loam rather than a silt solum. They are more calcareous than Svea soils.

Hamerly loam, 0 to 3 percent slopes (HdA).—This nearly level to gently undulating soil occurs throughout the county. The areas are on slight rises in the glacial till, and many of them are oriented in a northwest-southeast direction.

This soil is closely associated with Parnell silty clay loam, Svea loam, Flom loam, and Vallers silty clay loam. Small areas of those soils were included with this one in mapping. Svea soils were in many of the nearly level areas surrounding the rises on which this soil occurs. Flom or Vallers soils were included in the lower, wetter areas. Parnell soils were included in small, wet depressions, some of which are flooded for several days after the higher ground has dried.

In the northwestern part of the county this soil occurs with Tara and McIntosh soils. Here it has a silt loam surface layer 8 to 14 inches thick. Some small areas of Tara and McIntosh were included with this soil in mapping.

All crops common in the county are grown on this soil. Crop response is variable and poor in the spots that have high content of lime. Soil blowing is a hazard, partly because the soil is on slight elevations. Practices are needed that control erosion, improve fertility, and maintain a high content of organic matter. Capability unit IIe-4; windbreak suitability group 5.

Hantho Series

The Hantho series is made up of deep, moderately well drained soils that formed in moderately thick windblown silty materials. These nearly level to gently sloping soils occur throughout the county but are mostly in the northwestern part.

In a representative profile the surface layer is neutral, black and very dark gray silt loam about 15 inches thick. The subsoil is neutral, very dark grayish-brown and dark grayish-brown, friable silt loam about 9 inches thick. The underlying material is a friable grayish-brown silt loam and silty clay loam having faint, light-gray and light olive-brown mottles. In the upper part this material is strongly calcareous, but it grades to calcareous with depth.

The organic-matter content is high. The available water capacity is high, and permeability is moderate. The natural fertility is high.

These soils are easy to work. Erosion control is one of the main concerns in managing them.

Representative profile of Hantho silt loam, 0 to 2 percent slopes, NE. corner of NW¼NE¼ sec. 36, T. 120 N., R. 41 W.

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

A1—8 to 12 inches, black (10YR 2/1) silt loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

A3—12 to 15 inches, very dark gray (10YR 3/1) silt loam; very dark grayish brown (10YR 3/2) when crushed; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B21—15 to 20 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, coarse, prismatic structure breaking to weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B22—20 to 24 inches, dark grayish-brown (2.5Y 4/2) silt loam; weak, coarse, prismatic structure breaking to weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

C1ca—24 to 29 inches, grayish-brown (2.5Y 5/2) silt loam; few, fine, faint, light olive-brown mottles; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

C2—29 to 46 inches, grayish-brown (2.5Y 5/2) silt loam; many, fine, distinct, light-gray and light olive-brown mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C3—46 to 60 inches, grayish-brown (2.5Y 5/2) silty clay loam; many, fine, distinct, light-gray and light olive-brown mottles; weak, fine, subangular blocky structure; friable; calcareous.

The A horizon ranges from 9 to 16 inches in thickness. The B horizon ranges from 8 to 14 inches in thickness and from silty clay loam or silt loam to very fine sandy loam. Lime is leached to depths of 14 to 28 inches. Glacial till is at depths of 40 to 72 inches in many places.

Hantho soils differ from Tara and Svea soils in having silt loam throughout the profile. They differ from Bearden in having a B horizon.

Hantho silt loam, 0 to 2 percent slopes (HhA).—This nearly level soil occurs throughout the county in irregularly shaped areas.

Included with this soil in mapping were small areas of Rothsay, Tara, and Perella soils. Also included were about 200 acres having a slope of 3 percent. In a small area in sections 23 and 24 of Tara Township, lime has been leached to a depth of more than 40 inches. In some places, small, unmappable, poorly drained depressional soils were included. These are the Parnell or Perella depressional soils.

This soil is well suited to corn and soybeans. Soil blowing is a hazard in fields left bare in winter and spring. Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Capability unit I-1; windbreak suitability group 1.

Hattie Series

The Hattie series consists of deep, well drained and moderately well drained soils that formed in fine-textured calcareous glacial till. These nearly level to rolling upland soils occur mainly in Kerkhoven and Hegbert Townships.

In a representative profile, the surface layer is a neutral, black clay about 7 inches thick. The underlying material is a calcareous, firm, dark grayish-brown clay loam in the upper 5 inches. This grades to grayish-brown clay with depth and contains light-gray lime concretions. Below this material is light olive-brown clay loam that has a few yellowish-brown and light brownish-gray mottles.

The organic-matter content is high. The available water capacity is high. Permeability is very slow. Natural fertility is moderate because the high content of lime causes an imbalance of plant nutrients.

Soil compaction and fertility imbalance are the main hazards in farming these soils.

Representative profile of Hattie clay, 6 to 12 percent slopes, eroded, in a cultivated field 900 feet south and 100 feet west of NE. corner of sec. 1, T. 122 N., R. 43 W.

Ap—0 to 7 inches, black (2.5Y 2/0) clay; moderate to strong, very fine to fine, angular blocky structure; firm; neutral; abrupt, smooth boundary.

C1—7 to 12 inches, dark grayish-brown (2.5Y 4/2) clay loam; moderate to strong, very fine to fine, angular blocky structure; firm; calcareous tongues of black from A horizon; calcareous; clear, wavy boundary.

C2—12 to 28 inches, grayish-brown (2.5Y 5/3) clay loam; moderate, very fine to fine, angular blocky structure; firm; light-gray lime concretions; some vertical cleavage; calcareous; clear, wavy boundary.

C3—28 to 50 inches, light olive-brown (2.5Y 5/4) clay loam; few, fine, distinct, yellowish-brown and light brownish-gray mottles; moderate, very fine to fine, angular blocky structure; firm; occasional partings in lower horizons indicate clay flows and incipient prisms; calcareous.

The A horizon ranges from 7 to 12 inches in thickness, from clay loam to clay in texture, and from neutral to slightly alkaline (calcareous) in reaction. The C1 and C2 horizons are clay loam or clay.

The Hattie soils are finer textured than the Buse soils. They lack the B horizon of the Nutley soils.

Hattie clay, 6 to 12 percent slopes, eroded (HtC2).—The small irregular, rolling areas of this soil occur mainly in Kerkhoven and Hegbert Townships. The profile of this soil is the one described as representative for the series.

Included with this soil in mapping were small areas of Nutley soils that make up about 15 percent of the acreage of this soil. The Nutley soils are at the lower elevations. Also included were small areas of the Barnes and Buse soils. In addition, some included small spots at the top of the hills are completely eroded. Some areas steeper than 12 percent also were included.

Water erosion is a serious hazard and has already reduced the organic-matter content and rate of water infiltration.

All common crops are grown on this soil. Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Applications of nitrogen, phosphorus, and potassium are needed. Capability unit IIIe-1; windbreak suitability group 5.

Hattie-Nutley clays, 2 to 6 percent slopes (HuB).—The gently sloping to undulating soils of this complex occur mainly in parts of Kerkhoven and Hegbert Townships. Areas are irregular in shape, and most of them have been dissected by drainageways. The two kinds of soil occur in such an intricate pattern that separating them on the soil map is not practical. Hattie soils occupy about 60 percent of the mapped areas and Nutley soils about 40 percent.

Included in this unit in mapping were small areas of Barnes loam and areas that are calcareous on, or just beneath, the surface. About half the acreage has been moderately eroded. Nearly two-thirds of the original surface layer has been lost in these eroded areas. These areas are calcareous in most places and are on the upper part of slopes.

All crops are grown on these soils, but the soils are difficult to work. They are sticky when wet and easily compacted. During dry periods they shrink, crack, and dry out. Erosion is a serious hazard because of the slow rate of water infiltration.

Management is needed that controls erosion, prevents soil compaction, and maintains a high organic-matter content and nutrient level. Both soils in capability unit IIe-1; Hattie part in windbreak suitability group 5, and Nutley part in windbreak suitability group 1.

Hecla Series

In the Hecla series are deep, moderately well drained soils that formed in outwash sands. These nearly level to gently undulating soils are in the lake-plain areas throughout the county.

In a representative profile, the surface layer is neutral, very dark gray loamy sand about 14 inches thick. The subsoil is a neutral, very dark grayish-brown and dark grayish-brown, loose loamy sand about 9 inches thick. The lower part has a few dark-brown, dark yellowish-brown, and light olive-brown mottles. The underlying material is neutral, mottled, dark grayish-brown and light olive-brown, loose sand. It has brown, strong-brown, light olive-brown, yellowish-brown, and grayish-brown mottles.

The organic-matter content is medium. The natural fertility is low because of the kind of parent material. The available water capacity is very low. Permeability is rapid.

Droughtiness, low fertility, and soil blowing are serious hazards. Crop yields are low. These soils are well suited as grassland.

Representative profile of Hecla loamy sand, 0 to 3 percent slopes, in a cultivated area, 100 feet north of approach to the area, in SE¼SE¼ sec. 35, T. 122 N., R. 40 W.

Ap—0 to 8 inches, very dark gray (10YR 3/1) loamy sand; weak, coarse, angular blocky structure; very friable; neutral; abrupt, smooth boundary.

A1—8 to 14 inches, very dark gray (10YR 3/1) loamy sand; weak, medium, subangular blocky structure; very friable; neutral; gradual, wavy boundary.

B2—14 to 18 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, medium, subangular blocky structure; loose; neutral; gradual, wavy boundary.

B3—18 to 23 inches, dark grayish-brown (2.5Y 4/2) loamy sand; few, fine, distinct, dark-brown, dark yellowish-brown, and light olive-brown mottles; weak, medium, subangular blocky structure; loose; neutral; gradual, wavy boundary.

C1—23 to 36 inches, dark grayish-brown (2.5Y 4/2) sand; few, fine, distinct, brown, strong-brown, yellowish-brown, and light olive-brown mottles; single grain; loose; neutral; gradual, wavy boundary.

C2—36 to 60 inches, light olive-brown (2.5Y 5/4) sand; common, medium, prominent, brown, strong-brown, and grayish-brown mottles; single grain; loose; weak cementation; neutral.

The A horizon ranges from 10 to 18 inches in thickness. Depth to free lime is more than 40 inches. The C horizon is highly mottled; the sands are of medium size but include some fine and coarse grains.

The Hecla soils are coarser textured than the Clontarf or Malachy soils. They have lower chroma in the A horizon than the Maddock soils.

Hecla loamy sand, 0 to 3 percent slopes (HvA).—This nearly level to gently sloping soil is in the lake-plain area in the north-central part of the county. The soil areas are elongated and oriented in a southeasterly direction. Small areas of wind-drifted soil are common, especially along fence rows.

Included with this soil in mapping were small areas of Clontarf, Hamar, Arveson, and Malachy soils. On the lower part of the slopes, where this soil borders the poorly drained soils, lime commonly is within 30 inches of the surface. In many places this soil contains buried soil layers. Also included were areas having a sandy surface layer and some small areas that are hummocky because they have been greatly affected by soil blowing.

All of the common crops are grown, but those that mature early make the best use of the limited moisture. Droughtiness is a persistent problem in unprotected fields. This soil likely has greatest potential under a grassland type of farming. Capability unit IVs-1; windbreak suitability group 6.

Hegne Series

The Hegne series consists of deep, calcareous, poorly drained soils that formed in fine-textured, water-laid clayey material. These nearly level soils are in the south-central part of the county.

In a representative profile, the surface layer is calcareous, black clay about 7 inches thick. The upper part of the underlying material is strongly calcareous, gray and olive-gray, firm clay. This grades to calcareous, gray and light olive-gray clay. Below this is strongly calcareous, olive-gray silty clay loam that has olive and yellowish-brown mottles.

The organic-matter content is high. The available water capacity is high, but permeability is very slow. The natural fertility is moderate because the high lime content of the soil causes an imbalance of available plant nutrients. The water table is high during the early part of the growing season.

Most areas of these soils are cultivated. Wetness is the main hazard. With adequate drainage and proper soil management, these soils are well suited to all crops grown in the county.

Representative profile of nearly level, cultivated Hegne clay, 200 feet south and 400 feet east of NW. corner of sec. 10, T. 120 N., R. 39 W.

Ap—0 to 7 inches, black (2.5Y 2/0) clay; weak, fine, subangular blocky structure; firm; calcareous; abrupt, smooth boundary.

C1ca—7 to 12 inches, gray (5Y 5/1) clay; weak, fine, subangular blocky structure; firm; strongly calcareous; clear, smooth boundary.

C2ca—12 to 15 inches, olive-gray (5Y 5/2) clay; weak, very fine, subangular blocky structure; slightly sticky; gypsum crystals are common; strongly calcareous; clear, wavy boundary.

C3—15 to 19 inches, gray (5Y 5/1) clay; weak, fine, subangular blocky structure; slightly sticky; calcareous; clear, wavy boundary.

C4—19 to 25 inches, light olive-gray (5Y 6/2) clay; weak, fine, subangular blocky structure; slightly sticky; calcareous; clear, wavy boundary.

C5—25 to 60 inches, olive-gray (5Y 5/2) silty clay loam; common, fine, distinct, olive and yellowish-brown mottles; weak, fine, subangular blocky structure; slightly sticky; strongly calcareous.

The A horizon is 6 to 18 inches in thickness, clay loam to clay in texture, and calcareous to strongly calcareous. Tongues of the A horizon extend to a depth of 30 inches in some places. A light-colored lime zone, 6 to 12 inches thick, occurs in the upper part of the C horizon. The C horizon is calcareous to strongly calcareous. Gypsum crystals are common in most areas.

Hegne soils are finer textured than Colvin soils, and they are more calcareous than the Fulda soils. They differ from Shakopee soils in having a moderately fine textured lower C horizon; the Shakopee soils have a coarse-textured lower C horizon.

Hegne clay (Hy).—This nearly level to slightly depressional soil is in the lake-plain area in the south-central part of the county. The areas are broad and irregular in shape. Early in the growing season, this soil is wet because of the high water table. Late in May the surface layer generally is dry enough to permit tillage.

Included with this soil in mapping were small areas of Bearden, Colvin, and Fulda soils. In some places the layer of maximum lime accumulation is at a depth below 16 inches. Also included were areas totaling about 2,000 acres of very poorly drained silty clays that occur in nearly level areas along Shakopee Creek.

Most areas of this soil are drained by surface ditches, which are adequate in most years. This soil is used intensively for corn and soybeans, and yields are favorable. Sugar beets are well suited to this soil. Applications of phosphorus and potassium are needed to offset the high lime content. Soil blowing is a hazard in bare fields during winter and spring. This soil is seriously compacted if worked when it is too wet. Capability unit IIw-1; windbreak suitability group 4.

Lamoure Series

The Lamoure series consists of deep, poorly drained soils that formed in highly calcareous, silty stream deposits. These nearly level soils occur on bottom lands adjacent to rivers and streams throughout the county.

In a representative profile, the surface layer is calcareous, black and very dark gray silty clay loam and silt loam about 26 inches thick. The underlying material is calcareous, very dark grayish-brown to olive-gray silty clay loam. It has pale-yellow and yellowish-brown mottles.

The organic-matter content is high. The available water capacity is high. Natural fertility is moderate because content of lime is high. Permeability is moderately slow. The water table fluctuates with the water level in the nearby stream. During spring the water table is at a depth of about 2 feet, but it drops to 4 or 5 feet later in the season.

Lamoure soils ordinarily are flooded early in spring. Many areas are small and irregular in shape and are therefore used for pasture or wildlife.

Representative profile of nearly level Lamoure silty clay loam in a cultivated area, 450 feet east and 500 feet north of the SW. corner of NW¼ of sec. 15, T. 122 N., R. 42 W.

Ap—0 to 7 inches, black (10YR 2/1) silty clay loam; cloddy but breaks to weak, fine, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.

A11—7 to 14 inches, black (10YR 2/1) silt loam; weak, fine, subangular blocky structure; friable; calcareous; clear, smooth boundary.

A12—14 to 26 inches, very dark gray (2.5Y 3/1) silt loam; weak, fine, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

C1—26 to 30 inches, very dark grayish-brown (2.5Y 3/2) silty clay loam; few, fine, distinct, pale-yellow and yellowish-brown mottles; massive; friable; calcareous; clear, smooth boundary.

C2—30 to 38 inches, dark grayish-brown (2.5Y 4/2) silty clay loam; common, fine, distinct, pale-yellow and yellowish-brown mottles; massive; firm; calcareous; clear, smooth boundary.

C3—38 to 48 inches, grayish-brown (2.5Y 5/2) silty clay loam; common, fine, distinct, pale-yellow and yellowish-brown mottles; massive; firm; calcareous; clear, smooth boundary.

C4—48 to 60 inches, olive-gray (5Y 4/2) silty clay loam; few, fine, distinct, yellowish-brown and pale-yellow mottles; massive; firm; calcareous.

The Ap and A11 horizons range from 10 to 16 inches in thickness, and from loam to silt loam or silty clay loam in texture. The C horizon has hues of 2.5Y and 5Y. Thin lenses of sand occur within the profile in many places.

The Lamoure soils are more calcareous than the Perella soils. They have a thinner solum than the Rauville soils.

Lamoure silty clay loam (Lm).—This nearly level soil is adjacent to rivers and streams, mainly the Pomme de Terre and Chippewa Rivers. The areas are generally elongated and parallel to the streams. This soil has the profile described as representative for the series.

Included with this soil in mapping were small areas of Rauville silty clay loam, Alluvial land, frequently flooded, and La Prairie silty clay loam. The Rauville soils are in old stream meanders.

Most of this soil is farmed, but some areas are wooded or pastured. Additional drainage is needed, though most areas have been drained by surface ditches.

All crops common to the county are grown on this soil. Sugar beets are well suited. The high content of lime causes an imbalance of available plant nutrients. Applications of nitrogen, phosphorus, and potassium are needed for maximum production. Capability unit IIw-3; windbreak suitability group 4.

Lamoure-Rauville complex (Lr).—These soils are in nearly level to slightly depressional areas next to the rivers and streams throughout the county, but they are mainly along the Pomme de Terre and Chippewa Rivers. The soil areas are irregular in shape.

The poorly drained Lamoure soil makes up about 60 percent of this complex, Rauville soil about 35 percent, and undifferentiated soils the remaining 5 percent. The Lamoure soil is in the nearly level areas bordering old stream channels, and the Rauville soil is in the old meandering channels. Included in mapping are a few small sandy areas.

The Lamoure soil is subject to flooding following spring runoff or periods of heavy rainfall. The Rauville soil is flooded during most of the growing season or whenever there is slight rise of water in the stream.

About half of this complex is now cultivated. It is difficult to work because the Rauville soil is often flooded. This complex is excellent for grazing. Both soils in capability unit IIw-3; Lamoure part in windbreak suitability group 4, and Rauville part in windbreak suitability group 9.

La Prairie Series

The La Prairie series consists of deep, moderately well drained soils that formed in calcareous, moderately fine textured stream deposits. These nearly level soils are on bottom lands along the rivers and streams of the county.

In a representative profile, the surface layer is neutral, black and very dark gray silty clay loam about 17 inches thick. The suboil, about 19 inches thick, is calcareous, friable, very dark grayish-brown silty clay loam that grades to very dark gray clay loam with depth. The underlying material is calcareous, grayish-brown, friable clay loam that has light olive-brown mottles. It is stratified with thin lenses of clay.

The organic-matter content is high. The available water capacity is high, and permeability is moderately slow. The natural fertility is high.

These are highly productive soils when properly managed. They generally do not occur in large areas and are farmed in accord with the adjacent soils.

Representative profile of La Prairie silty clay loam, in a cultivated field on the Pomme de Terre River bottom, 1,200 feet east and 320 feet north of SW. corner of NW¼SW¼ sec. 15, T. 122 N., R. 42 N.

A11—0 to 10 inches, black (10YR 2/1) silty clay loam; weak, very fine, angular blocky structure; very friable; neutral; abrupt, smooth boundary.

A12—10 to 17 inches, very dark gray (10YR 3/1) silty clay loam; weak, medium, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B21—17 to 26 inches, very dark grayish-brown (10YR 3/2) silty clay loam; weak, coarse, subangular blocky structure; friable; calcareous; gradual, wavy boundary.

B22—26 to 36 inches, very dark gray (10YR 3/1) clay loam; moderate, fine, angular blocky structure; friable; contains small lime concretions; calcareous; gradual, wavy boundary.

C—36 to 60 inches, grayish-brown (2.5Y 5/2) clay loam; few, fine, faint, light olive-brown mottles; somewhat stratified to depth of 60 inches so that thin lenses of well-sorted clay lie between layers of moderate, fine, angular blocky clay loam; friable; calcareous.

The A horizon ranges from 12 to 20 inches in thickness and from silt loam to silty clay loam in texture. Depth to free lime is 12 to 24 inches.

The La Prairie soils are better drained than the Lamoure soils. They have a thicker solum than the Hantho soils. They have a dark A horizon thinner than that in the Darnen soils.

La Prairie silty clay loam (Ls).—This nearly level soil occupies areas adjacent to streams throughout the county, but is mainly along the Pomme de Terre River. The soil areas are generally elongated and parallel to the streams. They lie adjacent to the poorly drained Rauville and Lamoure soils and the droughty Renshaw and Sioux soils.

Included with this soil in mapping were small areas of Rauville and Lamoure soils. The Rauville soil is in the depressional old stream meanders. The Lamoure soil is in slightly lower lying areas than the La Prairie soil. Also included were some areas underlain by sand or gravel at a depth below 4 feet.

Most of this soil is cropped, but some small areas are wooded. All crops common to the county are grown. Sugar beets are well suited. Capability unit I-1; windbreak suitability group 1.

Maddock Series

The Maddock series are deep, well-drained soils that formed in sandy outwash partly shifted by wind. These nearly level to sloping soils are in the southwestern part of the county. Some small areas are in the uplands throughout the county.

In a representative profile, the surface layer is slightly acid and neutral, very dark brown and very dark grayish-brown loamy fine sand about 17 inches thick. The underlying material is loose, weakly cemented fine sand. In the upper part this sand is noncalcareous and dark grayish brown, but it grades to calcareous and dark yellowish brown with depth.

The organic-matter content is medium. Permeability is rapid, and available water capacity is low. The natural fertility is low.

Soil blowing, droughtiness, and low fertility are serious limitations if these soils are farmed.

Representative profile of Maddock loamy fine sand, 0 to 2 percent slopes, under bromegrass, 75 feet north of field approach in SE¼SE¼SE¼ sec. 5, T. 120 N., R. 43 W.

A11—0 to 12 inches, very dark brown (10YR 2/2) loamy fine sand; weak, very fine, subangular blocky structure; very friable; slightly acid; gradual, wavy boundary.

A12—12 to 17 inches, very dark grayish-brown (10YR 3/2) loamy fine sand; weak, very fine, subangular blocky structure; very friable; neutral; gradual, wavy boundary.

C1—17 to 22 inches, dark grayish-brown (10YR 4/2) fine sand; single grained; loose; weak cementation; neutral; gradual, wavy boundary.

C2—22 to 50 inches, dark yellowish-brown (10YR 4/4) fine sand; single grained; loose; weak cementation; neutral; gradual, wavy boundary.

C3—50 to 64 inches, dark yellowish-brown (10YR 4/4) fine sand; single grained; loose; weak cementation; calcareous.

The A horizon ranges from 9 to 18 inches in thickness. The C horizon is fine and medium sands. In the Appleton area, free lime occurs at a depth of near 4 feet, but the range in depth is from 40 to 70 inches. In the rest of the county, the lime is ordinarily at a depth of about 30 inches, but the range in depth is from 18 to 42 inches.

Maddock soils are less calcareous than the Torning soils. They are coarser textured than the Shible or Edison soils. They are better drained than the Hecla or Clontarf soils.

Maddock loamy fine sand, 0 to 2 percent slopes (McA).—This nearly level soil is in broad, irregular areas in the southwestern part of the county. It has the profile described as representative for the series. Drifts along fence rows are common, and in some places they reach a height of 4 feet.

This soil occurs close to Shible soils, Maddock sandy loam, and Edison and Renshaw soils; and in many places small areas of those soils were included with this one in mapping.

Where this soil is at the base of slopes or in slight depressions, the surface soil is 18 to 24 inches thick. In some places free lime is within 30 inches of the surface.

Soil blowing is serious in fields left bare during winter and spring. Droughtiness is a serious hazard late in summer.

All crops common to the area are grown on this soil. Early maturing crops make the best use of the limited moisture. Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Capability unit IVs–3; windbreak suitability group 6.

Maddock loamy fine sand, 2 to 6 percent slopes (McB).—This gently sloping soil is mainly in the southwestern part of the county. The areas are generally elongated and oriented in a northwest to southeast direction, or they slope gently toward potholes or drainageways. Drifts of soil material are common along fence rows.

This soil occurs close to Shible, Edison, and Torning soils. In many places small areas of those soils were included in mapping. In some places finer textured material occurs within 40 inches of the surface. The more sloping areas have been subject to erosion and have a surface layer less than 8 inches thick. At the base of slopes, where soil material has accumulated, the surface layer is thicker than normal, or 18 to 24 inches thick.

Soil blowing is a serious hazard in fields left bare during winter and spring. Droughtiness is serious late in summer.

All crops common to the area are grown. Early maturing crops make best use of the limited available moisture. Management is needed that controls erosion and maintains content of organic matter and plant nutrients. Capability unit IVs–3; windbreak suitability group 6.

Maddock loamy fine sand, 6 to 12 percent slopes (McD).—This sloping soil is mainly in the southwestern part of the county. It has short, uniform slopes toward drainageways and potholes. The surface soil is less than 8 inches thick.

This soil is associated with the Torning soils, and in some places small areas of those soils were included in mapping. The surface soil is thicker where material from nearby slopes has accumulated. A few areas have slopes greater than 12 percent.

Soil blowing is a hazard in bare fields during winter and spring. Water erosion is a hazard early in summer. Droughtiness is a persistent hazard.

Management is needed that controls erosion and increases the content of organic matter and plant nutrients. This soil is best suited to permanent grass. Capability unit IVs–2; windbreak suitability group 6.

Maddock sandy loam, 0 to 4 percent slopes (MdB).—This nearly level to gently sloping soil is in the sandy, wind-shifted outwash areas of the county, mainly in Appleton, Edison, and West Bank Townships. The soil areas are irregular in shape and size.

This sandy loam occurs next to Shible soils, Maddock loamy sand, and Renshaw soils. In many places small areas of these soils were included with this soil in mapping.

In some places free lime is within 30 inches of the surface. The underlying material in places contains coarse sand and some pebbles. Where this soil is at the base of slopes, its surface layer is 18 to 24 inches thick.

Soil blowing is a serious hazard in unprotected fields. Wind-drifted material is common on soils throughout the area and gives evidence of past erosion. Droughtiness is a persistent hazard.

All crops common to the area are grown on this soil. Early maturing crops make the best use of the limited moisture. Supplemental irrigation is beneficial, but some washing can occur in the more sloping areas. Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Capability unit IIIs–2; windbreak suitability group 6.

Maddock-Dune land complex (Mk).—Small, nearly level to gently undulating areas of this complex occur throughout the county, but are mostly in sections 34, 35, and 36 of Camp Lake Township. Fence row wind drifts, dunes, and field drifts are common. Some of the complex is cropped, but most is under permanent vegetation. This complex must be carefully protected from soil blowing. Capability unit VIs–2; windbreak suitability group 6.

Maddock Series, Loamy Subsoil Variant

These are deep, somewhat excessively drained soils that formed in wind-shifted outwash sands, which are underlain by calcareous, medium-textured material. These level to gently sloping soils are mostly near Appleton.

In a representative profile, the surface layer is very dark grayish-brown loamy sand about 6 inches thick. The subsoil is dark yellowish-brown, loose and friable fine sand about 11 inches thick. Under this is a buried profile, which is a sandy loam that is neutral, very dark brown, and friable in the upper 13 inches. This sandy loam grades to loam in the lower part, and is underlain by neutral, dark yellowish-brown and light brownish-gray, friable loam. Next layer is calcareous, light olive-brown, friable loam that has strong-brown mottles.

The organic-matter content is low. The available water capacity is low to moderate. Permeability is rapid in the upper part and moderate in the substratum. The natural fertility is moderate.

Soil blowing and droughtiness are the major hazards.

Representative profile of Maddock loamy sand, loamy subsoil variant, 0 to 3 percent slopes, in a cultivated area, 425 feet east and 90 feet south of 3rd pole north of intersection, SW. corner of sec. 24, T. 120 N., R. 42 W.

Ap—0 to 6 inches, very dark grayish-brown (10YR 3/2) loamy sand; weak, medium, angular blocky structure; loose; neutral; abrupt, smooth boundary.

B21—6 to 13 inches, dark yellowish-brown (10YR 4/4) fine sand; weak, medium, angular blocky structure; loose; neutral; gradual, wavy boundary.

B22—13 to 17 inches, dark yellowish-brown (10YR 4/4) fine sand; weak, medium, angular blocky structure; friable; neutral; abrupt, smooth boundary.

IIA11b—17 to 21 inches, very dark brown (10YR 2/2) sandy loam; dark yellowish brown when crushed; weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

IIA12b—21 to 30 inches, very dark brown (10YR 2/2) loam; very dark grayish brown when crushed; moderate, medium, angular blocky structure; friable; neutral; gradual, wavy boundary.

IIB2b—30 to 42 inches, dark yellowish-brown (10YR 4/4) and light brownish-gray (10YR 6/2) loam; moderate, medium, angular blocky structure; friable; neutral; gradual, wavy boundary.

IICb—42 to 60 inches, light olive-brown (2.5Y 5/4) loam; common, fine, distinct, strong-brown mottles; moderate, medium, angular blocky structure; friable; calcareous.

The A horizon ranges from loamy sand or loamy fine sand to fine sandy loam, from 6 to 10 inches in thickness, and from very dark gray to very dark grayish brown in color. The B horizon ranges from 8 to 20 inches in thickness and from loamy fine sand to fine sand in texture. The buried A horizon is 8 to 15 inches thick and sandy loam to loam. The buried B horizon ranges from 8 to 16 inches in thickness and from fine sandy loam to loam in texture. In some places the buried soil is underlain by sand.

Maddock, loamy subsoil variant, differs from Maddock soils in being underlain by loamy material. These soils have higher hue and chroma than Swenoda soils and lack the mottling. They differ from Malachy, loamy subsoil variant, in being noncalcareous.

Maddock loamy sand, loamy subsoil variant, 0 to 3 percent slopes (MbA).—This soil is in nearly level to gently sloping areas around Appleton. The areas are irregular in shape and lie adjacent to the Shible or Maddock soils. Wind-drifted soil material is common in fence rows.

Included with this soil in mapping were small areas of Shible, Maddock, Swenoda, or Hantho soils. In some small areas lime occurs between depths of 15 and 30 inches. Also included were some areas having slopes stronger than 3 percent.

Soil blowing is a serious hazard in unprotected fields. Droughtiness is a problem late in summer. All crops common in the county are grown though this soil is not well suited to them. Early maturing crops best utilize the limited moisture.

Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Capability unit IVs-3; windbreak suitability group 6.

Malachy Series

In the Malachy series are deep, moderately well drained and somewhat poorly drained soils that formed in calcareous loamy material overlying calcareous outwash sand. These nearly level soils are in the lake-plain area in the central part of the county.

In a representative profile, the surface layer is calcareous, black sandy loam about 16 inches thick. The subsoil is strongly calcareous and calcareous, very dark grayish-brown and dark grayish-brown, friable sandy loam in the upper 10 inches. The lower 8 inches is calcareous, loose, grayish-brown and light olive-brown loamy sand. The underlying material is calcareous, light brownish-gray and pale-brown, loose medium sand.

The organic-matter content is high. The natural fertility is low. The available water capacity is low. The permeability is moderately rapid.

Malachy soils are subject to soil blowing and nutrient imbalance.

Representative profile of Malachy sandy loam, 0 to 2 percent slopes, in a cultivated area, 400 feet east and 100 feet south of the NW. corner of sec. 30, T. 122 N., R. 40 W.

Ap—0 to 6 inches, black (10YR 2/1) sandy loam; weak, fine, granular structure; friable; calcareous; abrupt, smooth boundary.

A1—6 to 13 inches, black (10YR 2/1) sandy loam; weak, fine, medium, subangular blocky structure; friable; calcareous; clear, smooth boundary.

A3—13 to 16 inches, black (10YR 2/1) to very dark gray (10YR 3/1) sandy loam; weak, fine, medium, subangular blocky structure; friable; few channels of very dark grayish brown (2.5Y 3/2); calcareous; clear, wavy boundary.

B1—16 to 20 inches, very dark grayish-brown (2.5Y 3/2) to dark grayish-brown (2.5Y 4/2) sandy loam; weak, medium, prismatic structure; friable; strongly calcareous; clear, wavy boundary.

B2—20 to 26 inches, dark grayish-brown (2.5Y 4/2) sandy loam; common, fine, distinct, light olive-brown mottles; weak, fine and medium, subangular blocky structure; friable; calcareous; abrupt, wavy boundary.

B3—26 to 34 inches, variegated grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4 and 5/6) loamy sand; massive; breaks to single grain; loose; a few black concretions; calcareous; abrupt, wavy boundary.

IIC—34 to 60 inches, light brownish-gray (2.5Y 6/2) and pale-brown (10YR 6/3) medium sand; single grain; loose; calcareous.

The A horizon is 12 to 20 inches thick and calcareous to strongly calcareous. The depth to maximum lime accumulation is 16 to 24 inches. The underlying sands are generally medium, but fine sands are included.

Malachy soils are more calcareous than the Maddock or Clontarf soils.

Malachy sandy loam, 0 to 2 percent slopes (MmA).—This nearly level to gently sloping soil is mostly in the lake-plain area in the north-central part of the county. The soil areas are generally elongated and oriented in a southeasterly direction. Some areas are irregular and circular. Wind-drifted soil material is common in fence rows bordering fields.

Included with this soil in mapping were some small areas of Clontarf sandy loam, Hecla loamy sand, and poorly drained Arveson loam. Also included were places where a layer of lime accumulation occurs about 12 inches from the surface. In Six Mile Grove Township, the sands are finer than those in Clontarf Township.

All crops common to the county are grown on this soil. Soil blowing and drought are serious hazards.

Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Applications of nitrogen, phosphorus, and potassium are needed. Capability unit IIIs–3; windbreak suitability group 8.

Malachy Series, Loamy Subsoil Variant

These are moderately well drained soils that have formed in coarse-textured material overlying finer textured material. These nearly level soils are mostly on the lake plains in the central part of the county.

In a representative profile, the surface layer is calcareous, very dark gray sandy loam and fine sandy loam in the upper 15 inches and very dark brown, loose, loamy medium sand in the lower 7 inches. The subsoil is calcareous, very dark grayish-brown, loose loamy medium sand about 3 inches thick. The upper part of the underlying material is calcareous, dark-brown, loose medium sand. Under this is light olive-brown and light brownish-gray, friable silty clay loam that has strong-brown and light olive-brown mottles.

The organic-matter content is high. The natural fertility is moderate. The available water capacity is moderate. The permeability is moderately slow in the subsoil.

Most of the acreage of these soils is cultivated. Soil blowing is a hazard.

Representative profile of Malachy sandy loam, loamy subsoil variant, 0 to 2 percent slopes, in a moderately wind eroded area, 25 feet east and 240 feet north of SW. corner of SE¼ sec. 35, T. 121 N., R. 40 W.

Ap—0 to 6 inches, very dark gray (10YR 3/1) sandy loam; weak, fine, subangular blocky structure; loose when moist; calcareous; abrupt, smooth boundary.

A11—6 to 15 inches, very dark gray (10YR 3/1) fine sandy loam; weak, medium, subangular blocky structure; friable when moist; calcareous; gradual, wavy boundary.

IIA12—15 to 22 inches, very dark brown (10YR 2/2) loamy medium sand; single grained; loose when moist; calcareous; gradual, wavy boundary.

IIB2—22 to 25 inches, very dark grayish-brown (10YR 3/2) loamy medium sand; single grained; loose when moist; calcareous; gradual, wavy boundary.

IIC1—25 to 33 inches, dark-brown (10YR 3/3) medium sand; single grained; loose when moist; calcareous; gradual, wavy boundary.

IIIC2—33 to 40 inches, light olive-brown (2.5Y 5/4) silty clay loam; common, fine, distinct, strong-brown mottles; weak, fine, subangular blocky structure; friable when moist; calcareous; gradual, wavy boundary.

IIIC3—40 to 60 inches, light brownish-gray (2.5Y 6/2) silty clay loam; common, fine, faint, light olive-brown mottles; weak, fine, subangular blocky structure; friable when moist; calcareous.

The Ap and A11 horizons range from 8 to 16 inches in thickness, from sandy loam to fine sandy loam in texture, and from calcareous to strongly calcareous. The sand layer is 6 to 16 inches thick and occurs at depths of 15 to 36 inches. The underlying material includes loam, silt loam, silty clay loam, or clay loam.

Malachy, loamy subsoil variant, has a lower hue and chroma than the Maddock, loamy subsoil variant. They have a higher hue and chroma than Rockwell soils and lack the horizon of lime accumulation.

Malachy sandy loam, loamy subsoil variant, 0 to 2 percent slopes (MnA).—This nearly level soil is in the lake-plain area in the central part of the county. The soil areas are generally on slight rises.

Included with this soil in mapping were small areas of Swenoda sandy loam, Malachy sandy loam, Rockwell fine sandy loam, and Rockwell loam. Also included were small areas where the surface is noncalcareous, and other areas where the texture of the surface layer is a loam.

This soil is used intensively for corn and soybeans. Soil blowing is a hazard if fields are left bare. Droughtiness is a hazard during long dry periods.

Management is needed that controls erosion and maintains good soil tilth and a high level of fertility. Capability unit IIIs–3; windbreak suitability group 8.

Marsh

Marsh (Mo) is in undrained depressions that contain water throughout most of the year. These areas are covered by marsh reeds, sedges, and rushes. In some places areas of open water are in the middle of the marsh.

These areas have a high value for wildlife. They provide nesting, courting, and escape areas for waterfowl, furbearers, and upland game.

Most of these areas can be improved for wildlife by controlling the water level, increasing resting and courting areas, building dikes, and fencing out livestock. It is not practical to drain this unit because of its location relative to nearby streams or lakes. Not placed in a capability unit; windbreak suitability group 9.

Marysland Series

The Marysland series consists of poorly drained soils that formed in calcareous, water-laid loamy deposits that overlie calcareous sand or gravel. These nearly level soils are mostly on the lake plain in the central part of the county.

In a representative profile, to a depth of 9 inches, the surface layer is calcareous, black loam, high in organic-matter content. The next 3 inches is strongly calcareous, black, very friable sandy loam. The upper part of the underlying material is a strongly calcareous, olive-gray and light olive-gray, friable and very friable sandy loam and loam. With depth, this material grades to a calcareous, grayish-brown and light brownish-gray, loose fine and medium sand that has common yellowish-brown mottles and a few iron stains.

The organic-matter content is high. The natural fertility is moderate because the high lime content causes an imbalance of plant nutrients. The available water capacity is moderate. Permeability is moderate above the sands and rapid in the sands. These soils have a high water table early in summer that limits root growth.

Most areas of these soils are cropped. Wetness and fertility are the main limitations.

Representative profile of Marysland loam, in a grassed area, 900 feet east and 200 feet north of the SW. corner of sec. 4, T. 121 N., R. 40 W.

Ap—0 to 9 inches, black (10YR 2/1) loam; weak, medium, subangular blocky structure; very friable; high content of organic matter; calcareous; abrupt, smooth boundary.

A1ca—9 to 12 inches, black (10YR 2/1) sandy loam; very dark gray (10YR 3/1) when dry; weak, fine, granular structure; very friable; strongly calcareous; abrupt, wavy boundary.

C1ca—12 to 15 inches, olive-gray (5Y 4/2) sandy loam; light gray (5Y 7/2) when dry; weak, fine, subangular blocky structure; very friable; strongly calcareous; clear, irregular boundary.

C2ca—15 to 20 inches, olive-gray (5Y 4/2) loam; few, fine, distinct, olive-yellow mottles; weak, fine, medium, subangular blocky structure breaking to weak, fine, granular structure; very friable; contains dark root channels and calcium concretions; strongly calcareous; clear, wavy boundary.

C3ca—20 to 27 inches, light olive-gray (5Y 6/2) loam; few, fine, distinct, olive-yellow mottles; weak, medium, subangular blocky structure breaking to moderate, very fine, subangular blocky structure; friable; gray channels and calcium and magnesium concretions; strongly calcareous; abrupt, wavy boundary.

IIC4—27 to 40 inches, grayish-brown (2.5Y 5/2) and light brownish-gray (2.5Y 6/2) fine and medium sands; common, medium, prominent, yellowish-brown mottles; single grain; loose; calcareous; gradual, wavy boundary.

IIC5—40 to 60 inches, grayish-brown (2.5Y 5/2) and light brownish-gray (2.5Y 6/2) medium sands; single grain; loose; few iron stains; calcareous.

The A horizon is loam, sandy clay loam, or sandy loam and ranges from 7 to 14 inches in thickness. The Cca horizon in most places is olive gray, light olive gray, very dark gray, or dark gray, and it frequently is grayer with increasing depth. It is 9 to 16 inches thick. Depth to the underlying sand (IIC horizon) ranges from 22 to 40 inches. This sand is medium or fine but includes some coarse grains.

Marysland soils have a horizon of lime accumulation that Mayer soils do not. They are deeper to the underlying sand than the Arveson soils. They are coarser textured than the Borup or Colvin soils.

Marysland loam (Mp).—This nearly level or slightly depressional soil is mostly in the north-central part of the county. The areas are generally broad and irregular but in some places are elongated. These soils adjoin Arveson, Malachy, Mayer, and Hecla soils.

This soil is wet early in the growing season, when the water table is at a depth of about 2 feet. By the middle of June, the water table has dropped to a depth of 4 feet and the surface soil is free of excess water.

Included with this soil in mapping were small areas of Arveson soils and of Mayer soils in the depressions. In some places the surface layer is slightly to strongly calcareous. In places the underlying sands are coarse or fine instead of medium. The sand is coarser in the northern part of the area and finer in the southern part.

This soil needs additional drainage. Most areas have already been drained by surface ditches, which are adequate in most years.

This soil is used intensively for corn and soybeans. It is suited to sugar beets. Soil blowing is a problem in fields left bare during winter and spring. Applications of nitrogen, phosphorus, and potassium are needed. Capability unit IIw-4; windbreak suitability group 7.

Mayer Series

The Mayer series consist of poorly drained soils that formed in loamy material overlying calcareous sand and gravel. These nearly level soils are adjacent to the Pomme de Terre River and the East Branch Chippewa River, and in the outwash areas in Edison and West Bank Townships.

In a representative profile, the surface layer is calcareous, black and very dark grayish-brown loam about 22 inches thick. The subsoil is calcareous, olive-gray, friable clay loam about 7 inches thick. It has a few olive mottles. The upper part of the underlying material is calcareous, friable, olive-gray loam that has yellowish-brown and light-gray mottles. This is underlain by calcareous, grayish-brown and light olive-brown, loose sand and gravel.

The organic-matter content is high. The natural fertility is moderate because the content of lime is high and the underlying material is sand and gravel. The available water capacity is moderate. Permeability is moderate in the surface layer and subsurface layer but very rapid in the sand and gravel.

Mayer soils have a high water table in the early part of the growing season. This limits the thickness of the root zone.

Representative profile of Mayer loam, in a cultivated field, 300 feet south and 75 feet east of the NW. corner of NW¼SE¼ sec. 8, T. 121 N., R. 42 W.

Ap—0 to 7 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; highly organic; calcareous; abrupt, smooth boundary.

A11—7 to 13 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; calcareous; gradual, smooth boundary.

A12g—13 to 22 inches, very dark grayish-brown (2.5Y 3/2) loam; weak, fine, subangular blocky structure; friable; calcareous; gradual, smooth boundary.

Bg—22 to 29 inches, olive-gray (5Y 4/2) clay loam; few, fine, faint, olive mottles; weak, fine, subangular blocky structure; friable; calcareous; gradual, smooth boundary.

C1—29 to 33 inches, olive-gray (5Y 5/2) loam; medium, fine, prominent, yellowish-brown and light-gray mottles; massive; friable; calcareous; gradual, smooth boundary.

IIC2—33 to 60 inches, variegated grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4, 5/6) sand and gravel; single grained; loose; calcareous.

The A horizon ranges from 10 to 24 inches in thickness and is a silt loam, loam, or clay loam in texture. The depth to sand and gravel ranges from 24 to 40 inches, but sand generally is at a depth near 30 inches. The reaction of the surface soil is neutral to moderately alkaline.

Mayer soils lack the horizon of lime accumulation that is in the Marysland soils.

Mayer loam (Mr).—This level soil occurs throughout the county, but mainly in the valley along the Pomme de Terre River. It is in slightly depressional areas in the river terrace, adjacent to the droughty Renshaw and Sioux soils. Some small areas of this soil are in the upland, where they are adjacent to the Barnes or Flom soils. This soil has the profile described as representative for the series.

Included with this soil in mapping were small areas of Benoit loam and Renshaw loam. Also included were some depressional areas where gravel is at a depth of more than 40 inches, and also areas that are strongly calcareous.

Most of this soil has been artificially drained and is cropped. All crops common to the county are grown.

Drainage is the most serious limitation of this soil. Lack of suitable outlets is a problem in some locations. Capability unit IIw-4; windbreak suitability group 7.

Mayer loam, depressional (Ms).—This soil is in depressions in the lake-plain and outwash areas throughout the county. The soil areas are irregular in shape and variable in size. Along the Pomme de Terre River and south of Holloway they are generally long and winding. Areas of this soil contain surface water most of the year and have a cover of marsh grass.

The soil is variable and in many places has thin lenses of coarser or finer textured material within the profile. Included in mapping were some soils where lime has been leached down to the coarse-textured layer. In section 22, Marysland Township, there are a few areas of soils where the coarse-textured layer is below a depth of 40 inches and where the subsoil is finer textured. Small areas of the adjoining Mayer, Marysland, and Arveson soils were included with this soil in mapping.

This soil has a high value for wildlife because it provides cover for upland game and waterfowl. If it is to be farmed, additional drainage must be provided. Most areas have already been drained by surface ditches, which are adequate for most years. Corn and soybeans are the main crops.

Management is needed that provides proper drainage and maintains a high nutrient level. Applications of phosphorus and potassium are needed. Capability unit IIIw-4; windbreak suitability group 7.

McIntosh Series

In the McIntosh series are deep, moderately well drained, calcareous soils. These soils formed in water-laid silty material that overlies calcareous glacial till of loam texture. These nearly level to gently sloping soils occur in the northwestern and southeastern parts of the county.

In a representative profile, the surface layer is about 9 inches of calcareous, black silt loam over about 3 inches of strongly calcareous, very dark grayish-brown silt loam. The upper part of the underlying material is strongly calcareous, dark grayish-brown and light olive-brown silt loam to a depth of about 22 inches. This is underlain by calcareous, light olive-brown, friable loam that has many grayish-brown mottles.

The organic-matter content is high. The available water capacity is high. Permeability is moderate. The natural fertility is moderate because of an imbalance of plant nutrients caused by excess lime.

Most areas of these soils are cultivated.

Representative profile of McIntosh silt loam, 0 to 3 percent slopes, in a cultivated area, 100 feet south of field approach, NW¼NW¼NE¼ sec. 12, T. 122 N., R. 42 W.

Ap—0 to 9 inches, black (10YR 2/1) silt loam; weak, fine, subangular blocky structure; friable; calcareous; obrupt, smooth boundary.

A3ca—9 to 12 inches, very dark grayish-brown (2.5Y 3/2) silt loam; weak, fine, subangular blocky structure; friable; strongly calcareous; clear, wavy boundary.

C1ca—12 to 16 inches, dark grayish-brown (2.5Y 4/2) silt loam; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

C2ca—16 to 22 inches, light olive-brown (2.5Y 5/3) silt loam; weak, fine, subangular blocky structure; friable; strongly calcareous; clear, wavy boundary.

IIC3—22 to 29 inches, light olive-brown (2.5Y 5/4) loam; weak, fine, subangular blocky structure; friable; stone line at depth of 29 inches; calcareous; clear, wavy boundary.

IIC4—29 to 60 inches, light olive-brown (2.5Y 5/4) loam; many, medium, distinct, grayish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous.

The A horizon ranges from 8 to 12 inches in thickness and from silt loam to silty clay loam in texture. It ranges from calcareous to strongly calcareous. The zone of lime accumulation is 5 to 15 inches thick and strongly calcareous. Thickness of the silt cap ranges from 18 to 40 inches but generally is near 24 inches.

The McIntosh soils are underlain by glacial till, but the entire profile of the Bearden soils developed in lacustrine material. McIntosh soils differ from Hamerly soils in having a solum formed in sorted silt loam material, whereas the entire profile of Hamerly soils formed in glacial till. McIntosh soils are better drained than Winger soils.

McIntosh silt loam, 0 to 3 percent slopes (MtA).—This nearly level soil occurs in the southeastern and northwestern parts of the county. The areas are irregularly shaped, are slightly elevated above surrounding landscape, and in places are oriented in a southeasterly direction.

Included with this soil in mapping were small areas of Winger, Bearden, Hamerly, and Tara soils, all of which occur close to this soil. The small included areas of Winger soils are in lower places within or along the edge of this soil. The Hamerly soils generally are on slight rises where the silt cap is thin and the glacial till is exposed. Included in some places, were areas where the surface layer is leached to a depth of 5 to 10 inches or where the content of lime is more than normal and the surface layer has a grayish color. It is common to find pebbles on the surface.

All crops common in the county are grown on this soil. Sugar beets are well suited. Soil blowing is a hazard in fields left bare during winter and spring. Management is needed that controls erosion and maintains a high content of plant nutrients. Applications of nitrogen, phosphorus, and potassium are needed. Capability unit IIe-4; windbreak suitability group 5.

Muck and Peat

Muck and peat consists of very poorly drained soils that formed in organic material. These soils generally occur in large depressional areas.

Muck and peat (Mu).—This is a deep, very poorly drained soil that formed in organic material deposited in depressions. Slopes range from 0 to 2 percent. The native vegetation is marsh grasses, reeds, and sedges. This soil is associated with the Blue Earth and Parnell soils and differs from them in having developed from organic material. It is mainly in the northeastern part of the county.

In a representative profile the peat is more than 42 inches thick and free lime is generally at a depth of 18 to 24 inches.

The content of organic matter is very high. The available water capacity is very high. The natural fertility is low. Permeability is variable.

The management problems are very poor drainage because of the high water table, low fertility, danger of early or late frost, and soil blowing during periods of drought. Peat needs drainage before it can be used for farming. When undrained, it is excellent wildlife habitat that provides cover for upland game and waterfowl. When drained it is suited to all of the common crops. Small grains tend to lodge, however, and corn and soybeans are sometimes damaged by early frost. Capability unit IIIw-6; windbreak suitability group 9.

Muck and peat, calcareous (Mv).—This is a calcareous, deep, very poorly drained soil that formed in calcareous organic sediments. It occurs in large depressions that originally were shallow lakes or ponds. The native vegetation was marsh grass, reeds, and sedges.

This soil has a thicker layer of muck or peat than the associated Blue Earth or Parnell soils. Thickness of the peat is more than 40 inches. This soil differs from the mapping unit Muck and peat in being calcareous.

The available water capacity is very high. Natural fertility is low. Permeability is variable.

Wetness, low fertility, danger of frost damage, and soil blowing are hazards of farming this soil. Additional drainage is needed before this soil can be farmed. When drained, it produces all of the common crops, but small grains lodge and corn is often damaged by early frost. When undrained, this soil is excellent wildlife habitat. It provides cover for upland game and waterfowl. Capability unit IIIw–6; windbreak suitability group 9.

Muck and peat, calcareous, shallow (Mw).—This is a very poorly drained soil that developed in calcareous organic matter overlying calcareous loamy glacial till. This soil is in large depressional areas that originally were shallow lakes or ponds. The native vegetation is marsh grasses, reeds, and sedges. This soil is associated with Blue Earth and Parnell soils and with Muck and peat. It differs from Blue Earth and Parnell soils in having a thicker layer of muck or peat. It is more calcareous than Muck and peat and is underlain by loamy material within 40 inches of the surface.

The thickness of the muck and peat ranges from 12 to 40 inches. The available water capacity is very high. Natural fertility is low. Permeability is variable.

Wetness, low fertility, frost damage, and soil blowing are hazards in farming this soil. When it is cropped, it is best suited to silage corn or soybeans. Small grains lodge severely, and corn for grain seldom matures. Capability unit IIIw–6; windbreak suitability group 9.

Muck and peat, shallow over loam (Mx).—This is a very poorly drained soil in depressions. It developed in organic material overlying calcareous loamy glacial till. Slopes are 0 to 2 percent. The native vegetation is marsh grasses, reeds, and sedges. This soil is associated with the Blue Earth and Parnell soils and with Muck and peat. It differs from Blue Earth and Parnell soils in having a layer of peat more than 12 inches thick, and from Muck and peat in having less than 42 inches of peat overlying glacial till. This soil is in the eastern third of the county.

The depth of peat over the glacial till ranges from 12 to 42 inches. Free lime is at a depth of 20 to 24 inches. The organic-matter content is very high. The available water capacity ranges from high to very high, depending upon the depth of the peat. The inherent fertility is low. The permeability is variable.

The management problems are drainage, low fertility, danger of damage by early or late frost, and soil blowing where the areas have been drained.

Surface drainage is adequate for limited cropping, but for complete drainage a system of tile should be installed. Early maturing crops are best suited to this soil. At present, it is generally used for silage corn and small grains. If it is partially drained, it is excellent for pasture. Where not drained, it provides good cover for wildlife. Capability unit IIIw–1; windbreak suitability group 9.

Muck and peat, shallow over sand (My).—This is a very poorly drained organic soil that overlies calcareous sand. It occurs in a large slough between Danvers and Benson. The native vegetation is marsh grasses, reeds, and sedges.

Muck and peat is 12 to 40 inches thick over sand. The reaction is slightly to strongly calcareous. The available water capacity is high. The inherent fertility is low. The permeability is variable in the muck and peat and rapid in the sand.

This soil is now used for wildlife and recreation. It is an excellent habitat for ducks, pheasants, and deer. It can be farmed only if additional drainage is provided. Flooding, frost damage, low fertility, and soil blowing are all hazards of farming this soil. Capability unit IVw–3; windbreak suitability group 9.

Nutley Series

The Nutley series consists of deep, moderately well drained to somewhat poorly drained soils that formed in fine-textured calcareous glacial till. These soils are nearly level to undulating. They are in the northeastern and northwestern parts of the county.

In a representative profile, the surface layer is neutral, black clay about 7 inches thick. The subsoil is neutral, dark grayish-brown, firm clay about 8 inches thick. The upper part of the underlying material is calcareous, dark grayish-brown, firm clay. This grades to strongly calcareous, dark grayish-brown to light olive-brown, firm silty clay loam. Under this is calcareous, light olive-brown, firm silty clay loam.

The organic-matter content is high. The available water capacity is high. Natural fertility is high. Permeability is very slow.

These fine-textured soils are susceptible to compaction and water erosion.

Representative profile of Nutley clay from an area of Hattie-Nutley clays, 2 to 6 percent slopes, in a plowed field, 1,000 feet south and 40 feet east of the NW. corner of sec. 24, T. 122 N., R. 37 W.

Ap—0 to 7 inches, black (10YR 2/1) grading to very dark gray (10YR 3/1) clay; moderate, very fine, angular blocky structure; firm; neutral; abrupt, smooth boundary.

B2—7 to 15 inches, dark grayish-brown (2.5Y 4/2) clay; weak, medium, prismatic structure breaking to moderate, very fine, angular blocky structure; firm; many very dark gray channels and tongues; neutral; clear, wavy boundary.

C1—15 to 27 inches, dark grayish-brown (2.5Y 4/2) clay; weak to moderate, medium, prismatic structure; very dark gray tongues; thin patchy clay films; firm; calcareous; abrupt, smooth boundary.

C2ca—27 to 36 inches, dark grayish-brown (2.5Y 4/2) silty clay loam grading to light olive-brown (2.5Y 5/3) loam; moderate, very fine, angular blocky structure; some horizontal cleavage; firm; strongly calcareous; gradual, wavy boundary.

C3—36 to 60 inches, light olive-brown (2.5Y 5/3) silty clay loam; moderate, very fine, angular blocky structure with some horizontal cleavage; firm; calcareous.

The A horizon is clay loam to clay 6 to 12 inches thick. Tongues of the A horizon extend 20 to 30 inches into the underlying material. Depth to lime is variable and ranges from 12 to 24 inches.

Nutley soils differ from the Hattie soils in having a B horizon. They are finer textured than the Barnes or Svea soils. They are better drained than the Fulda soils.

Nutley-Hattie clays, 0 to 2 percent slopes (NhA).—These nearly level soils are in the northwestern part of the county. They are in broad and irregular areas dissected by many small drainageways.

These soils are in such a complex arrangement that it is not practical to map them separately. Nutley soils occupy about 60 percent of the area, and Hattie soils about 35 percent.

Included in mapping were small areas of Svea loam and Barnes loam, and in many of the wetter drainageways or depressions, Fulda silty clay. In some places the depth to lime is greater than 24 inches, and in others it is at a depth of less than 12 inches. In a few places lime is on the surface. Also included in mapping were some areas where the underlying material is a clay loam.

All crops common to the county are grown on these soils. They are difficult to work because they are sticky when wet and are easily compacted. They shrink, crack, and dry out during the hot summer. Soil blowing is a hazard in fields left bare during spring and winter.

Management is needed that controls erosion, maintains a high content of organic matter and plant nutrients, and prevents soil compaction. Both soils in capability unit IIe–1; Nutley part in windbreak suitability group 1, and Hattie part in windbreak suitability group 5.

Oldham Series

The Oldham series consists of deep, poorly drained, calcareous soils that formed in potholes and sloughs, mainly in the southeastern part of the county.

In a representative profile, the surface layer is calcareous, black and very dark gray silty clay loam about 26 inches thick. The upper part of the underlying material is calcareous, friable, very dark gray silty clay loam. This grades to strongly calcareous, olive-gray, firm silty clay loam. Beneath this is a calcareous, olive-gray, firm silt loam that has grayish-brown and strong-brown mottles.

The organic-matter content is high. The available water capacity is high. The natural fertility is moderate because of the high content of lime. The permeability is moderately slow. The water table is at or near the surface and restricts the root zone of plants.

Wetness is a severe limitation. Drainage must be provided before these soils can be farmed.

Representative profile of Oldham silty clay loam, 1,400 feet east and 150 feet south of the NW. corner of sec. 21, T. 120 N., R. 38 W.

Ap—0 to 8 inches, black (10YR 2/1) silty clay loam; weak, fine, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.

A11—8 to 16 inches, black (10YR 2/1) silty clay loam; weak, fine, subangular blocky structure; firm; calcareous; clear, smooth boundary.

A12—16 to 26 inches, very dark gray (10YR 3/1) silty clay loam; weak, fine, angular blocky structure; friable; calcareous; clear, smooth boundary.

C1g—26 to 30 inches, very dark gray (5Y 3/1) silty clay loam; weak, fine, angular blocky structure; friable; calcareous; clear, smooth boundary.

C2ca—30 to 36 inches, olive-gray (5Y 5/2) silty clay loam; massive; firm; strongly calcareous; clear, smooth boundary.

C3—36 to 54 inches, olive-gray (5Y 5/2) silt loam; common, medium, distinct, grayish-brown and strong-brown mottles; massive; firm; mottles increase with depth, but lime decreases with depth; calcareous; few small pebbles in this horizon and throughout profile.

Texture of the A horizon ranges from silt loam to silty clay loam or to loam. The A horizon is 16 to 30 inches thick. The very dark gray combined A12 and C1g horizons are 10 to 20 inches thick. Gypsum crystals are present in many places.

The Oldham soils are calcareous; the Parnell or Perella soils, in contrast, are not calcareous. They do not have so thick a horizon of lime accumulation as the Colvin, depressional, soils.

Oldham silty clay loam (Om).—This soil is calcareous at the surface. It occurs in shallow potholes and sloughs that are flooded in the growing season but are ordinarily dry by mid-July. Included with this soil in mapping were small areas of Vallers, Winger, Hamerly, and Parnell soils. The Parnell soils are in the deepest areas of the Oldham soil.

This soil requires additional drainage if it is farmed. Most areas already have surface ditches, but, for complete drainage, a tile system should be installed. When it is drained, all common crops can be grown on this soil. In some places, however, small grain lodges and corn and soybeans do not mature because of frost damage. Applications of nitrogen, phosphorus, and potassium are needed to modify the high lime content of this soil. Capability unit IIIw–2; windbreak suitability group 4.

Parnell Series

The Parnell series consists of deep, very poorly drained soils that formed in potholes and sloughs in the northeastern and northwestern parts of the county.

In a representative profile, the surface layer is neutral, black silty clay loam about 18 inches thick. The subsoil is neutral, black, friable silty clay loam and silty clay about 22 inches thick. The underlying material is neutral, olive-gray, friable silty clay loam in which olive mottles are common.

The organic-matter content is high. The available water capacity is high. The permeability is very slow. The natural fertility is high. The water table is at or near the surface and limits the root zone of plants.

Wetness is a serious hazard. These soils cannot be farmed without additional drainage.

Representative profile of Parnell silty clay loam, 100 feet west of road and 125 feet south of NE. corner of SE¼ sec. 10, T 121 N., R. 37 W.

O1—3 inches to 0, duff.

A11—0 to 6 inches, black (2.5Y 2/0) silty clay loam; moderate, fine, angular blocky structure; friable; neutral; abrupt, smooth boundary.

A12g—6 to 10 inches, black (2.5Y 2/0) silty clay loam; very dark gray (2.5Y 3/1) when dry; weak, thin, platy structure; friable; olive root stains; brown plates; neutral; clear, smooth boundary.

A13—10 to 18 inches, black (2.5Y 2/0) silty clay loam; very dark gray (2.5Y 3/1) when crushed; weak, thin, platy structure breaking to weak, fine, subangular blocky structure; friable; some bleached sand grains; neutral; gradual, wavy boundary.

B21t—18 to 24 inches, black (2.5Y 2/0) silty clay loam; very dark gray (5Y 3/1) when dry; few, fine, distinct, olive-brown mottles; moderate, fine, angular blocky structure; friable; continuous clay films on vertical faces; neutral; gradual, wavy boundary.

B22t—24 to 40 inches, black (2.5Y 2/1) silty clay; moderate, fine, angular blocky structure; friable; continuous clay films on vertical faces; neutral; gradual, wavy boundary.

C1—40 to 46 inches, olive-gray (5Y 5/2) silty clay loam; massive; neutral; tongues of A1 extend to depth of 42 inches; friable; gradual, wavy boundary.

C2—46 to 60 inches, olive-gray (5Y 5/2) silty clay loam; common, medium, distinct, olive mottles; massive; friable; neutral.

The black A horizon is 18 to 40 inches thick. When the soil is dry, a very dark gray horizon is evident in many places at a depth of 6 to 14 inches. This horizon is 12 to 18 inches thick and contains bleached sand grains; it may be a weak A2 horizon. The B2t horizon begins at a depth of 18 to 40 inches and is silty clay loam or silty clay. A 6- to 12-inch gray, noncalcareous, eluviated horizon in some places occurs below the B2t horizon. The C horizon is normally silty clay loam, but loam textures occur in many places. A thin layer of muck or peat is on the surface in many places.

The Parnell soils differ from Oldham by being noncalcareous. They differ from Perella and Flom soils in having a B2t horizon.

Parnell silty clay loam (Pc).—This soil occurs in deep potholes and sloughs. It is flooded during spring and early in the growing season, but it often becomes dry in August. It has the profile described as representative for the series.

This soil is close to Flom and Vallers soils. Included in mapping, at outside edges of areas of this soil are small patches of Oldham silty clay loam. Also included was a small area of lake borderland around Lake Shible in Shible Township.

This soil area, undrained, provides excellent wildlife habitat. If it is used for farming, additional drainage must be provided. Most areas already have been drained by surface ditches and are now farmed. These areas still fill with water in spring and are slow to warm up. For complete farm drainage, tile must be installed. Capability unit IIIw-1; windbreak suitability group 3.

Parnell and Flom soils (0 to 2 percent slopes) (Pf).—This mapping unit contains both Flom silty clay loam and Parnell silty clay loam. These soils are in slightly depressional, nearly level areas that are generally elongated and irregular but in many places are circular. They are ordinarily wet after spring runoff and heavy rains in summer.

The soils of this mapping unit occur in an unpredictable pattern. In the eastern part of the county, about 75 percent of an area is Parnell soil and 25 percent is Flom. In the western part of the county, the ratio is 60 percent Parnell and 40 percent Flom. The Parnell soil has the profile described as representative for the Parnell series, and the Flom soil, the profile that is representative for the Flom series.

In waterways on the rolling moraine or at the base of slopes, these soils have a thicker surface layer that is brownish and contains some sand and pebbles that have washed in from adjoining sloping soils.

This mapping unit occurs close to the Svea, Hamerly, and Vallers soils, and in many areas these soils were included in mapping.

These soils need additional drainage. Open ditches provide adequate drainage in most years, but a tile system is needed for complete drainage. When adequately drained, this mapping unit is used intensively for corn and soybeans, and it is well suited to sugar beets. Capability unit IIw-2; windbreak suitability group 3.

Perella Series

The Perella series consists of deep, poorly and very poorly drained soils that formed in water-laid silty material. These soils are in depressions in the south-central and western parts of the county.

In a representative profile, the surface soil is neutral, black and very dark gray silt loam about 22 inches thick. The subsoil is neutral, dark grayish-brown, grayish-brown, and olive-brown, friable silt loam about 8 inches thick. It has a few yellowish-brown mottles. The underlying material is light brownish-gray and grayish-brown, friable silt loam that is strongly calcareous in the upper part but becomes calcareous with depth. It has yellowish-brown and gray mottles.

The organic-matter content is high. The available water capacity is high. The permeability is moderate. The natural fertility is high. The water table is high and limits the root zone for plants.

When properly drained, these soils are suited to the crops commonly grown in the county.

Representative profile of Perella silt loam, in a cultivated field, 280 feet south of road, 300 feet east of farm road, NE¼NW¼NE¼ sec. 31, T. 120 N., R. 40 W.

Ap—0 to 7 inches, black (10YR 2/1) silt loam; weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A11—7 to 14 inches, black (10YR 2/1) silt loam; weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

A12—14 to 18 inches, very dark gray (10YR 3/1) silt loam; weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

A13g—18 to 22 inches, very dark gray (10YR 3/1) to dark grayish-brown (2.5Y 4/2) silt loam; weak, fine, subangular blocky structure; friable; neutral; gradual, irregular boundary.

B21g—22 to 28 inches, dark grayish-brown and grayish-brown (2.5Y 4/2, 5/2) silt loam; few, fine, distinct, yellowish-brown mottles; weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

B22—28 to 30 inches, olive-brown (2.5Y 4/4) silt loam; few, fine, distinct, yellowish-brown mottles; weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

C1ca—30 to 35 inches, light brownish-gray (2.5Y 6/2) silt loam; many, medium, distinct, yellowish-brown mottles; weak, medium, platy structure breaking to weak, fine, subangular blocky structure; friable; strongly calcareous; clear, smooth boundary.

C2—35 to 54 inches, grayish-brown (2.5Y 5/2) silt loam; many, medium, distinct, gray and yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous.

The texture of the A horizon includes silty clay loam and silt loam. The A horizon is noncalcareous. The C horizon is silt loam or silty clay loam and is neutral to strongly calcareous. In many areas gypsum crystals are present in the C horizon.

The Perella soils differ from the Flom soils in having developed in sorted silty material, instead of glacial till. Perella soils have a medium-textured subsoil, whereas the Parnell soils are clayey in part of the B2t horizon. It differs from Colvin and Oldham by being noncalcareous in the solum.

Perella silt loam (Pr).—This nearly level soil is in the silty areas of the county. The areas are generally irregular and adjacent to Hantho or Tara soils. This soil has the profile described as representative for the series.

Included with this soil in mapping were some small areas of Perella depressional soils and Parnell, Hantho, Colvin, and Flom soils. Also included were some areas of soils slightly calcareous at or near the surface.

Most areas of this soil can be farmed with additional surface drainage. Tile drainage, however, would remove the hazard of wetness.

Corn and soybeans are the major crops. This soil is also well suited to sugar beets.

Soil blowing is a problem in bare fields during winter and spring. Capability unit IIw–2; windbreak suitability group 3.

Perella silty clay loam, depressional (Ps).—This soil is in deep potholes and sloughs throughout the south-central part of the county. It is flooded during spring and early in the growing season, but in some places it is dry by August. In many areas it is calcareous in the upper 6 inches.

This soil is closely associated with the Colvin and Winger soils, which ordinarily surround it. In mapping, some small areas of those soils were included with this soil. Included also, as a narrow rim around areas of this soil, were small bodies of Colvin soil, depressional.

When this Perella soil is undrained, it is covered by marsh and makes excellent wildlife habitat. If it is to be used for farming, however, additional drainage must be provided. Most areas have already been drained by surface ditches and are now farmed. These areas still fill with water in spring, and are slow to warm. For complete drainage, tile must be installed.

When this soil is drained, all crops common to the area are grown on it. At times, however, small grains lodge and corn and soybeans do not mature. Capability unit IIIw–1; windbreak suitability group 3.

Rauville Series

The Rauville series consists of deep, very poorly drained soils that formed in calcareous stream-deposited alluvial silts. These soils occur in old stream meanders in the nearly level to depressional bottom lands along streams throughout the county. The native vegetation is marsh grasses, reeds, and sedges.

In a representative profile, the surface layer is calcareous, black silty clay loam about 34 inches thick. The underlying material is a calcareous, very dark gray, sticky silty clay loam in which there are brown root channels. Beneath this, at a depth of about 50 inches, is a calcareous, very dark gray, slightly sticky gravelly loam.

The organic-matter content is high. The available water capacity is high. Permeability is moderately slow. The natural fertility is high.

The management problems are drainage and flooding. Because of its position, drainage of this soil is not feasible without deepening of the adjacent stream channel.

Representative profile of Rauville silty clay loam, in an old meander in the Pomme de Terre River bottom, 600 feet east of NW. corner of SW¼NE¼ sec. 8, T. 121 N., R. 42 W.

A11—0 to 6 inches, black (2.5Y 2/0) silty clay loam; massive; friable; calcareous; gradual, wavy boundary.

A12—6 to 24 inches, black (2.5Y 2/0) silty clay loam; moderate, fine, angular blocky structure; sticky; calcareous; gradual, wavy boundary.

A13g—24 to 34 inches, black (5Y 2/1) silty clay loam; massive; sticky; calcareous; gradual, wavy boundary.

C1g—34 to 50 inches, very dark gray (5Y 3/1) silty clay loam; massive; sticky; brown root channels are common throughout; calcareous; gradual, wavy boundary.

IIC2—50 to 60 inches, very dark gray (5Y 3/1) gravelly loam; massive; slightly sticky; calcareous.

The A horizon is 24 to 36 inches thick and is silt loam or silty clay loam. The C1 horizon is 12 to 18 inches thick. The IIC2 horizon is a loamy gravel, gravelly loam, or sandy loam and occurs at depths below 42 inches. The entire profile is calcareous.

Rauville soils have a thicker A horizon than the Lamoure, Parnell, or Oldham soils.

Rauville silty clay loam (Ra).—This is a level to depressional soil that generally occurs in old meanders on the flood plain of streams. Slopes range from 0 to 1 percent.

In many places this soil is associated with the poorly drained Lamoure soils. Along the Pomme de Terre River, this soil is underlain by gravel at depths of 42 inches or more. Along the Chippewa River, it is underlain by coarse sands. In some places sand and gravel are not found in the profile. A thin layer of peat or muck is on the surface in some places.

This soil is best suited as a habitat for wildlife, but in some places it can be used for pasture. Drainage is not now practical, because suitable outlets are lacking. Soil management would need to take into account the needs of wildlife and the need for restricted grazing. Capability unit VIw–1; windbreak suitability group 9.

Renshaw Series

The Renshaw series consists of somewhat excessively drained soils that formed in loamy material overlying calcareous sand and gravel. These nearly level to rolling soils occur throughout the county but are mostly in river-outwash areas.

In a representative profile, the surface layer is neutral, black and very dark brown loam about 11 inches thick. The subsoil is a neutral, dark-brown, friable loam about 5 inches thick. The underlying material is a calcareous, brown sand and gravel.

The organic-matter content is medium. The natural fertility is low because the underlying material is sand and gravel. The available water capacity is low. Permeability is moderate in the loam and rapid in the gravel.

Droughtiness and low fertility limit productivity of these soils. The soils are a good source of road gravel.

Representative profile of Renshaw loam, 0 to 2 percent slopes, in a cultivated field, 200 feet east and 50 feet south of NW. corner of the NE¼ sec. 8, T. 121 N., R. 42 W.

Ap—0 to 6 inches, black (10YR 2/1) loam; weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A1—6 to 11 inches, very dark brown (10YR 2/2) loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B2—11 to 16 inches, dark-brown (10YR 3/3) loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

IIC1ca—16 to 22 inches, brown (10YR 4/3) sand and gravel; single grained; loose; calcium crusts on lower surfaces; calcareous; gradual, wavy boundary.

IIC2—22 to 60 inches, brown (10YR 4/3) gravel; single grained; loose; calcareous.

The A horizon is 6 to 12 inches thick and is loam or sandy loam. The B horizon is 5 to 12 inches thick and is loam or sandy loam. Free lime is in the underlying gravel. Depth to sand and gravel ranges from 12 to 24 inches.

Renshaw soils are underlain by sand and gravel, but Sverdrup soils are underlain mainly by medium sand. Renshaw soils have a thicker solum than the Sioux soils and are thinner to gravel than the Fordville soils.

Renshaw loam, 0 to 2 percent slopes (ReA).—This nearly level soil occurs throughout the county but is mostly along the Pomme de Terre River and along the East Branch Chippewa River in Camp Lake Township. It has the profile described as representative for the series.

This soil is in broad, irregularly shaped areas that lie adjacent to the Fordville, Sioux, and Benoit soils. Many small areas of those soils were included with this soil in mapping. The Fordville soils included in mapping generally are in lower positions in the landscape, and Sioux soils are on the rises and ridges. Benoit soils are in the wetter, depressed areas.

In many places areas were included where there is an increase of clay content in the zone immediately above the gravel. In Appleton and Edison Townships, this soil in many places has a second dark-colored layer just above the sand and gravel. This layer is beneath the surface soil and subsoil and is thought to be a buried surface layer. About 1,200 acres having this buried layer was included in mapping. In the area northwest of Danvers, this soil has about 20 inches of silt loam over the sand and gravel.

All crops common to the county are grown on this soil. Droughtiness is a serious problem. Early maturing crops better utilize the available moisture and are best suited to this soil. Soil blowing is a problem in bare fields during winter and spring. Management that controls erosion and conserves moisture is needed. Capability unit IIIs–1; windbreak suitability group 6.

Renshaw loam, 2 to 6 percent slopes (ReB).—This gently sloping soil occurs throughout the county. It is within the glacial moraines of the northeastern and northwestern parts of the county and in the outwash areas of the Pomme de Terre and Chippewa Rivers. In the moraine areas it occurs with Barnes-Buse loams and Fordville soils. In the outwash areas its lies adjacent to the Fordville and Sioux soils. Small areas of those soils were included in mapping areas of this soil. Included Fordville soils are in the more uniform, lower lying positions; and included Sioux soils are on small gravelly bumps or ridges.

The thickness of the soil profile varies from the top to the bottom of slopes. Near the top of a slope, the soil is thinner than normal, or about 12 inches thick. At the base of a slope, because of soil accumulation, the profile is thicker than normal, or 20 to 24 inches thick.

All crops common to the county are grown on this soil. Droughtiness is a serious hazard, and crop failures are common. Early maturing crops better utilize the available moisture and are best suited to this soil. Soil blowing is a hazard in bare fields during winter and spring. Management that controls erosion and conserves moisture is needed. Capability unit IIIe–2; windbreak suitability group 6.

Renshaw loam, 6 to 12 percent slopes, eroded (ReC2).—This rolling soil is mainly in glacial till areas but also occurs on outwash along the Pomme de Terre and Chippewa Rivers. This soil has lost up to two-thirds of its original surface soil. The surface layer now is mixed with material from the subsoil and for this reason has a dark-brown color.

The slopes are short and irregular, and most of the erosion has taken place on the upper part of the slopes. At the base of the slopes, where soil has accumulated, the soil is as thick or thicker than the typical soil.

This soil occurs adjacent to Barnes-Buse loams and Sioux soils. Included with this soil in mapping were many small, gravelly bumps or ridges of Sioux soils. Also included were some areas only slightly eroded, and 20 acres in Appleton Township that are too bouldery for cultivation.

This soil has low organic-matter content and low fertility as a result of erosion. All crops common to the county are grown on it, but droughtiness is a serious problem and water erosion is a moderate hazard. Management that controls soil erosion and conserves moisture is needed. Capability unit IVe–2; windbreak suitability group 6.

Renshaw stony loam, 0 to 6 percent slopes (RhB).—This nearly level and gently sloping soil is in broad areas southwest of Appleton. Included with it in mapping were some moderately well drained soils and some soils underlain by sands.

Most of this soil is used for pasture or hay. Some areas are cultivated, but these contain numerous stones. It would be economically feasible to clear the stones. When used for crops, this soil is subject to soil blowing in winter and early in spring. In periods of dry weather, crops are damaged by drought. Capability unit VIe–3; windbreak suitability group 10.

Renshaw and Fordville very stony loams (Rk).—These soils are southwest of the city of Appleton. They are so stony that it is not economically feasible to clear them for crops. They are used for hay or pasture. In about half of the acreage, stones are so numerous and protrude to such an extent that the use of haying equipment is not practical.

These soils are good for pasture, but care should be taken to avoid overgrazing them late in July and in August, when they become dry. These soils lose some of their value for hay when they are grazed. They become compacted and more stones are exposed and protrude above the ground. Capability unit VIe–3; suitability group 10.

Rockwell Series

The Rockwell series consists of deep, poorly drained soils that formed in stratified water-laid silt and sand. These soils are in the central part of the county.

In a representative profile, about 12 inches of the surface layer is calcareous, black loam and about 4 inches is strongly calcareous, very dark gray, friable loam. The underlying material is strongly calcareous, grayish-brown loam that grades to a light olive-brown, calcareous loamy fine sand. This loamy fine sand is 10 inches thick and distinctly mottled. Below this is a light yellowish-brown, mottled, calcareous loam that grades to silt loam with depth.

The organic-matter content is high. The available water capacity is moderate. Permeability is moderate. The natural fertility is moderate. Rockwell soils have a high water table in the early part of the growing season that limits growth of roots. The high lime content causes an imbalance of plant nutrients.

Representative profile of Rockwell loam, in a nearly level cornfield, 145 feet west and 40 feet south of telephone pole, in SE¼NE¼NW¼ sec. 10, T. 120 N., R. 40 W.

Ap—0 to 7 inches, black (2.5Y 2/0) loam; weak, fine, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.

A11—7 to 12 inches, black (2.5Y 2/1) loam; weak, medium, subangular blocky structure; friable; calcareous; clear, smooth boundary.

A12ca—12 to 16 inches, very dark gray (2.5Y 3/1) loam; weak, fine, subangular blocky structure; friable; strongly calcareous; clear, wavy boundary.

C1ca—16 to 24 inches, grayish-brown (2.5Y 5/2) loam; few, fine, faint, light olive-brown mottles; weak, fine, subangular blocky structure; friable; strongly calcareous; clear, wavy boundary.

IIC2—24 to 34 inches, light olive-brown (2.5Y 5/4) loamy fine sand; moderate, fine, distinct, brown and gray mottles; weak, fine, subangular blocky structure; loose; calcareous; gradual, wavy boundary.

IIIC3—34 to 48 inches, light yellowish-brown (2.5Y 6/3) loam; common, fine, distinct, brown and gray mottles; weak, fine, subangular blocky structure; friable; manganese concretions common; calcareous; gradual, wavy boundary.

IIIC4—48 to 60 inches, light yellowish-brown (2.5Y 6/3) silt loam; common, fine, distinct, brown and gray mottles; weak, fine, subangular blocky structure; friable; manganese concretions common; calcareous.

The texture of the A horizon is loam and sandy loam. The C1ca horizon is 8 to 20 inches thick and strongly calcareous. The IIC2 horizon is more than 6 inches thick and ranges from loamy fine sand to sand in texture. The IIIC3 and IIIC4 horizons are loam, silt loam, or silty clay loam.

Rockwell soils have a finer textured C horizon than the Marysland or Arveson soils. They are coarser textured than the Colvin or Borup soils.

Rockwell loam (Rm).—This nearly level soil is on the lake plain in the central part of the county. The areas are broad, irregular, and elongated. Many of them are oriented in a southeasterly direction. This soil has the profile described as representative for the series.

Included with this soil in mapping were small areas of Colvin silty clay loam, Rockwell fine sandy loam, and Marysland loam. Also included were small grayish areas that have a very strongly calcareous surface layer. In some small places, very poorly drained depressions were included. These depressions ordinarily contain the depressional phases of Perella silty clay loam or Mayer loam.

All crops common to the area are grown on this soil. Sugar beets are well suited. Most areas have been drained by surface ditches, which are adequate in most years. Tile is needed, however, for optimum drainage. Soil blowing is a hazard in bare fields during winter and spring.

Management is needed that controls erosion, provides adequate drainage, and maintains a balance of plant nutrients. Applications of nitrogen, phosphorus, and potassium are needed. Capability unit IIw-3; windbreak suitability group 4.

Rockwell fine sandy loam (Rn).—This soil is on the nearly level lake plain in the central part of the county. The areas are irregular and in some places are elongated and oriented in a southeasterly direction.

Included with this soil in mapping were small areas of Rockwell loam, Arveson loam, and Fossum sandy loam. Many small depressions containing Venlo fine sandy loam or Mayer loam were included. Also included were small grayish areas that are very strongly calcareous.

All of the common crops are grown on this soil. Soil blowing is a serious hazard in unprotected fields during winter and spring. Wetness is a serious hazard. Most fields are drained by surface ditches, and this is adequate for most years. In some seasons, however, crop growth is retarded by wetness. Applications of phosphorus and potassium are needed to offset the high lime content of this soil. Capability unit IIIw-3; windbreak suitability group 4.

Rothsay Series

The Rothsay series consist of deep, well-drained soils that have formed in calcareous, wind-sorted silty material. These nearly level to gently sloping soils occur throughout the county but are mostly in West Bank and Edison Townships.

In a representative profile, the surface layer is neutral, black and very dark gray silt loam about 13 inches thick. The subsoil is neutral, friable silt loam about 9 inches thick. It is dark grayish brown in the upper part and grades to dark yellowish brown in the lower part. The underlying material is friable silt loam. In the upper 8 inches this material is light olive brown and strongly calcareous, but with depth it becomes light yellowish brown and less calcareous.

The organic-matter content is high. The available water capacity is high. The natural fertility is high. Permeability is moderate.

These soils respond well to good management. Soil blowing and water erosion are slight hazards.

Representative profile of Rothsay silt loam, 2 to 6 percent slopes, 50 feet east in an alfalfa field, 20 feet north to terrace from the SW. corner of the NW¼ sec. 6, T. 121 N., R. 38 W.

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

A1—8 to 13 inches, very dark gray (10YR 3/1) silt loam; weak, medium, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B1—13 to 16 inches, very dark grayish-brown (10YR 3/2) silt loam; dark grayish brown (10YR 4/2) crushed; weak, medium, prismatic breaking to weak, medium, subangular blocky structure; friable; tongues of the A1 extend through this horizon; neutral; gradual, wavy boundary.

B2—16 to 22 inches, dark yellowish-brown (10YR 4/4) silt loam; weak, medium, prismatic breaking to weak, medium, subangular blocky structure; friable; neutral; gradual, wavy boundary.

C1ca—22 to 30 inches, light olive-brown (2.5Y 5/4) silt loam; very pale brown (10YR 7/3) when dry; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, smooth boundary.

C2—30 to 60 inches, light yellowish-brown (2.5Y 6/4) silt loam; pale yellow (2.5Y 8/4) when dry; weak, fine, subangular blocky structure; friable; calcareous.

The A horizon is 8 to 14 inches thick and silt loam or very fine sandy loam in texture. Depth to free lime ranges from 16 to 30 inches. Pebbles and small stones are on the surface in many places.

The Rothsay soils differ from Barnes and Doland by having an entire profile formed in well-sorted silty material. They are better drained than the Hantho soils. They differ from Zell in having a B horizon.

Rothsay silt loam, 0 to 2 percent slopes (RoA).—This nearly level soil occurs throughout the county. The areas are irregularly shaped, are slightly elevated from the surrounding landscape, and in places are oriented in a southeasterly direction.

Small areas of Hantho silt loam, Doland silt loam, or Flandreau silt loam were included with this soil in mapping. Also included were some areas where lime has been leached to a depth of more than 30 inches or where the lime is closer to the surface than 16 inches. In a few places, small calcareous spots show on the surface.

All crops common to the county are grown on this soil. Soil blowing is a hazard in fields left bare during winter and spring. Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Capability unit I–1; windbreak suitability group 1.

Rothsay silt loam, 2 to 6 percent slopes (RoB).—This gently sloping soil ordinarily is irregularly shaped, but a few areas are elongated and slope toward waterways. This soil has the profile described as representative for the series.

Included with this soil in mapping were small areas of Doland silt loam that have till within 40 inches of the surface. Also, at the base of slopes and in drainageways, where soil material has washed in and accumulated, there are small areas of Darnen soils. Also included were some small areas of the Zell soils that are grayish and strongly calcareous.

All crops common in the county are grown on this soil. Soil blowing and water erosion are hazards in unprotected fields. Droughtiness is a hazard during long, dry periods.

Management that controls erosion and maintains a high content of organic matter and plant nutrients is needed. Capability unit IIe–1; windbreak suitability group 1.

Sandy Lake Beaches

Sandy lake beaches (Sa) occur on beaches of existing lakes or dried-up lakes. The surface layer is a mucky sand, sand, or loamy sand. Lake-washed sands are within a few inches of the surface. The native vegetation is reeds, sedges, and cattails. These beaches are, for the most part, nearly level. In some places, however, they are on ridges that were formed by ice pressure.

Drainage is poor and very poor. Free lime occurs throughout the profile. Inherent fertility and available water capacity are low. Soil drainage is difficult. Most of this land is used as either pasture or wildlife habitat. Capability unit VIw–1; windbreak suitability group 7.

425-738—73——4

Shakopee Series

Shakopee series consists of dark-colored, poorly drained soils that formed in calcareous water-laid silts and clays overlying calcareous outwash sand. These nearly level soils occur in the lake-plain area in the central part of the county.

In a representative profile, the surface layer is about 7 inches of calcareous, black clay over about 5 inches of strongly calcareous, dark-gray clay. The underlying material is strongly calcareous, gray, friable clay that grades to calcareous, olive-gray, friable silty clay. Below this, at a depth of 38 inches, is calcareous, grayish-brown, loose fine sand that has light olive-brown mottles.

The organic-matter content is high. The available water capacity is moderate. Permeability is very slow in the subsoil layers and rapid in the underlying sands. The natural fertility is moderate, because the high lime content causes an imbalance of plant nutrients.

These soils have a high water table that restricts root growth during the early part of the growing season.

Representative profile of Shakopee clay, having slopes of 0 to 1 percent, in a cultivated area, 400 feet south of the NE. corner of sec. 33, T. 121 N., R. 41 W.

Ap—0 to 7 inches, black (10YR 2/1) clay; moderate, fine, angular blocky structure; friable; calcareous; abrupt, smooth boundary.

A3ca—7 to 12 inches, dark-gray (2.5Y 4/1) clay; moderate, very fine, angular blocky structure; friable; strongly calcareous; clear, wavy boundary.

C1ca—12 to 17 inches, gray (5Y 5/1) clay; moderate, very fine, angular blocky structure; friable; strongly calcareous; clear, wavy boundary.

C2—17 to 38 inches, olive-gray (5Y 5/2) silty clay; few, fine, faint, olive mottles; moderate, very fine, angular blocky structure; friable; tongues of the A3ca extend to depth of 18 inches; calcareous; clear, wavy boundary.

IIC3—38 to 60 inches, grayish-brown (2.5Y 5/2) fine sand; common, medium, distinct, light olive-brown mottles that are more distinct with depth; single grained; loose; calcareous.

The A horizon is silty clay loam or clay that is calcareous to strongly calcareous. Depth to sand ranges from 24 to 40 inches but generally is around 34 inches. The underlying sand is mostly fine but is medium in some places.

The Shakopee soils are more calcareous than the Fulda silty clay, sand subsoil variant. They differ from Hegne soils by being underlain by sand. They are finer textured than the Marysland soils.

Shakopee clay (Se).—This soil is in nearly level areas or slightly depressed areas and occurs in the central part of the county, mainly along Judicial Ditch 8 in Marysland Township, and along the Chippewa River in Swenoda Township. The soil areas are broad and irregular.

Areas of this soil adjoin areas of Marysland loam, Fulda silty clay, sand subsoil variant, and Hegne clay soils. Included with this soil in mapping were small areas of Marysland loam and Fulda silty clay, sand subsoil variant. Also included were some places where the underlying sands are at a depth near 4 feet, and some where sands are less than 24 inches from the surface.

This soil is wet during spring when the water table is about 2 feet from the surface. By the middle of June, the water table drops to a depth of 4 feet and the surface soil is free of excess water.

All crops common to the county are grown on this soil. Nearly all of this soil is drained by surface ditches, which are adequate in most years. Soil blowing is a hazard in fields left bare during winter and spring. Applications of nitrogen, phosphorus, and potassium are needed. Capability unit IIw–1; windbreak suitability group 7.

Shible Series

The Shible series consists of deep, well-drained soils that formed in moderately coarse textured materials deposited by water. These soils are nearly level to gently sloping and are in the southwestern part of the county, near the city of Appleton.

In a representative profile, the surface layer is neutral, black and very dark gray fine sandy loam about 10 inches thick. The subsoil is neutral, friable fine sandy loam and sandy loam about 14 inches thick. Its upper part is very dark grayish brown, and the lower part is brown. The underlying material is brown loamy fine sand and pale-brown loamy sand in the upper part, and with depth it grades to calcareous, light brownish-gray, loose fine sand.

The organic-matter content is medium. The natural fertility is moderate because the underlying material is sand. The available water capacity is medium. Permeability is moderately rapid.

Representative profile of Shible fine sandy loam, 0 to 2 percent slopes, in a cultivated field, 230 feet south of field approach and 490 feet west, in NE¼NW¼SE¼ sec. 6, T. 120 N., R. 43 W.

Ap—0 to 6 inches, black (10YR 2/1) to very dark gray (10YR 3/1) fine sandy loam; weak, fine, angular blocky structure; friable; neutral; abrupt, smooth boundary.

A1—6 to 10 inches, very dark gray (10YR 3/1) fine sandy loam; weak, fine, angular blocky structure; friable; neutral; clear, irregular boundary.

B1—10 to 14 inches, very dark grayish-brown (10YR 3/2) fine sandy loam; weak, medium, angular blocky structure; friable; neutral; gradual, wavy boundary.

IIB2b—14 to 24 inches, brown (10YR 4/3) sandy loam; moderate, coarse, prismatic breaking to moderate, medium, angular blocky structure; friable; dark-brown coatings; pore fillings; tongues of B1 extend to depth of 22 inches; neutral; gradual, wavy boundary.

IIIC1—24 to 28 inches, brown (10YR 5/3) loamy fine sand; single grained structure; very friable; neutral; clear, smooth boundary.

IIIC2—28 to 42 inches, pale-brown (10YR 6/3) loamy sand; single grained; very friable; neutral; clear, smooth boundary.

IIIC3—42 to 54 inches, light brownish-gray (2.5Y 6/2) fine sand; single grained; loose; calcareous.

In many places a dark-colored horizon occurs above the subsoil. It suggests the possibility of a buried profile.

The A horizon ranges from 8 to 14 inches in thickness. The B1 horizon ranges from 4 to 10 inches in thickness and from loamy sand to loam in texture. In many places the lower part is loamy sand. The IIB2 horizon ranges from sandy loam to loam in texture and from 6 to 15 inches in thickness. The C horizon is a loamy fine sand to fine sand. Carbonates occur 40 to 60 inches from the surface but in places are at a depth of about 30 inches.

Shible soils are coarser textured than the Edison soils. They have a finer textured, thicker solum than the Maddock soils.

Shible fine sandy loam, 0 to 2 percent slopes (SfA).—This nearly level soil occurs northwest of Appleton and in Edison and West Bank Townships. The soil areas are generally broad and irregular in shape, or they are elongated and oriented in a northwest-southeast direction. Wind has blown soil material into drifts along fence rows in places. Some of these drifts are 4 feet high. This soil has the profile described as representative for the series.

This soil occurs close to Edison, Maddock, Clontarf, and Renshaw soils. In some places small areas of these soils were included with this soil in mapping.

Soil blowing is a hazard in fields left unprotected during winter and spring. Droughtiness is a hazard in some seasons.

All crops common to the area are grown on this soil. Management is needed that maintains a high content of organic matter and plant nutrients. Capability unit IIIs–2; windbreak suitability group 6.

Shible fine sandy loam, 2 to 6 percent slopes (SfB).—This gently sloping soil is northwest of Appleton and in Edison and West Bank Townships. The areas are generally elongated and oriented in a northwest-southeast direction. Drifts of soil material in fence rows are common. Some areas have been subject to moderate erosion, and in these places the brown subsoil is exposed.

Shible soils occur close to the Edison, Maddock, and Clontarf soils. In some places small areas of these soils were included in mapping this soil.

Soil blowing is a hazard in fields left bare during winter and spring. Water erosion is a hazard early in summer. Droughtiness is a slight hazard.

All crops common to the area are grown on this soil. Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Capability unit IIIs–2; windbreak suitability group 6.

Sioux Series

In the Sioux series are nearly level to steep, excessively drained soils that formed in loamy outwash material overlying calcareous gravel. These soils occur throughout the county.

A representative profile has a surface layer of neutral, black and very dark gray sandy loam about 8 inches thick. The underlying material is calcareous, dark grayish-brown and dark yellowish-brown loose gravel.

The organic-matter content is medium. The available water capacity is very low. Permeability is very rapid. The natural fertility is very low.

These droughty soils are good sources of gravel for road construction.

Representative profile of Sioux sandy loam, 0 to 2 percent slopes, in a field covered with stubble, 200 feet east of western boundary on field road, in NW¼NW¼NW¼ sec. 21, T. 122 N., R. 42 W.

Ap—0 to 5 inches, black (10YR 2/1) sandy loam; weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

A1—5 to 8 inches, very dark gray (10YR 3/1) sandy loam; strong, coarse, prismatic structure breaking to weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

IIC1—8 to 12 inches, dark grayish-brown (10YR 4/2) gravel; single grained; loose; calcareous; gradual, wavy boundary.

IIC2—12 to 50 inches, dark yellowish-brown (10YR 4/4) gravel; single grained; loose; calcareous.

The A horizon is 6 to 12 inches thick and sandy loam, loamy sand, or loam in texture. The C horizon is loamy sand, gravelly loamy sand, or gravel.

The Sioux soils are coarser textured than the Renshaw or Fordville soils and lack a B horizon.

Sioux sandy loam, 0 to 2 percent slopes (SsA).—This soil occurs throughout the county. It has the profile described as representative for the series. Most of it is in the outwash area along the Pomme de Terre River and the East Branch Chippewa River. Here it occurs on the higher rises or bumps and is slightly elevated from the somewhat excessively drained Renshaw soils.

Included with this soil in mapping were small areas of Renshaw loam, and some small eroded areas that are gravelly on the surface.

All of the common crops are grown on this soil. Droughtiness is a serious hazard. Early maturing crops make the best use of the limited amount of moisture available. Capability unit IVs–2; windbreak suitability group 9.

Sioux sandy loam, 2 to 6 percent slopes (SsB).—This nearly level to gently sloping soil occurs throughout the county. On the river terrace, it occurs as short breaks toward streams or drainageways, adjacent to the somewhat excessively drained Renshaw soils. In the glaciated uplands it occurs with the Barnes-Buse loams, where it occurs as small hills or knobs in the undulating topography.

This soil has lost part of its original surface layer, but its profile otherwise is similar to that described as representative for the series. The surface layer and the upper part of the underlying material have been mixed, and the soil has a brownish cast.

Included with this soil in mapping were small areas of Renshaw loam and Barnes-Buse loams and spots that are gravelly on the surface.

All of the common crops are grown on this droughty soil. Early maturing crops make the best use of the limited moisture available. Water erosion has lowered the content of organic matter and plant nutrients. Capability unit IVs–2; windbreak suitability group 9.

Sioux sandy loam, 6 to 12 percent slopes (SsC).—This sloping to rolling soil is mostly in the glacial uplands with the Barnes and Buse soils. Some small areas, however, are on the terrace breaks along streams or waterways. On these terrace breaks it is adjacent to the droughty Renshaw soils. The soil areas are irregular in the uplands and are elongated and narrow in the terrace areas.

This soil has lost part of its original surface layer. The surface layer and the upper part of the underlying material have been mixed, and the soil has a brownish cast. Except for changes resulting from loss of soil material from the surface layer, this soil has a profile like that described for the series.

Included with this soil in mapping were small areas of Renshaw loam, of Barnes-Buse loams, and of spots that are gravelly on the surface.

Grasses and small grains are best suited to this soil. Water erosion and droughtiness are serious hazards. Capability unit IVs–2; windbreak suitability group 9.

Sioux sandy loam, 12 to 25 percent slopes (SsE).—This rolling to steep soil occurs throughout the county, but it is mostly in the glacial upland where it adjoins Buse-Barnes soils.

Included with this soil in mapping were small areas of Renshaw loam, of Buse-Barnes loams, of spots that are gravelly on the surface, and of areas underlain by sand.

This soil is not suited to crops, and it is best kept under a permanent cover of grass. Water erosion is a serious hazard if the soil is farmed. When it is pastured, care should be taken to prevent overgrazing. Capability unit VIs–1; windbreak suitability group 9.

Spottswood Series

The Spottswood series consists of well-drained soils that formed in loam-textured outwash that is moderately deep over calcareous sand and gravel. These soils are nearly level and occur throughout the county.

In a representative profile, the surface layer is neutral, black and very dark brown loam about 16 inches thick. The subsoil is neutral, dark-brown, friable loam about 8 inches thick. The upper part of the underlying material is calcareous, brown, friable sandy loam. This grades to calcareous, pale-brown, loose sand and gravel.

The organic-matter content is high. The natural fertility is medium. The available water capacity is moderate. Permeability is moderate in the surface and subsoil layers and very rapid in the gravel.

These soils are moderately droughty. They are a source of sand and gravel for road construction.

Representative profile of Spottswood loam from an area of Spottswood-Fordville loams, 0 to 2 percent slopes, in a cultivated field, 1,200 feet west and 200 feet north of SE. corner of sec. 16, T. 122 N., R. 42 W.

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

A1—8 to 16 inches, very dark brown (10YR 2/2) loam; weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

B2—16 to 24 inches, dark-brown (10YR 3/3) loam; moderate, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

C1ca—24 to 30 inches, brown (10YR 5/3) sandy loam; weak, fine, subangular blocky structure; friable; calcareous; clear, smooth boundary.

IIC2—30 to 60 inches, pale-brown (10YR 6/3) sand and gravel; single grained; loose; calcareous.

The A horizon ranges from 8 to 16 inches in thickness. The B horizon is 8 to 12 inches thick. Depth to free lime ranges from 18 to 30 inches. Depth to sand and gravel ranges from 24 to 40 inches but is ordinarily at a depth near 28 inches. In many places there is an increase in the clay content in a layer just above the gravel.

The Spottswood soils have lower chroma in the B horizon than the Fordville soils. They are deeper to gravel than the Renshaw soils. They have a coarser textured C horizon than the Sverdrup soils.

Spottswood-Fordville loams, 0 to 2 percent slopes (StA).—These nearly level soils occur throughout the county but are mainly along the Pomme de Terre River and East Branch Chippewa River. In outwash areas they lie adjacent to the droughty Renshaw and Sioux soils. In the glacial moraine areas, they are near the Barnes and Sverdrup soils. The Fordville soil in this mapping unit has the profile described as representative for the Fordville series.

Included with this unit in mapping were some small areas in which the underlying gravel is less than 24 inches from the surface, areas where the gravel is more than 40 inches from the surface, and some areas that are moderately well drained. Also included were areas totaling about 1,600 acres that have a buried soil beneath the surface soil. These areas having the buried layer are north and east of the city of Appleton.

All crops common to the county are grown on these soils. Soil blowing is a problem in fields left bare during winter and spring. Droughtiness is a hazard during long dry periods.

Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Applications of nitrogen and phosphorus are needed. Capability unit IIs–1; windbreak suitability group 2.

Svea Series

The Svea series consists of deep, moderately well drained soils that formed in calcareous glacial till of loam texture. These soils are nearly level to gently sloping and are in the northwestern and eastern parts of the county.

In a representative profile, the surface layer is neutral, black and very dark brown loam about 16 inches thick. The subsoil is dark grayish-brown and light olive-brown, friable loam about 8 inches thick. The upper part is neutral, and the lower part is calcareous. The underlying material is calcareous and strongly calcareous, mottled, grayish-brown and light brownish-gray, friable loam.

The organic-matter content is high. The available water capacity is high. Permeability is moderate. Natural fertility is high.

Most areas of these soils are cultivated. They respond well to good management.

Representative profile of Svea loam, 0 to 2 percent slopes, in a cornfield, 600 feet east on fence line and 280 feet north, in SW¼SW¼SW¼ sec. 10, T. 121 N., R. 37 W.

Ap—0 to 8 inches, black (10YR 2/1) loam; very dark gray (10YR 3/1) when crushed; weak, fine, angular blocky structure; friable; neutral; abrupt, smooth boundary.

A12—8 to 13 inches, black (10YR 2/1) loam; very dark gray (10YR 3/1) when crushed; weak, very fine, angular blocky structure; friable; neutral; abrupt, smooth boundary.

A3—13 to 16 inches, very dark brown (10YR 2/2) loam; very dark grayish brown (10YR 3/2) when crushed; weak, very fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

B1—16 to 20 inches, dark grayish-brown (2.5Y 4/2) loam; very dark grayish-brown (2.5Y 3/2) coatings on peds; weak, medium, prismatic breaking to weak, fine, subangular blocky structure; friable; neutral; abrupt, smooth boundary.

B2—20 to 24 inches, light olive-brown (2.5Y 5/4) loam; dark grayish-brown (2.5Y 4/2) coatings on peds; weak, moderate, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.

C1ca—24 to 31 inches, grayish-brown (2.5Y 5/2) loam; common, fine, distinct, yellowish-brown mottles; weak, medium to fine, subangular blocky structure; friable; contains calcium and manganese concretions; horizontal fracture; strongly calcareous; clear, smooth boundary.

C2ca—31 to 46 inches, grayish-brown (2.5Y 5/2) and light olive-brown (2.5Y 5/4) loam; common, medium, prominent, yellowish-brown mottles; weak, fine, subangular blocky structure; friable; contains calcium threads and manganese concretions; horizontal fracture; calcareous; clear, smooth boundary.

C3—46 to 60 inches, light brownish-gray (2.5Y 6/2), light olive-brown (2.5Y 5/4), and yellowish-red (5YR 5/8) loam; massive; friable; calcareous.

The A horizon ranges from 10 to 18 inches in thickness, and from clay loam or silt loam to loam in texture. The B horizon is 6 to 12 inches thick and is loam or clay loam. Faint mottling occurs in the B horizon in a few places. Lime is leached to a depth of 12 to 24 inches. A layer of lime accumulation is present beneath the B horizon. Pebbles and stones are common throughout the profile. In a few areas, a continuous pebble line is present.

The Svea soils have lower chromas than the Barnes soils. They have a thinner solum than the Darnen soils. They have a loam A horizon, in contrast to the silt loam A horizon in Tara soils.

Svea loam, 0 to 2 percent slopes (SuA).—This nearly level soil occurs mainly in the eastern and northwestern parts of the county. It has the profile described as representative for the series. It is on slight rises in the nearly level till plain.

Included with this soil in mapping were small areas of poorly drained Parnell and Flom soils or well-drained Barnes soils. Many small knobs of light-colored, highly calcareous Hamerly soils also were included. In the western part of the county, this soil has a thin covering of silt on it and includes small areas of Tara soils.

This soil has few limitations and is farmed intensively. Corn and soybeans are the main crops. Soil blowing is a hazard in fields left unprotected during winter and spring. Management is needed that maintains good soil tilth and the content of organic matter and plant nutrients. Capability unit I–1; windbreak suitability group 1.

Svea loam, 2 to 4 percent slopes (SuB).—This gently sloping soil occurs mainly in the eastern part of the county. In most places the slopes are smooth, are 75 to 150 feet long, and have a gradient of 3 or 4 percent. In some places, however, the slopes are steeper. The soil areas are irregular in shape, and most of them are less than 10 acres in size.

Included with this soil in mapping were small knobs of highly calcareous Hamerly soils and small areas of Barnes soils. In the western part of the county, some areas of this soil are covered by a thin layer of silt, and many areas include some small areas of Doland soils. Also included in mapping were some moderately eroded areas, which are near the top of the slope or where Svea and Hamerly soils join this soil.

This soil is used intensively for corn and soybeans. Soil blowing is a hazard in fields left bare during winter and spring. Water erosion is a slight problem on stronger slopes. Management is needed that maintains a high content of organic matter and provides protection from erosion. Capability unit IIe–1; windbreak suitability group 1.

Svea stony loam, 0 to 2 percent slopes (SvA).—This nearly level soil occurs southwest of Appleton. It is so bouldery that it is now used mostly for hay or pasture. It is economically feasible to clear the soil of boulders. Some areas have been partly cleared and are now cultivated, but boulders are still numerous and interfere with tillage. Management is needed that maintains a high content of organic matter and plant nutrients. Bare fields are subject to soil blowing during winter and spring.

Uncleared, this soil is good for hay or pasture. Capability unit Vs–1; windbreak suitability group 10.

Svea very stony loam (0 to 2 percent slopes) (Sw).—This nearly level soil is southwest of Appleton. It is so bouldery that clearing it for crops is not economically feasible. Use is restricted to pasture and hay, and about three-fourths of the acreage can be used for hay. The boulders that protrude above the ground are spaced in such a way that use of haying equipment is ordinarily possible. When the hay meadows are used for pasture, however, the soil becomes compacted, more boulders are exposed, and the value of soil for meadow is decreased. On one-fourth of the acreage boulders are so numerous and protrude above the ground to such an extent that use of haying equipment is not practical. This soil is good for pasture. Capability unit Vs–1; windbreak suitability group 10.

Sverdrup Series

The Sverdrup series consists of somewhat excessively drained soils. These are loamy soils that are shallow over coarse and medium sand. They are nearly level to gently sloping and occur throughout the county.

In a representative profile, the surface layer is neutral, black sandy loam about 8 inches thick. The subsoil is neutral, friable sandy loam about 8 inches thick. The upper part is a dark brown; the lower part is dark grayish brown. The underlying material is calcareous, dark grayish-brown medium sand that grades to brown medium sand in which there is some coarse sand and fine gravel.

The organic-matter content is high. The available water capacity is low. Permeability is moderately rapid. The natural fertility is low.

Droughtiness and low fertility are major problems in managing these soils.

Representative profile of Sverdrup sandy loam, 2 to 6 percent slopes, 1,000 feet south and 40 feet west of NE. corner of NW¼ of sec. 31, T. 122 N., R. 37 W.

Ap—0 to 8 inches, black (10YR 2/1) sandy loam; weak, medium, angular blocky structure; friable; neutral; abrupt, smooth boundary.

B21—8 to 13 inches, dark-brown (10YR 3/3) sandy loam; weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

B22—13 to 16 inches, dark grayish-brown (10YR 4/2) sandy loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

IIC1—16 to 25 inches, dark grayish-brown (10YR 4/2) medium sand; single grained; loose; calcareous; gradual, wavy boundary.

IIC2—25 to 30 inches, brown (10YR 4/3) medium sand; some coarse sand and fine gravel; single grained; loose; calcareous; gradual, wavy boundary.

IIC3—30 to 55 inches, brown (10YR 5/3) medium sand; some coarse sand and fine gravel; single grained; loose; calcareous.

The A horizon ranges from 6 to 14 inches in thickness, from sandy loam to loam in texture, and from neutral to alkaline in reaction. The B horizon is 8 to 16 inches thick. Depth to sand is 14 to 30 inches. The sands are generally medium and coarse but in many areas they contain small stones. Free lime is at a depth ranging from 12 to 36 inches.

The Sverdrup soils have a B horizon, but Maddock soils do not. Sverdrup soils have a finer textured C horizon than the Renshaw soils. They have a coarser textured C horizon than the Barnes soils.

Sverdrup sandy loam, 0 to 2 percent slopes (SxA).—This nearly level soil occurs throughout the county, both on the upland and in outwash areas along rivers and streams. They are generally elongated and parallel the drainageways.

Included with this soil in mapping were small areas of Renshaw loam, Barnes loam, and Maddock loamy fine sand. Also included were some areas that have a strongly calcareous surface layer.

All crops common to the county are grown on this soil. Early maturing crops are best suited. Droughtiness is a serious hazard. Soil blowing is a hazard in unprotected fields.

Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Capability unit IIIs–2; windbreak suitability group 6.

Sverdrup sandy loam, 2 to 6 percent slopes (SxB).—This soil is gently sloping to undulating. It is mainly in the glacial uplands where it is surrounded by the Barnes-Buse soils. The areas are generally circular or irregular in shape and relatively small in size. This soil has the profile described as representative for the series.

Included with this soil in mapping were small areas of Renshaw loam, Barnes loam, and Maddock loamy fine sand. One-third of these areas are moderately eroded, having lost nearly two-thirds of their original surface layer. Also included were some areas where the surface layer is strongly calcareous. Most of these areas are on the brows of the hills. The slopes are ordinarily smooth and 75 to 150 feet in length. Water runoff causes an erosion hazard. Soil blowing is a hazard in unprotected fields.

All of the common crops are grown on this soil. Early maturing crops are best suited to this soil because of the hazard of drought.

Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Capability unit IIIs–2; windbreak suitability group 6.

Swenoda Series

The Swenoda series consists of deep, moderately well drained soils that formed in stratified water-laid deposits. These soils are nearly level to slightly depressional and occur mostly in the north-central and southwestern parts of the county.

In a representative profile, the surface layer is neutral, black and very dark gray sandy loam about 17 inches thick. The subsoil is neutral, dark grayish-brown, friable sandy loam about 5 inches thick. The upper part of the underlying material is neutral, dark grayish-brown, loose loamy sand. Below this, at a depth of about 34 inches, is a neutral, dark grayish-brown, friable sandy loam that has yellowish-brown mottles. This is underlain by firm, grayish-brown, olive-gray, and light olive-brown silt loam that is strongly calcareous in the upper part, but less calcareous with increase in depth. This silt loam has light brownish-gray mottles.

The organic-matter content is high. The available water capacity is moderate. Natural fertility is moderate. Permeability is moderately rapid in the upper part of the profile and moderate in the finer textured substratum.

Droughtiness and soil blowing are hazards in farming these soils.

Representative profile of Swenoda sandy loam, 0 to 2 percent slopes, in a cultivated field, 400 feet north and 500 feet west of SE. corner of SW¼ sec. 36, T. 121 N., R. 41 W.

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

A12—9 to 17 inches, very dark gray (10YR 3/1) sandy loam; weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

B2—17 to 22 inches, dark grayish-brown (2.5Y 4/2) sandy loam; weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

IIC1—22 to 31 inches, dark grayish-brown (2.5Y 4/2) loamy sand; few, fine, distinct, yellowish-brown mottles; single grained; loose; neutral; clear, smooth boundary.

IIC2—31 to 34 inches, dark grayish-brown (2.5Y 4/2) sandy sand; single grained; loose; neutral; clear, smooth boundary.

IIIC3—34 to 36 inches, dark grayish-brown (2.5Y 4/2) sandy loam; few, fine, distinct, yellowish-brown mottles; weak, fine, subangular blocky structure; friable; neutral; clear, smooth boundary.

IIIC4ca—36 to 42 inches, olive-gray (5Y 5/2) silt loam; massive; firm; strongly calcareous; gradual, smooth boundary.

IIIC5ca—42 to 50 inches, grayish-brown (2.5Y 5/2) silt loam; massive; firm; calcareous; clear, smooth boundary.

IIIC6—50 to 60 inches, light olive-brown (2.5Y 5/4) silt loam; common, medium, distinct, light brownish-gray mottles; massive; firm; calcareous.

The A horizon is 10 to 20 inches thick. Depth to the finer textured layer is 20 to 40 inches, and sand occurs in many places beneath the finer textured layer. The finer textured layer is loam, silt loam, clay loam, or sandy loam. The coarse-textured layer is loamy sand or sand and is more than 6 inches thick. Free lime is leached to a depth of 30 to 48 inches and ordinarily is in the finer textured substratum. The sands are medium and fine.

The Swenoda soils have loamy textures in the lower part of the C horizon, whereas Clontarf soils have a sandy texture throughout the C horizon. Swenoda soils are better drained than the Hamar soils.

Swenoda sandy loam, 0 to 2 percent slopes (SyA).—This nearly level soil is on the lake plain in the north-central part of the county and on wind-shifted outwash in the southwestern part of the county. The soil areas are elongated and oriented in a southeasterly direction. Wind-drifted soil material is common in fence rows.

Included with this soil in mapping were small areas of Clontarf sandy loam, Shible sandy loam, and Hecla loamy sand. In some places the lime is at a depth of less than 30 inches, and in other places it is at a depth of more than 48 inches.

All crops common to the area are grown on this soil. Soil blowing is a problem in fields left bare during winter and spring. Droughtiness is a problem during long dry periods.

Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Capability unit IIIs-3; windbreak suitability group 8.

Tara Series

The Tara series consists of deep, moderately well drained soils that formed in sorted silty material overlying calcareous glacial till of loam texture. These soils are nearly level and occur throughout the county but are mostly in Tara, Marysland, and Moyer Townships.

In a representative profile, the surface layer is neutral, black and very dark gray silt loam about 17 inches thick. The subsoil is neutral, friable silt loam about 7 inches thick. The upper part is very dark grayish brown, and with depth this grades to olive brown with dark grayish-brown mottles. The underlying material is mottled light olive-brown, friable loam. The upper part is strongly calcareous, and at a depth of about 28 inches the material is calcareous.

The organic-matter content is high. The available water capacity is high. Permeability is moderate. The natural fertility is high. Soil blowing is a hazard in fields left bare during winter and spring.

Most areas of these soils are farmed intensively.

Representative profile of Tara silt loam, 0 to 2 percent slopes, in a cultivated field, 50 feet north of field approach and 20 feet east, in SW¼NW¼SW¼ sec. 13, T. 122 N., R. 42 W.

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

A11—8 to 13 inches, black (10YR 2/1) silt loam; weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

A12—13 to 17 inches, very dark gray (10YR 3/1) silt loam; weak, fine, prismatic breaking to weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B21—17 to 20 inches, very dark grayish-brown (10YR 3/2) silt loam; weak, coarse, prismatic breaking to weak, fine, subangular blocky structure; friable; neutral; gradual, wavy boundary.

B22—20 to 24 inches, olive-brown (2.5Y 3/4) silt loam; few, fine, faint, dark grayish-brown and very dark grayish-brown mottles; weak, coarse, prismatic breaking to weak, fine, subangular blocky structure; friable; neutral; gradual, smooth boundary.

IIC1ca—24 to 28 inches, light olive-brown (2.5Y 5/4) loam; few, fine, distinct, light brownish-gray mottles; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

IIC2—28 to 60 inches, light olive-brown (2.5Y 5/4) loam; common, medium, distinct, light brownish-gray and yellowish-brown mottles; weak, fine, subangular blocky structure; friable; calcareous.

The A horizon is 14 to 20 inches thick. The thickness of the silt cap ranges from 18 to 40 inches but ordinarily is near 24 inches. Depth to free lime ranges from 14 to 30 inches, and the lime generally is at the contact with the glacial till. The texture of the underlying glacial till is loam or clay loam.

The Tara soils differ from Svea in having a silt loam solum. They have a loam C horizon, as compared to the silt loam C horizon of the Hantho soils. They have a thinner A horizon than the Darnen soils.

Tara silt loam, 0 to 2 percent slopes (TaA).—This nearly level soil occurs throughout the county but is mainly in the western part. It is on slight rises in the nearly level, silt-capped areas or in some instances is in nearly level to slightly depressional areas in the undulating moraine.

Included with this soil in mapping were some small areas of Svea and Doland soils and small areas where the silt cap is more than 40 inches thick. Also included were small spots that are limy on the surface. Where this soil occurs within the glacial moraine, the silt cap is not so well sorted and contains more sand. Included also was about 140 acres having slopes of 3 and 4 percent. On these slopes water erosion is a slight hazard.

All crops common to the county are grown on this soil. Management is needed that controls soil blowing and maintains a high content of organic matter and plant nutrients. Capability unit I-1; windbreak suitability group 1.

Torning Series

The Torning series consists of deep, excessively drained soils that formed in highly calcareous wind-shifted outwash sands. These nearly level to gently sloping soils occur throughout the county but are mainly in the southeastern part.

In a representative profile, the surface layer is calcareous, very dark grayish-brown and dark grayish-brown loamy fine sand about 12 inches thick. The underlying material is grayish-brown fine sand. The upper part is strongly calcareous, but this material becomes calcareous with depth.

The organic-matter content is medium. The available water capacity is very low. Permeability is rapid. Natural fertility is low because the high content of lime causes an imbalance of plant nutrients and a deficiency of phosphorus and potassium.

Droughtiness and low fertility are serious hazards on these soils.

Representative profile of Torning loamy fine sand, 0 to 6 percent slopes, in flax stubble, 540 feet north and 400 feet east of the SW. corner of NW¼NW¼ sec. 31, T. 120 N., R. 42 W.

Ap—0 to 8 inches, very dark grayish-brown (10YR 3/2) loamy fine sand; single grained; very friable; calcareous; abrupt, smooth boundary.

AC—8 to 12 inches, dark grayish-brown (10YR 4/2) loamy fine sand; grayish brown (10YR 5/2) when dry; single grained; loose; calcareous; smooth boundary.

C1ca—12 to 30 inches, grayish-brown (10YR 5/2) fine sand; light gray (10YR 7/2) when dry; single grained; slightly hard when dry; strongly calcareous; gradual, smooth boundary.

C2—30 to 60 inches, grayish-brown (2.5Y 5/2) fine sand; single grained; soft; calcareous.

The Ap horizon is 6 to 10 inches thick and slightly to strongly calcareous. In some places the A horizon is leached of carbonates to a depth of 6 inches. The zone of maximum lime accumulation is below the A horizon and is 12 to 24 inches thick. The underlying sands are fine.

The Torning soils are calcareous; the Maddock soils are noncalcareous. They are coarser textured than the Buse or Zell soils.

Torning loamy fine sand, 0 to 6 percent slopes (ToB).—This nearly level to gently sloping soil occurs mainly in the southwestern part of the county. The areas are generally small and circular and commonly slope toward potholes and drainageways.

Included with this soil in mapping were small areas of Maddock loamy fine sand and Shible fine sandy loam. Also included was an area southwest of Appleton in which the soils are fine and very fine sand in texture.

All crops common in the county are grown on this soil. Small grains are best at utilizing the limited moisture available. Droughtiness is a serious hazard. Soil blowing is a hazard in unprotected fields, and the high lime content causes an imbalance of plant nutrients.

Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Applications of nitrogen, phosphorus, and potassium are needed to offset the high lime content. Capability unit IVs-3; windbreak suitability group 6.

Vallers Series

The Vallers series are deep, poorly drained and somewhat poorly drained, calcareous soils that formed in calcareous glacial till of loam structure. They are nearly level. These soils are on broad flats, on rims around potholes, or on slight rises within Parnell and Flom soil areas. They occur throughout the county but are mainly in Dublin, Pillsbury, and Tara Townships.

In a representative profile, the surface layer is about 11 inches of calcareous, black silty clay loam and about 4 inches of strongly calcareous, very dark grayish-brown clay loam. The upper part of the underlying material is strongly calcareous, mottled, light brownish-gray clay loam. This grades to calcareous, olive-gray loam.

The organic-matter content is high. Available water capacity is high, and permeability is moderately slow. The natural fertility is moderate because the high content of lime causes an imbalance of plant nutrients. The Vallers soils have a high water table during the early part of the growing season that limits growth of roots.

Most areas of these soils are cropped. Wetness and nutrient imbalance are the main hazards.

Representative profile of a Vallers silty clay loam, in a nearly level plowed field, 860 feet west and 50 feet north of the SE. corner of sec. 11, T. 120 N., R. 38 W.

Ap—0 to 8 inches, black (10YR 2/1 silty clay loam; weak, fine, angular blocky structure; friable; calcareous; abrupt, smooth boundary.

A11—8 to 11 inches, very dark gray (10YR 3/1) clay loam; weak, fine, anuglar blocky structure; friable; calcareous; clear, smooth boundary.

A12ca—11 to 15 inches, very dark grayish-brown (2.5Y 3/2) clay loam; weak, fine, angular blocky structure; friable; strongly calcareous; clear, smooth boundary.

C1ca—15 to 20 inches, light brownish-gray (2.5Y 6/2) clay loam; few, fine, faint, light olive-brown mottles; weak, fine, angular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

C2—20 to 24 inches, olive, (5Y 5/3) loam; fine, distinct, gray and yellowish-brown mottles; weak, fine, angular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

C3—24 to 54 inches, olive-gray (5Y 5/2) loam; common, medium, distinct, yellowish-brown and gray mottles; massive; friable; manganese concretions are common; calcareous.

The A horizon ranges from 8 to 16 inches in thickness and from clay loam or silty clay loam to silt loam in texture. It is slightly to strongly calcareous. The underlying material is loam or clay loam and is strongly mottled.

The Vallers soils differ from Parnell, Flom, and Perella soils in having a thicker layer of lime accumulation. They formed entirely in glacial till, whereas Winger formed in lacustrine material and glacial till.

Vallers-Winger silty clay loams (Va).—These nearly level to slightly depressional soils occur throughout the glacial till areas in the southeastern part of the county. Areas of these soils are generally broad and nearly level, but in some places they are elongated and lie in narrow drainageways.

The soils of this mapping unit occur in such an intricate arrangement that it is not practical to separate them. Vallers soil makes up about 60 percent of the mapping unit, and Winger soil about 35 percent. The Winger soil generally is in lower positions than the Vallers. Small stones and pebbles are common on the surface of both.

Included with this soil in mapping were small areas of Parnell silty clay loam, Oldham silty clay loam, Perella silt loam, and Hamerly loam.

The major soils of this mapping unit need additional drainage. Most areas have been drained by surface ditches, which are adequate for most years. Tile drainage is needed, however, for complete drainage.

Corn and soybeans are grown on these soils. Sugar beets are well suited. Applications of nitrogen, phosphorus, and potassium are needed. Capability unit IIw–3; windbreak suitability group 4.

Venlo Series

The Venlo series consists of deep, very poorly drained soils that have formed in calcareous water-laid sands. These nearly level soils are in slight depressions in the lake plain in the north-central part of the county.

In a representative profile, the surface layer is neutral, black fine sandy loam about 16 inches thick. The underlying material is neutral, loose, olive-gray loamy fine sand with faint olive and yellowish-brown mottles. This material grades to a dark greenish-gray fine sand.

The organic-matter content is high. Available water capacity is low, and permeability is rapid. Natural fertility is low.

Venlo soils have a high water table, ordinarily within 2 feet of the surface, that severely limits cropping. These are wet soils, and drainage outlets are difficult to obtain. These soils provide good wildlife habitat.

Representative profile of Venlo fine sandy loam, 75 feet NW. from road in center of slough, SE¼NE¼NE¼ sec. 15, T. 121 N., R. 40 W.

A1—0 to 8 inches, black (N 2/0) highly organic fine sandy loam; weak, fine, subangular blocky structure; friable; thin, irregular channels of gray (5YR 6/1), bleached sand; neutral; abrupt, smooth boundary.

A3—8 to 16 inches, black (N 2/0) fine sandy loam; weak, fine, angular blocky structure; friable; light yellowish-brown and very dark-gray convolutions of loamy sand; neutral; gradual, irregular boundary.

C1g—16 to 23 inches, olive-gray (5Y 5/2) loamy fine sand; few, fine, faint, olive mottles; massive; loose; black and very dark gray convolutions of sandy loam; neutral; abrupt, irregular boundary.

C2g—23 to 36 inches, olive-gray (5Y 5/2) loamy fine sand with a bluish cast; few, fine, faint, olive mottles; an occasional yellowish-brown mottle; massive; loose; some very dark gray root channels; neutral; clear, irregular boundary.

C3g—36 to 48 inches, olive-gray (5Y 5/2) fine sand; common, fine, faint, olive mottles and bluish-green channels in the fine sand; single grained; loose; neutral; clear, wavy boundary.

C4g—48 to 60 inches, dark greenish-gray (5BG 4/1) fine sand; single grained; loose; neutral.

The A horizon ranges from 14 to 20 inches in thickness and from loamy fine sand to fine sandy loam in texture. The sand is generally fine, but some coarse grains are included. Depth to free lime ranges from 42 inches to more than 60 inches. Tongues and convolutions of the A horizon extend into the C horizon to a depth of 24 inches. The C3 and C4 horizons are ordinarily fine sand, but some medium and coarse sands occur.

The Venlo soils have a coarser textured A horizon than Mayer loam, depressional. They have a grayer profile than the Hamar soils.

Venlo fine sandy loam (Ve).—This nearly level soil is in shallow depressions within the lake-plain area in the north-central part of the county. Most areas are irregular in shape, but many are elongated and oriented in a southeasterly direction. This soil is flooded during the early part of the growing season.

Included with this soil in mapping were some small spots that are calcareous at the surface, and some small areas of Hamar sandy loam and of Arveson loam. Also included were about 200 acres of small areas that have a fine-textured layer in the subsoil.

This very poorly drained soil needs additional drainage if it is cropped. Most of the smaller areas have already been drained by surface ditches, which are adequate in most years. Many of the larger areas are still undrained, contain surface water during a large part of the year, and are under a marsh grass type of vegetation.

This soil has high value for wildlife; it provides nesting and mating areas for waterfowl. Capability unit IVw–2; windbreak suitability group 7.

Winger Series

The Winger series consists of deep, poorly drained and somewhat poorly drained soils that formed in calcareous water-laid silts overlying calcareous loam glacial till. These soils are nearly level and occur in the lake-plain areas of the county.

In a representative profile, the surface layer is about 10 inches of calcareous, black silty clay loam and about 6 inches of strongly calcareous, very dark gray silty clay loam. The upper part of the underlying material is strongly calcareous, dark-gray and olive-gray, friable silty clay loam. It has a few olive mottles. This grades to calcareous, firm, light olive-brown loam. Olive-yellow, yellowish-brown, and brownish-gray mottles are common.

The organic-matter content is high. The available water capacity is high. Permeability is moderately slow. The natural fertility is moderate because the high pH reduces the availability of phosphorus and potassium.

Winger soils have a high water table during the early part of the growing season. This greatly limits the root zone of plants.

Representative profile of a Winger silty clay loam, nearly level, in a cultivated field, 1,100 feet south and 60 feet west of NE. corner of sec. 18, T. 122 N., R. 41 W.

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

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

A1gca—10 to 16 inches, very dark gray (2.5Y 3/1) silty clay loam; weak, very fine, subangular blocky structure; friable; some black and grayish-brown root channels; strongly calcareous; clear, smooth boundary.

C1ca—16 to 21 inches, dark-gray (5Y 4/1) silty clay loam; few, fine, faint, olive mottles; weak, very fine, subangular blocky structure; friable; strongly calcareous; clear, smooth boundary.

C2ca—21 to 26 inches, olive-gray (5Y 5/2) silty clay loam; few, fine, faint, olive mottles; weak, very fine, subangular blocky structure; friable; strongly calcareous; clear, smooth boundary.

IIC3—26 to 37 inches, olive-gray (5Y 5/2) loam; common, coarse, prominent, olive-yellow and yellowish-brown mottles; massive; firm; calcareous; clear, smooth boundary.

IIC4—37 to 60 inches, variegated light olive-brown (2.5Y 5/4, 5/6) and light brownish-gray (2.5Y 6/2) loam; common, medium, distinct, light yellowish-brown and light brownish-gray mottles; massive; firm; iron concretions; ground water at depth of 48 inches; calcareous.

The A horizon is 10 to 18 inches thick, is silt loam or silty clay loam in texture, and is calcareous to strongly calcareous. Depth to the glacial till is 18 to 40 inches.

Winger soils have formed in lacustrine material and glacial till, in contrast to Vallers soils, which formed entirely in glacial till. They have a loam texture in the lower part of the C horizon, but Colvin soils are silty clay throughout the C horizon.

Winger silty clay loam (Ws).—This is a nearly level to slightly depressional soil on the lake plain. Its areas generally are broad, but they are elongated in some places near drainageways.

Included with this soil in mapping were small areas of McIntosh silt loam, Vallers silty clay loam, Perella silty clay loam, depressional, and Colvin silty clay loam. Small stones and pebbles occur on the surface in many places.

This poorly drained soil is in need of additional drainage. Most areas have been drained by surface ditches. These are adequate in most years, but tile systems are needed for complete drainage.

This soil is used intensively for corn and soybeans and is well suited to sugar beets. Applications of nitrogen, phosphorus, and potassium are needed. Soil blowing is a hazard in fields left bare during winter and spring. Capability unit IIw–3; windbreak suitability group 4.

Zell Series

The Zell series consists of deep, somewhat excessively drained soils that formed in well-sorted, calcareous silt. These soils occur throughout the county but are mainly east of Appleton and in Kerkhoven Township.

In a representative profile, the surface layer is calcareous, black silt loam about 10 inches thick. The underlying material is calcareous, friable silt loam that is brown in the upper part but grades to yellowish brown with depth.

The organic-matter content is medium. The natural fertility is moderate because the high content of lime in the soil causes an imbalance of plant nutrients.

Water erosion and fertility imbalance are serious limitations of these soils.

Representative profile of Zell silt loam from an area of Zell-Rothsay silt loams, 2 to 6 percent slopes, in a cultivated field, 900 feet east and 200 feet north of SW. corner of sec. 29, T. 120 N., R. 41 W.

Ap—0 to 6 inches, black (10YR 2/1) silt loam; weak, fine, subangular blocky structure; friable; calcareous; abrupt, smooth boundary.

A1—6 to 10 inches, black (10YR 2/1) silt loam; moderate, medium, angular blocky structure; friable; calcareous; clear, wavy boundary.

C1ca—10 to 18 inches, brown (10YR 5/3) silt loam; weak, fine, subangular blocky structure; friable; strongly calcareous; gradual, wavy boundary.

C2—18 to 60 inches, yellowish-brown (10YR 5/8) silt loam; weak, fine, subangular blocky structure; friable; calcareous.

The A horizon is 6 to 12 inches thick and calcareous to strongly calcareous. The zone of maximum lime accumulation is just beneath the A horizon. The profile is calcareous throughout.

Zell differs from Buse in having a stone-free profile and from Rothsay soils by being calcareous throughout the profile.

Zell-Rothsay silt loams, 2 to 6 percent slopes (ZrB).—In this mapping unit, Zell and Rothsay soils occur in such an intricate pattern that their separation on the soil map is not practical. The Zell soil is ordinarily surrounded by the Rothsay soil. The Zell soil occupies about 80 percent of the acreage, and Rothsay soil, most of the rest. Areas of this unit are irregular in shape and ordinarily are on slopes toward drainageways or potholes.

The Zell soil has the profile described as representative for the Zell series. The Rothsay soil has a profile similar to that described for the Rothsay series. In Kerkhoven Township, some areas were included in mapping that are underlain by very fine sand. Erosion is quite variable on this mapping unit. The lower parts of a slope can have a thick, dark surface layer, but the upper parts, a thin, grayish surface layer. Included were some areas having slope of more than 6 percent.

The soils of this mapping unit occur in small areas and are generally farmed with the surrounding soils. All the common crops are grown. Soil blowing is a problem in bare fields during winter and spring. Application of nitrogen, phosphorus, and potassium are needed to offset the high content of lime.

Management is needed that controls erosion and maintains a high content of organic matter and plant nutrients. Both soils in capability unit IIe–2; Zell part in windbreak suitability group 5, and Rothsay part in windbreak suitability group 1.

Zell-Rothsay silt loams, 6 to 12 percent slopes (ZrC).—In this mapping unit Rothsay and Zell soils are in such a complex pattern that it is not practical to show them separately on the soil map. The Zell soil makes up about 80 percent of the acreage, and the Rothsay soil, most of the rest. This mapping unit is mainly in Kerkhoven and Edison Townships. Ordinarily, the areas are irregular, are small, and slope toward drainageways or potholes. Slopes are uniform and 150 to 250 feet long. The profiles of these soils are similar to those described for the respective series.

In Kerkhoven Township, areas containing a large amount of very fine sand were included in mapping, and also some small areas of Torning loamy fine sand. Also included were some areas that have slopes of more than 12 percent.

Erosion is variable. The lower parts of slopes have a thick, black surface layer, but the upper parts have a thin, grayish surface layer. Some small spots on the crests of hills have lost all of the original surface soil. These areas are brown at the surface.

All crops common in the county are grown on the soils of this mapping unit. Water erosion is a serious hazard. Nitrogen, phosphorus, and potassium fertilizer are needed to offset the high content of lime. Both soils in capability unit IIIe–1; Zell part in windbreak suitability group 5, and Rothsay part in windbreak suitability group 1.

Use and Management of the Soils

This section discusses management of soils for production of crops and pasture, field and farmstead windbreaks, wildlife and recreation areas, and various kinds of engineering work.

Use of the Soils for Crops and Pasture

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. Production can be increased from medium to high by use of good management.

Most of the farmland in the county is used for production of corn, soybeans, oats, wheat, barley, and alfalfa. The soils range in productivity from marginal to high.

The sloping soils in the county are subject to water erosion. Use of terraces, contour farming, minimum tillage, and stripcropping reduces runoff and helps to control erosion. Return of crop residue increases the infiltration rate, which increases the amount of water available for plant growth.

Soil blowing occurs throughout the county but is most severe on the sandy soils in its north-central and southwestern parts. Use of wind stripcropping, crop residue management, minimum tillage, stubble mulching, and field shelterbelts helps to control soil blowing. Most soil blowing occurs where fields are left unprotected in winter and spring; therefore, fields plowed in fall should be left rough so that crop residue is exposed and the soil is protected. Fall plowing is more suitable than spring plowing on the poorly drained soils because they are difficult to work when they are wet in spring.

Artificial drainage is needed if the wet, nearly level or depressional areas are farmed. Open ditches are commonly used to remove surface water from low areas and closed depressions and to provide outlets for tile drainage systems. Tile drainage systems can be installed in most of the soils.

Crops grown on most of the soils in the county respond to the application of fertilizer. The soils are especially low in content of phosphorus. The need for fertilizer depends on the kind of soil, the past and present management, and the crop that is grown. Soil tests can provide part of the information that is needed to choose the best kinds and amounts of fertilizer.

About 10 percent of the acreage in Swift County is used for pasture, and Kentucky bluegrass is the main grass species growing on this acreage. Other forage species that are found in association with bluegrass include redtop, timothy, white clover, quackgrass, and various annual and perennial weeds. About 10 percent of the Kentucky bluegrass pasture has been improved by use of fertilizer and controlled grazing, and another 10 percent has been fertilized and reseeded to productive adapted species such as bromegrass, alfalfa, birdsfoot trefoil, and reed canarygrass. The grasses can be planted in pure stands, but bromegrass generally is seeded in combination with a legume.

Most pastures in Swift County are grazed too closely at times during the grazing season. This decreases the vigor and productivity of the forage and increases water loss and hazard of erosion.

The management of pastureland requires attention to the stocking rate in accordance with the amount of forage produced on different kinds of soil. The management of grazing, or grazing the various species at their proper height, is necessary with all forage species and on all soils. Other measures for the management of pasture are use of fertilizer, control of weeds and brush, clipping to encourage uniform regrowth, development of watering facilities, placing salt where it will encourage uniform grazing, and reseeding to more productive species.

Bromegrass, bluegrass, and alfalfa are well suited to the medium-textured soils such as those of the Barnes, Bearden, and Svea series. Alfalfa stands, however, thin out after a few years. To maintain high production of alfalfa-grass mixtures, it may be necessary to reseed the alfalfa periodically or to fertilize the grass after alfalfa disappears.

Reed canarygrass, Garrison creeping foxtail, meadow foxtail, and meadow fescue are suited to wet, poorly drained soils such as those of the Oldham, Parnell, and Arveson series. Where these soils are partially drained, birdsfoot trefoil is well suited.

Bromegrass or a mixture of bromegrass and alfalfa is suited to excessively drained to well drained, moderately sandy and sandy soils such as those of the Hecla, Maddock, and Swenoda series.

Capability grouping

Capability grouping shows, in a general way, the suitability of soils for most kinds of field crops. The groups are made according to the limitations of the soils when used for field crops, the risk of damage when they are used, and the way they respond to treatment. The grouping does not take into account major and generally expensive landforming that would change slope, depth, or other characteristics of the soils; does not take into consideration possible but unlikely major reclamation projects; and does not apply to rice, cranberries, horticultural crops, or other crops requiring special management.

Those familiar with the capability classification can infer from it much about the behavior of soils when used for other purposes, but this classification is not a substitute for interpretations designed to show suitability and limitations of groups of soils for forest trees or engineering.

In the capability system, all kinds of soils are grouped at three levels: the capability class, subclass, and unit. These are discussed in the following paragraphs.

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

Class I soils have few limitations that restrict their use.

Class II soils have moderate limitations that reduce the choice of plants or that require moderate conservation practices.

Class III soils have severe limitations that reduce the choice of plants, require special conservation practices, or both.

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

Class V soils are not likely to erode but have other limitations, impractical to remove, that limit their use largely to pasture, range, woodland, or wildlife.

Class VI soils have severe limitations that make them generally unsuited to cultivation and limit their use largely to pasture or range, woodland, or wildlife.

Class VII soils have very severe limitations that make them unsuited to cultivation and that restrict their use largely to pasture or range, woodland, or wildlife.

Class VIII soils and landforms have limitations that preclude their use for commercial plants and restrict their use to recreation, wildlife, or water supply, or to esthetic purposes. (None in Swift County)

Capability Subclasses are soil groups within one class; they are designated by adding a small letter, *e*, *w*, *s*, or *c*, to the class numeral, for example, IIe. The letter *e* shows that the main limitation is risk of erosion unless close-growing plant cover is maintained; *w* shows that water in or on the soil interferes with plant growth or cultivation (in some soils the wetness can be partly corrected by artificial drainage); *s* shows that the soil is limited mainly because it is shallow, droughty, or stony; and *c*, used in only some parts of the United States but not in Swift County, shows that the chief limitation is climate that is too cold or too dry.

In class I there are no subclasses, because the soils of this class have few limitations. Class V can contain, at the most, only the subclasses indicated by *w*, *s*, and *c*, because the soils in class V are subject to little or no erosion, though they have other limitations that restrict their use largely to pasture, range, woodland, wildlife, 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-3 or IIIe-1. Thus, in one symbol, the Roman numeral designates the capability class, or degree of limitation; the small letter indicates the subclass, or kind of limitation, as defined in the foregoing paragraphs; and the Arabic numeral specifically identifies the capability unit within each subclass.

In the following pages the capability units in Swift County are described, and suggestions for the use and management of the soils are given. The names of the soil series represented are mentioned in the description of each capability unit, but the listing of the series name does not necessarily indicate that all the soils of a series are in the same capability unit. To find the capability classification of any given soil, refer to the "Guide to Mapping Units."

CAPABILITY UNIT I-1

This unit consists of soils of the Barnes, Darnen, Doland, Hantho, La Prairie, Rothsay, Svea, and Tara series. These are well drained and moderately well drained soils that mainly have slopes of less than 2 percent. They range in texture from loam to silty clay loam and have a root zone that extends to a depth of more than 60 inches.

These soils are easily tilled and are readily permeable to roots, air, and water. Available water capacity is high. Organic-matter content and nutrient supplying capacity are high. Hazard of erosion is slight when the fields are not under crop cover.

These soils are well suited to crops commonly grown in the county and are farmed intensively. Corn is the main crop. These soils are also suited to grasses and trees and to the development of wildlife habitat.

The soils in this unit can be farmed intensively to row crops under a high level of management. Return of crop residue helps to maintain organic-matter content and to keep good soil tilth. These soils are often plowed in fall. When plowing is left rough, the furrows help to control soil blowing, catch snow in winter, and let the soil warm up faster in spring. Use of field windbreaks is also an effective means of catching snow and controlling soil blowing.

Crops respond to application of nitrogen and phosphorus. Special attention should be given to the phosphorus content, since the high pH of the subsoil keeps the availability of phosphorus at a low level.

CAPABILITY UNIT IIe-1

This unit consists of soils of the Barnes, Buse, Doland, Hattie, Nutley, Rothsay, and Svea series. These are well drained and moderately well drained soils having slopes of 0 to 6 percent. They range in texture from loam to clay and are more than 60 inches thick. These soils have an unrestricted root zone.

The soils in this unit are easily tilled and are readily permeable to roots, air, and water. The Hattie and Nutley soils, however, are heavy clay loam. They are slowly permeable and are more easily compacted than the other soils. All of these soils have high organic-matter content and nutrient supplying capacity. Available water capacity is high.

These soils are farmed intensively. Corn is the most common crop, but soybeans and small grains grow well. These soils are also well suited to grasses and trees and to the development of wildlife habitat.

The main limitation to farming is erosion. Erosion generally occurs late in spring when the soils are not protected from the rain. Soil blowing may occur on unprotected fields in winter and spring.

Row crops can be grown intensively on these soils under a high level of management. Return of crop residue helps to maintain organic-matter content and to keep good soil tilth. These soils are often plowed in fall. When the plowing is left rough, the furrows help to control soil blowing and catch snow in winter. Soil and water losses because of runoff are reduced by keeping good tilth in the plow layer. Minimum tillage and stubble mulching help to keep the soils permeable to water. Use of terracing and contour tillage should be considered where slopes are suitable (fig. 2).

Crops respond well to application of nitrogen and phosphorus. The supply of phosphorus is generally deficient because the high pH of the subsoil limits the amount that is available. Availability of phosphorus and potassium is generally low where the soils are light colored and calcareous.

CAPABILITY UNIT IIe-2

This unit consists of soils of the Buse, Barnes, Zell, and Rothsay series. These are somewhat excessively drained and well-drained, slightly eroded to moderately eroded soils having slopes of 2 to 6 percent. They are loam or silt loam in texture, are more than 60 inches deep, and have an unrestricted root zone.

These soils are easily tilled and are permeable to roots and air. The Buse and Zell soils have slow infiltration of water in the surface layer, because the high concentration of lime results in poor soil structure. Organic-matter content of the soils in this unit is moderate. Nutrient supplying capacity is only moderate in the Buse and Zell soils because of the high lime content of the soil, but in the Barnes and Rothsay soils it is high. Available water capacity is high.

These soils are farmed intensively, and corn, soybeans, and oats are the main crops. They are also suited to grasses, legumes, and trees, and to the development of wildlife habitat.

Erosion is the main limitation to farming. Erosion occurs mainly late in spring, when the soils are not protected from heavy spring rains. Soil blowing occurs on bare fields in winter and spring. In most places the thin surface layer has been eroded from the upper part of the slope or mixed with the subsoil through plowing, thus forming a highly calcareous plow layer.

When erosion control practices such as use of terraces or contour farming are applied, the cropping system can be more intensive. Crop production is generally lower on the eroded slopes, because the organic-matter content is lower and the lime content is high. Applying manure and fertilizer to these areas increases production. Sodded waterways are needed wherever runoff collects or as outlets for terraces or diversions.

Figure 2.—**Stripcropping on Barnes-Buse loams, 2 to 6 percent slopes, eroded.**

Return of crop residue helps to maintain the organic-matter content and to keep good tilth. These soils are often plowed in fall. When the plowing is left rough, the furrows help to control soil blowing and catch snow in winter. Use of practices such as minimum tillage and stubble mulching helps to keep the soil permeable and thus reduces loss of moisture through runoff.

Crops respond especially well to the application of nitrogen and phosphorus. Phosphorus is "tied up" by the lime in the soil and is not available to plants. The supply of phosphorus and potassium is generally low in the eroded areas.

CAPABILITY UNIT IIe-3

This unit consists of soils of the Edison, Flandreau, and Fordville series. These are well-drained, gently sloping soils having slopes of 2 to 6 percent. They range in texture from silt loam to very fine sandy loam and are underlain by sand or gravel at a depth of 24 to 40 inches.

These soils are easily tilled and are readily permeable to roots, air, and water. They have high organic-matter content, but nutrient supplying capacity is only moderate because of the limited root zone. The available water capacity is moderate.

Corn, soybeans, oats, and legumes are grown intensively on these soils. They are also suited to grasses and trees and to the development of wildlife habitat.

These soils can be farmed intensively if they are tilled across the slope. Return of crop residue helps to maintain the organic-matter content and to keep good soil tilth. If these soils are farmed up and down the slope, more years of meadow in the rotation helps control soil loss. These soils are generally plowed in fall after a small grain crop has been harvested. If the plowing is left rough, the furrows help to control erosion and catch snow in winter and spring.

Use of minimum tillage and stubble mulching helps to keep the soils permeable and to reduce runoff. Erosion can be controlled by use of terracing and contour farming where slopes are suitable. Sodded waterways are needed wherever water collects and causes washing. Soil blowing is a hazard on fields left unprotected in winter and in spring. Droughtiness occurs during prolonged dry periods.

These soils respond well to application of nitrogen and phosphorus.

CAPABILITY UNIT IIe-4

This unit consists of soils of the Bearden, Glyndon, Hamerly, and McIntosh series. These are moderately well drained, level or nearly level, slightly eroded, high-lime soils having slopes of 0 to 3 percent. They range in texture from loam to silty clay loam, are more than 60 inches deep, and have an unrestricted root zone. The Glyndon soils, however, are underlain by very fine sand at a depth of 24 to 40 inches.

The soils in this unit are easily tilled and are permeable to roots and air. The surface layer has slow infiltration because the concentration of lime results in poor soil structure. Organic-matter content is high, but the nutrient supplying capacity is only moderate because of the high lime content. Available water capacity is generally high, but in the Glyndon soils, it is moderate.

These soils are farmed intensively. Corn is the main crop, but sugar beets grow well. Soybeans, oats, wheat, barley, and flax are well suited. These soils are also suited to growing legumes, grasses, and trees, and to the development of wildlife habitat.

The main limitations to farming are the hazard of soil blowing and the degree of fertility relative to the high lime content. High pH reduces the availability of certain elements, such as phosphorus, potassium, iron, and zinc. Crops respond well to nitrogen and phosphorus.

Return of crop residue helps to maintain the organic-matter content and to keep good soil tilth. Use of practices such as minimum tillage, crop residue management, and stubble mulching helps to keep the soils permeable. Use of terracing, contour tillage, and stripcropping should be considered where the slopes are suitable.

The high lime content of these soils causes the soil granules to break down into smaller particles that are easily blown by the wind. Because soil blowing is a problem on unprotected fields in winter and spring, these soils are commonly plowed in fall and left rough. This reduces soil blowing and allows the cloddy soil to mellow from the freezing and thawing that occur in winter. Use of field windbreaks also helps to control soil blowing.

CAPABILITY UNIT IIs-1

This unit consists of soils of the Edison, Embden, Estelline, Flandreau, Spottswood, and Fordville series and of the Fulda series, sand subsoil variant. These are moderately well drained and well drained soils having slopes of 0 to 2 percent. They range in texture from silt loam to very fine sandy loam and are underlain by sand or gravel at a depth of 24 to 40 inches.

These soils are easily tilled and are readily permeable to roots, air, and water. Available water capacity is moderate. Organic-matter content is high, but nutrient supplying capacity is only moderate because of the restricted root zone. The Fulda series, sand subsoil variant, has a very slowly permeable layer above the sand subsoil.

The soils in this unit are farmed intensively. Corn is the main crop, but soybeans and small grains are well suited. These soils are also well suited to grasses, legumes, and trees, and to the development of wildlife habitat.

If a medium level of management is used, a cropping system that includes a green-manure crop every third year is adequate. If a high level of management is used, however, row cropping is practical year after year.

Droughtiness occurs during prolonged dry periods, and soil blowing may be a problem on fields left unprotected in winter and spring.

These soils can be plowed in spring, but fields that are plowed in fall after the spring grain crop has been harvested generally are left rough to help control soil blowing in winter and spring. Stubble mulching and field windbreaks can also be used to control soil blowing.

These soils hold 6 to 8 inches of available moisture, which normally is not enough for favorable crop production. Irrigation of these soils late in July and in August prevents crop losses that would result from droughtiness. Use of sodded waterways in drainageways crossing these soils prevents erosion from cutting into the coarse-textured substratum.

These soils respond well to application of nitrogen and phosphorus.

CAPABILITY UNIT IIw-1

This unit consists of soils of the Fulda, Hegne, and Shakopee series and of the Fulda series, sand subsoil variant. These are poorly drained, level or nearly level soils on the lake plain. They are silty clay and clay in texture. The soil of the Fulda series, sand subsoil variant, and the Shakopee soil are underlain by fine sand at a depth of 24 to 40 inches. The Hegne and Fulda soils consist of silty clay that is more than 60 inches deep. Thickness of the root zone in soils of this unit is determined by the depth to the water table. The water table is normally at a depth of 2 feet in spring and drops to about 5 feet in fall.

Organic-matter content is high. Nutrient supplying capacity is moderate to high. Available water capacity is moderate to high. Surface and internal drainage are slow, and water often ponds.

These soils are farmed intensively where adequately drained. Corn is the main crop, but soybeans, oats, legumes, and grasses grow well. These soils are also suited to trees and to the development of wildlife habitat.

If they are farmed under a medium level of management, which includes use of minimum tillage, proper fertilization, and the return of all crop residue, a cropping system that includes a green-manure crop every 4 years is adequate. Under a high level of management, row crops can be grown year after year.

The main limitation to farming is wetness. Most of these soils are drained by surface ditches, which remove the surface water rapidly and make continuous cropping practical. Partial crop failure, however, can be expected about 20 percent of the time. Use of tile drainage, which is well suited to the Hegne and Fulda soils, lowers the water table and provides an adequate root zone. The installation of tile in the soil of the Fulda series, sand subsoil variant, and in the Shakopee soil is difficult because the sandy substratum can plug tile lines.

These soils become compacted if they are tilled when they are wet. Use of minimum tillage and proper timing of field operations are important if compaction is to be avoided. Growing of a green-manure crop or an occasional deep-rooted legume helps to keep good tilth and to maintain subsoil permeability.

These soils are generally plowed in fall, which eliminates working the fields when they are too wet in spring. Leaving the plowing rough, so that crop residue is exposed, helps to control soil blowing and to catch snow. This also allows the cloddy, compacted soil to mellow from the freezing and thawing that occur in winter. Use of stubble mulching and field windbreaks helps to control soil blowing.

Droughtiness in dry periods is sometimes a hazard on the soil of the Fulda series, sand subsoil variant, and the Shakopee soil. Soil blowing of fields left bare is a severe hazard on these soils in winter and spring.

Crops respond well to application of nitrogen and phosphorus. The Hegne and Shakopee soils require special attention because they have a high lime content and a low phosphorus and potassium content.

CAPABILITY UNIT IIw-2

This unit consists of soils of the Parnell, Flom, and Perella series. These are poorly drained, slightly depressional to very gently sloping soils. They range in texture from silt loam to silty clay loam and are more than 60 inches deep. Thickness of the root zone is determined by the depth to the water table.

Organic-matter content and nutrient supplying capacity are high. Available water capacity is high, and permeability is moderately slow to moderate. Both surface and internal drainage are restricted.

These soils are farmed intensively. Corn is the main crop, but sugar beets, soybeans, small grains, and legumes are well suited. These soils are also suited to the planting of trees and the development of wildlife habitat.

Wetness is the main limitation to farming. The water table is often within 3 feet of the surface in spring. Sometimes the water is ponded on these soils for several days because of the moderately slow permeability. If these soils are tilled when wet, they become compacted and less permeable to roots and moisture.

Most of these soils are drained by open ditches. These remove the surface water early in the season, but there is still about 20 percent probability of partial crop failure. Tile drainage is needed to provide adequate internal drainage, which would lower the water table and provide an optimum root zone for plants. Water from the surrounding sloping land often collects and runs across these soils in drainageways. These drainageways can be shaped and sodded to prevent gullies from forming.

If these soils are adequately drained and fertilized, and all crop residue is returned, row crops can be grown year after year. Growing a green-manure crop, or occasionally a deep-rooted legume, helps to maintain good tilth and permeability in the subsoil. Minimum tillage and proper timing of field operations help to prevent soil compaction.

These soils generally are plowed in fall. This eliminates the need to work the fields in spring when they are too wet and allows the cloddy soils to mellow from freezing and thawing in winter. Soil blowing is a hazard on fields left unprotected in winter and spring. Leaving the plowing rough, so that the maximum amount of crop residue is exposed, helps to control soil blowing.

These soils are slow to warm up in spring. At that time plant nutrients are not always available to young plants, so it is important that starter fertilizer be applied. Crops respond well to application of nitrogen and phosphorus.

CAPABILITY UNIT IIw-3

This unit consists of soils of the Colvin, Lamoure, Rauville, Rockwell, Vallers, and Winger series. These are poorly drained and very poorly drained, calcareous, level soils. They are loam, silt loam, or silty clay loam in texture and are more than 60 inches deep. The Rockwell soil, however, has a layer of sand in the profile. For soils in this capability unit, the thickness of the root zone is limited by the depth to the water table. In spring the water table is within 2 feet of the surface.

Organic-matter content is high, but the nutrient supplying capacity is only moderate because of the high lime content of the soils. Available water capacity is generally high, but the Rockwell soil has only moderate available water capacity. Both surface and internal drainage are slow for all the soils.

These soils are farmed intensively where adequately drained. Corn is the main crop, but sugar beets, soybeans, small grains, and legumes are well suited. These soils are also well suited to grasses and trees and to the development of wildlife habitat.

Wetness is the main limitation to farming. Often in spring or after heavy rainfall, water is ponded on the surface for a few days because of the restricted permeability of the soils. If these soils are tilled when wet, the soil becomes compacted and less permeable to roots, water, and air.

Most of the soils are drained by open ditches (fig. 3). These remove the surface water early and permit cropping, but probability of partial crop failure is about 20 percent. Tile drainage is needed to lower the water table and provide an adequate root zone. Drainageways should be sodded where there is a hazard of gullying.

These soils generally are plowed in fall because they are too wet in spring. This allows the cloddy soil to mellow from the freezing and thawing that take place in winter. Soil blowing is reduced if the plowing is left rough and much crop residue is left on the surface. Soil blowing is also reduced by use of stubble mulching and field windbreaks.

Under a high level of management, which includes use of fertilizer, return of crop residue, and minimum tillage, row crops can be grown year after year. Use of minimum tillage and the proper timing of field operations help to prevent soil compaction. An occasional green-manure crop or a deep-rooted legume helps to keep good soil tilth and to keep the subsoil permeable.

These soils have a high lime content, and special attention should be given to the availability levels of phosphorus and potassium. Phosphorus is commonly "tied up" by lime and is not available to plants. Potassium is not readily available to plant roots because of the high pH of the soils.

CAPABILITY UNIT IIw-4

This unit consists of soils of the Borup, Marysland, and Mayer series. These are poorly drained, level to slightly depressional soils that formed in highly calcareous loam or silt loam underlain by sand or gravel at a depth of 24 to 40 inches. Thickness of the root zone is determined by depth to the water table. In spring the water table is often within 2 feet of the surface.

Organic-matter content is high, but nutrient supplying capacity is only moderate because the root zone is limited. Available water capacity is moderate.

These soils are farmed intensively where adequately drained. Corn is the most common crop, but soybeans, oats, and grass are also grown.

Wetness is the main limitation to farming. If these soils are tilled when wet, they become compacted and impermeable to water. They are generally plowed in fall instead of in spring, when they are too wet. This also allows the cloddy soil to mellow from freezing and thawing in winter. If the fall-plowed field is left rough, so that crop residue is exposed, soil blowing is reduced. Soil blowing is a problem on fields left unprotected in

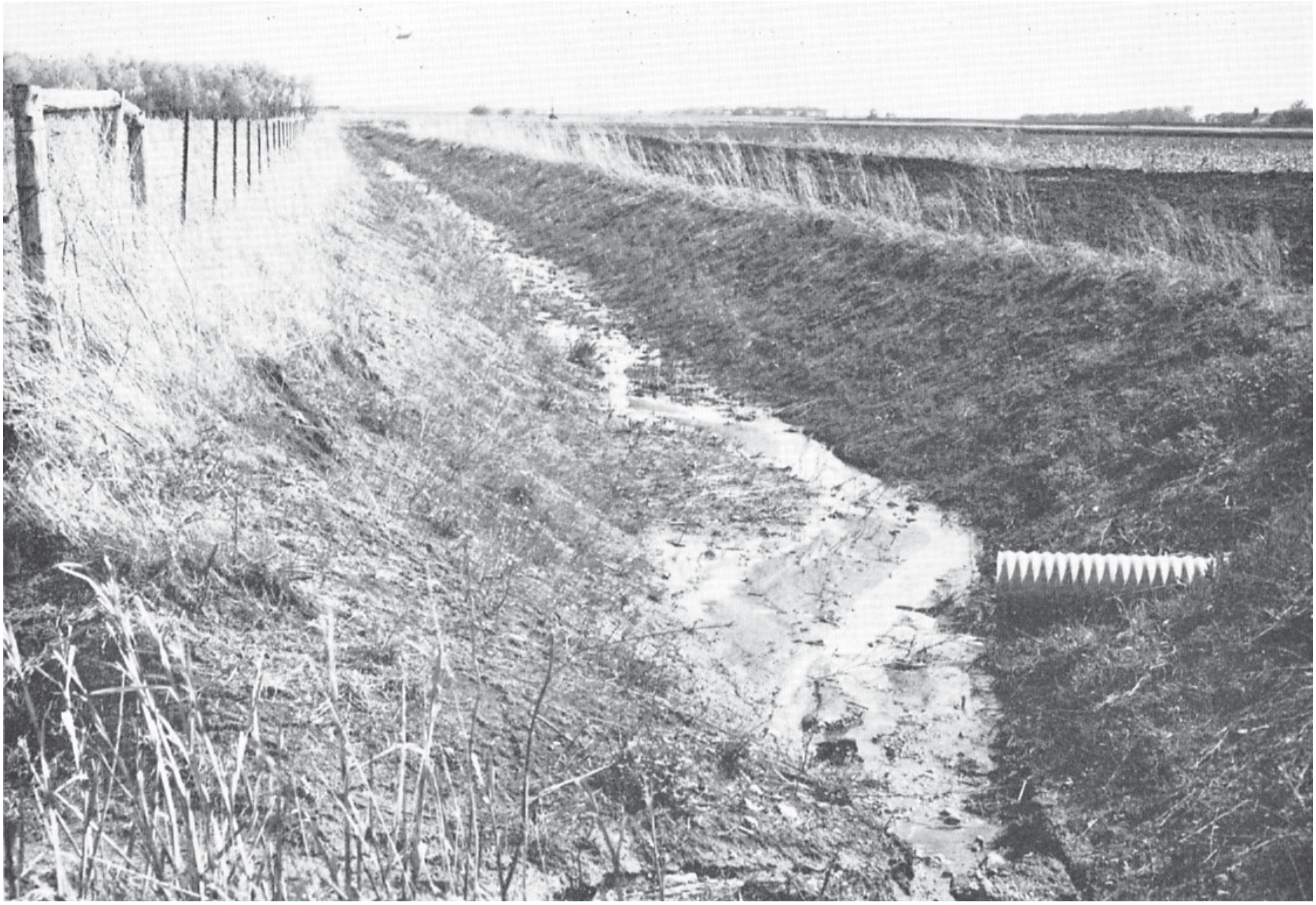

Figure 3.—**Open-ditch drainage on Colvin silty clay loam.**

winter and spring. Use of stubble mulching and field windbreaks also helps to control soil blowing.

Under a medium level of management that includes minimum tillage, return of crop residue, and application of adequate fertilizer, a cropping system that includes a green-manure crop every 4 years is adequate. Under a high level of management, these soils can be farmed to row crops year after year. Return of crop residue helps to keep good soil tilth. Use of minimum tillage and the proper timing of field operations help to prevent soil compaction.

Most areas of these soils have been drained by surface ditches. Use of tile drainage is difficult because the substratum is coarse textured. Sloughing and caving in are constant hazards when installing tile, and sand may flow into tile lines. Where runoff from surrounding slopes collects and runs across these soils, waterways should be shaped and sodded to prevent the water from cutting into the substratum.

Crops respond well to application of nitrogen and phosphorus. Special attention should be given to the amount of phosphorus applied, since the high pH of these soils keeps the amount of available phosphorus low. The Marysland and Borup soils have a particularly high lime content just below the surface layer.

CAPABILITY UNIT IIIe-1

This unit consists of soils of the Barnes, Buse, Hattie, Zell, and Rothsay series. These are rolling, somewhat excessively drained and moderately well drained, slightly eroded to moderately eroded soils having slopes of 6 to 12 percent. They range in texture from loam to clay, are more than 60 inches deep, and have an unrestricted root zone.

These soils are easily tilled and are permeable to roots and air. Infiltration of water is slow in the surface layer because of the high concentration of lime, which results in poor soil structure. The Barnes and Rothsay soils, however, are more permeable to water than are the other soils. Organic-matter content and nutrient supplying capacity are generally moderate, but organic-matter content is lower in eroded areas on hilltops. In these areas most of the topsoil has been removed by erosion or mixed with the subsoil through plowing. Available water capacity is high.

These soils are farmed intensively, and corn, soybeans, and small grains are the main crops. They are also suited to legumes, grasses, and trees, and to the development of wildlife habitat. Cropping can be more intensive if the fields are terraced and wheel track planting is practiced. Yields are generally lower on the eroded slopes because of the lower organic-matter content and the high lime content.

Erosion is the main limitation to farming. Erosion generally occurs late in spring, when the soils are not protected from heavy rain. Soil blowing occurs on the hilltops in winter and spring. These soils are seldom fully charged with water, and because of their slope, they often dry out in July or in August. Rainwater tends to run off rather than to soak into the soils.

Under a medium level of management that includes use of stripcropping, proper fertilization, and crop residue management, a cropping system that includes meadow in the rotation helps to control erosion. Where their use is practiced, contour stripcropping and terracing (fig. 4) help to control erosion and to conserve moisture. Sodded waterways are needed wherever runoff collects or as outlets from terraces or diversions. These soils are generally plowed in fall and left rough to reduce soil blowing and to catch snow.

Crops respond especially well to application of nitrogen and phosphorus. The availability of phosphorus and potassium is generally low in the eroded areas.

CAPABILITY UNIT IIIe-2

Renshaw loam, 2 to 6 percent slopes, is the only soil in this unit. This is a somewhat excessively drained, gently sloping to undulating soil that is underlain by sand and gravel at a depth of 12 to 24 inches.

This droughty soil is easily tilled and is readily permeable to roots, air, and water. It has a high organic-matter content, but nutrient supplying capacity is low because of the limited root zone. Available water capacity is low.

This soil is farmed intensively, and corn, soybeans, and oats are the main crops. Crop growth is hindered by low fertility and low available water capacity. Early maturing crops are best suited. This soil is also suited to growing grasses, legumes, and trees, and to the development of wildlife habitat.

Droughtiness and erosion are the main limitations. A moisture deficiency occurs annually. This soil is suited to supplemental irrigation. Because of the low available water capacity, however, the irrigation interval is short, or from 3 to 6 days.

Return of all crop residue helps to maintain organic-matter content, to keep good tilth, and to assure the maximum available water capacity of this soil. Crops respond well to nitrogen and phosphorus if moisture is available.

Soil blowing is a limitation on fields left bare in winter and spring. This soil generally is plowed in spring, because fall plowing exposes the soil to the strong winds of winter and spring.

Use of stubble mulching, minimum tillage, wind stripcropping, and field windbreaks is effective in controlling soil blowing and reducing the evaporation and transpiration rates of the soil and plants. Water erosion occurs in the more sloping areas, but on slopes that are suitable, contour tillage reduces erosion.

CAPABILITY UNIT IIIs-1

Renshaw loam, 0 to 2 percent slopes, is the only soil in this unit. This is a somewhat excessively drained soil

Figure 4.—**Push-up terraces on Barnes-Buse loams, 6 to 12 percent slopes, eroded.**

that is underlain by sand and gravel at a depth of 12 to 24 inches.

This droughty soil is easily tilled and is readily permeable to roots, air, and water. Organic-matter content is moderate, but the nutrient supplying capacity is low because of the restricted root zone. Available water capacity is low.

This soil is best suited to early maturing crops because of the limited amount of available moisture. Crop production is low to moderate. The main crops are small grains, soybeans, and corn. Hay crops produce well on the first cutting, but the second cutting is often low. This soil is also suited to grasses, legumes, and trees, and to the development of wildlife habitat.

Droughtiness is the main limitation to farming. The supply of moisture is generally inadequate by midsummer. Soil blowing is a problem on fields left unprotected in winter and spring. Return of crop residue helps to maintain organic-matter content, to keep good soil tilth, and to insure the maximum available water capacity of this soil. If supplemental irrigation is used, corn production is high if adequate fertilizer is provided and the plant population is increased. The interval between applications of water, however, should be only 3 to 6 days because of the low available water capacity.

This soil generally is plowed in spring, which reduces soil blowing. The stubble and stalks also catch snow in winter, which provides additional moisture for the soil. Use of stubble mulching, minimum tillage, wind stripcropping, and field windbreaks helps to control soil blowing and to reduce the evaporation and transpiration rates of the soil and plants.

Because this soil has a porous root zone, it is important to apply the proper amount of fertilizer. Excessive fertilization can damage plants in dry years, but in wet years some fertilizer may be leached out of the root zone.

CAPABILITY UNIT IIIs–2

This unit consists of soils of the Maddock, Shible, and Sverdrup series. These are well-drained and somewhat excessively drained soils having slopes of 0 to 6 percent. Their surface layer is sandy loam or fine sandy loam underlain by sand at a depth of 14 to 20 inches.

These soils are easily tilled and are readily permeable to roots, air, and water. Organic-matter content is moderate to high, but nutrient supplying capacity is only low to moderate because of the nature of the parent material. Available water capacity is moderate to low.

These soils are farmed intensively, but crop production is low. Corn, soybeans, and small grains are the main crops. Early maturing crops make the best use of the available moisture. These soils are also suited to grasses, legumes, and trees, and to the development of wildlife habitat.

Soil blowing is a severe hazard in fields left unprotected in winter and spring. These are moderately droughty soils because of the sandy substratum, and they commonly have a low moisture content by midsummer. Returning crop residue and plowing under a green-manure crop every 3 or 4 years help to maintain the organic-matter content, to keep good tilth, and to assure the highest available water capacity of these soils.

These soils can be plowed in spring. Stubble left standing over the winter helps to control soil blowing and catches snow, which provides additional moisture for the soils. If fields are plowed in fall, soil blowing is reduced by leaving the plowing rough so that the crop residue is exposed. Soil blowing, as well as the evaporation and transpiration rates of the soil and plants, is also reduced by use of stubble mulching, minimum tillage, wind stripcropping, and field windbreaks. Erosion is a hazard where slopes are more than 4 percent. Use of contour tillage on these slopes, where practical, helps to control erosion.

Crops respond well to application of nitrogen and phosphorus.

CAPABILITY UNIT IIIs–3

This unit consists of soils of the Clontarf, Malachy, and Swenoda series and of the Malachy series, loamy subsoil variant. These are moderately well drained soils having slopes of 0 to 2 percent. They are sandy loam in texture and are underlain by sand at a depth of 16 to 24 inches. The Malachy soil is calcareous. The soil of the Malachy series, loamy subsoil variant, and the Swenoda soil have a loamy subsoil.

These soils are easily tilled and are readily permeable to roots, air, and water. Organic-matter content is high, but nutrient supplying capacity is low to moderate because of the nature of the parent material. Available water capacity of the Malachy and Clontarf soils is low; available water capacity of the soil of the Malachy series, loamy subsoil variant, and the Swenoda soil is moderate.

These soils are farmed intensively, and corn, soybeans, and small grains are the main crops. By midsummer they generally do not contain adequate moisture for plant growth, so early maturing crops make the best use of the available moisture. These soils are also suited to grass, to legumes, and to the development of wildlife habitat.

Soil blowing is a severe hazard on these soils in winter and spring if fields are left unprotected, and droughtiness is an annual problem. The soils of this unit generally are plowed in spring. Fields plowed in fall generally are left rough to prevent soil blowing in winter and spring. Disking these soils, rather than plowing, leaves a rough surface that protects against soil blowing. Use of stubble mulching, wind stripcropping, and field shelterbelts helps to control soil blowing. Return of crop residue helps to maintain organic-matter content and to keep good soil tilth.

Crops respond to application of nitrogen and phosphorus, particularly on those soils that have high lime content.

CAPABILITY UNIT IIIw–1

This unit consists of soils of the Parnell and Perella series and Muck and peat, shallow over loam. These are very poorly drained, depressional soils. They are mainly silty clay loam in texture and are more than 60 inches deep. Thickness of the root zone is determined by depth to the water table. The water table generally is near the surface.

Organic-matter content and nutrient supplying capacity are high. Available water capacity is high. Permeability is moderate to moderately slow. Both internal and surface drainage are restricted.

These soils need drainage before they are farmed. Where adequately drained, they are farmed intensively. Crop production is low to moderate, and probability of crop failure is about 20 percent. Corn is the main crop, but good production of sugar beets, soybeans, and small grains can be expected. Grasses and legumes grow well, and excellent wildlife habitat can be developed in undrained areas.

Most areas of these soils are drained by surface ditches, which remove surface water early and make cropping practical. Tile drainage is needed to provide adequate internal drainage. This lowers the water table to provide an optimum root zone for plants and allows the soil to warm up earlier in spring.

Wetness is the main limitation to tilling these soils, and water commonly ponds on them for several weeks late in spring. Open ditches are used to remove surface water and to provide outlets for the tile drains. Shallow, open ditches that drain closed depressions should be sodded where gullying is a problem.

If these soils are tilled when wet, they become compacted and less permeable to roots and moisture. Use of minimum tillage and the proper timing of field operations help to prevent soil compaction. Growing of a green-manure crop, or occasionally a deep-rooted legume, helps to keep good tilth and to maintain permeability.

These soils are plowed in fall and left rough in winter and spring to prevent soil blowing. Fall plowing makes it unnecessary to work the soils in spring, when they are too wet, and allows the cloddy soil to mellow from freezing and thawing in winter. Trees normally used for field windbreaks are not well suited to these soils, because the water table is high.

Under a medium level of management that includes proper fertilization and the return of crop residue, a cropping system such as 3 years of corn followed by a small grain and a green-manure crop is adequate. These soils can be cropped even more intensively when they are completely drained, kept in good tilth, and given a high level of management.

Crops respond well to application of nitrogen and phosphorus. Since these soils are slow to warm up in spring, and plant nutrients are not always available to young plants, it is important to use a starter fertilizer to initiate plant growth.

CAPABILITY UNIT IIIw-2

This unit consists of soils of the Colvin and Oldham series. These are strongly calcareous, very poorly drained, depressional soils. They are silty clay loam in texture and are more than 60 inches deep. Thickness of the root zone is determined by depth to the water table.

Organic-matter content is high, but nutrient supplying capacity is only moderate because of the high pH of the soils. Available water capacity is high. Permeability is moderately slow.

These soils are farmed intensively where they are adequately drained. Corn is the main crop, but sugar beets, soybeans, and small grains are also well suited. Grasses and legumes grow well, and excellent wildlife habitat can be developed in undrained areas.

Wetness is the main limitation to farming these soils. Where undrained, the water table generally is near the surface of these soils. Water commonly ponds in these undrained areas for several weeks late in spring. Open ditches are used to remove surface water and to provide outlets for tile drains. Shallow ditches that drain closed depressions should be sodded where gullying is a problem.

Where these soils are completely drained, are in good tilth, and are farmed under a high level of management, they can be planted to row crops year after year. Under a medium level of management that includes adequate drainage, proper fertilization, and the return of crop residue, a cropping system such as 3 years of corn followed by a small grain and a green-manure crop is adequate.

Most areas of these soils have been drained by surface ditches, which remove surface water and permit cropping. These soils are poorly suited to moderately well suited to crops, and probability of crop failure is 20 percent. Tile drainage is needed to provide adequate internal drainage, which lowers the water table to provide an adequate root zone and allows the soils to warm up earlier in spring.

If these soils are worked when wet, they become compacted and less permeable to roots and water. Use of minimum tillage and proper timing of field operations help to prevent soil compaction. A green-manure crop, or occasionally a deep-rooted legume, helps to keep good soil tilth and to maintain permeability.

These soils are plowed in fall and left rough in winter and spring. This controls soil blowing and eliminates the need to work the soils in spring when they are too wet. It also allows the cloddy, compacted soils to mellow from freezing and thawing in winter.

Crops respond well to application of nitrogen and phosphorus. The high lime content of these soils "ties up" the phosphorus and keeps its availability low. Potassium generally is not available because of the high pH of these soils.

CAPABILITY UNIT IIIw-3

Rockwell fine sandy loam is the only soil in this unit. This is a poorly drained, calcareous soil having slopes of 0 to 2 percent. It has a fine sandy loam surface layer and a stratified sand subsoil that is underlain by loam or silt loam. The thickness of the root zone is determined by the depth to the water table.

The organic-matter content is high, but the nutrient supplying capacity is only moderate because of the high pH of the soil. Available water capacity is moderate. This soil has slow surface and internal drainage. The water table is within 2 feet of the surface in spring but drops to about 4 feet in August.

This soil is farmed intensively. Corn, soybeans, and small grains are the main crops, but it is also suited to grasses, legumes, and trees, or to the development of wildlife habitat.

Soil blowing is a serious problem on fields left unprotected in winter and spring. This soil is often plowed in fall and left rough to reduce soil blowing and to hold the snow. Disking, rather than plowing, leaves crop residue on the surface, which reduces soil blowing. Use of stubble mulching, wind stripcropping, and field windbreaks also helps to control erosion.

Most areas of this soil have been drained by shallow open ditches. This removes surface water quickly and makes continuous cropping feasible. Partial crop failure, however, can be expected about 20 percent of the time. Tile drainage can be installed in this soil, but some precautions must be taken. The tile should be placed in the loam substratum if practical. If the tile is placed in the sand layer, it should be blinded to keep sand from plugging the tile line.

If this soil is kept under a high level of management, including use of proper fertilization, return of crop residue, and minimum tillage, row crops can be grown on it year after year. Minimum tillage and the proper timing of field operations are important to keeping good tilth.

This soil has a high lime content. Phosphorus and potassium levels are generally low. Crops respond well to application of nitrogen and phosphorus.

CAPABILITY UNIT IIIw-4

Mayer loam, depressional, is the only soil in this unit. This is a very poorly drained, calcareous, depressional soil that is underlain by sand and gravel at a depth of 24 to 40 inches. Thickness of the root zone is determined by depth to the water table.

Organic-matter content is high, but nutrient supplying capacity is only moderate because of the restricted root zone. Available water capacity is moderate. Both internal and surface drainage are slow.

This soil needs drainage before it can be farmed. Where adequately drained, it is farmed intensively. Because this soil is slow to warm up in spring, corn and soybeans are the main crops; however, small grains and grasses are also commonly grown. Alfalfa and trees are not well suited because the water table is high. Where undrained, this soil provides excellent wildlife habitat.

Most areas of this soil have been drained by open ditches, which remove the surface water quickly and permit cropping. Crops do not grow well, however, and probability of crop failure is about 20 percent. Use of tile drainage is difficult because the substratum is sandy. Tile lines, where installed, should be blinded to prevent plugging.

Under a high level of management that includes adequate drainage, proper fertilization, return of crop residue, and proper timing of field operations, this soil can be farmed to row crops year after year.

If this soil is worked when wet, it becomes compacted and less permeable to roots and water. Use of minimum tillage and the proper timing of field operations help to prevent soil compaction. This soil is too wet to plow in spring. Fall plowing should be left rough to reduce soil blowing in winter. This also allows the cloddy, compacted soil to mellow from the freezing and thawing that occur in winter.

Special attention should be given to use of phosphorus and potassium. These nutrients are not generally available, because of the high pH of this soil.

CAPABILITY UNT IIIw-5

This unit consists of soils of the Arveson, Benoit, and Hamar series. These are poorly drained soils having slopes of 0 to 2 percent. They are loam and sandy loam in texture and are underlain by sand or gravel at a depth of 14 to 24 inches.

Organic-matter content is high, but nutrient supplying capacity is low because of the nature of the parent material. Available water capacity is low. Both internal and surface drainage are slow. The water table is within 2 feet of the surface in spring but generally drops to about 4 feet in August.

These soils are farmed intensively, and corn, soybeans, and small grains are the main crops. Crop production is poor to fair, and partial crop failure can be expected every 5 or 6 years. These soils are also suited to grasses and trees and to the development of wildlife habitat.

Most areas of these soils have been drained by open ditches, which remove surface water early in the season and permit cropping year after year. Such drainage, however, does not control the height of the water table. Use of tile drainage is risky because the coarse-textured subsoil may plug the tile.

These soils are often plowed in fall and left rough in winter and spring to reduce soil blowing and to hold snow. Disking these soils, rather than plowing, leaves a rough surface that resists soil blowing. Use of stubble mulching, wind stripcropping, and field windbreaks helps to control soil blowing. If these soils are given a medium level of management that includes adequate drainage, proper fertilization, and the return of crop residue, a cropping system that includes a green-manure crop every 3 or 4 years is adequate.

Crops respond well to application of nitrogen and phosphorus. The high pH of these soils reduces the availability of potassium, iron, and zinc. The Arveson and Benoit soils have a high lime content, which causes an imbalance of plant nutrients. The high lime content causes the phosphorus to be "tied up" and therefore not available to plants.

CAPABILITY UNIT IIIw-6

This unit consists of Blue Earth silt loam; of Muck and peat; Muck and peat, calcareous; and Muck and peat, calcareous, shallow. These are mainly very poorly drained organic soils that formed in shallow lakes and in large depressions. They generally have a peat or muck surface layer 1 to 6 feet thick that is underlain by loamy soil material. The Blue Earth soil has a silt loam surface layer. These soils are generally calcareous. The thickness of the root zone is determined by the depth to the water table. Where these soils are undrained, the water table is near the surface.

Organic-matter content is high, but nutrient supplying capacity is low because of the nature of the parent material. Available water capacity is high. Both internal and surface drainage are restricted. Ponding commonly occurs for several weeks late in spring and early in summer.

These soils are farmed intensively where adequately drained. Corn and soybeans are the main crops. Early maturing field corn is occasionally grown. Late and early frosts and flooding are annual problems. Small grain grows well, but the grain often lodges and is not harvestable. Corn produces good silage, for example, but the grain often does not mature. Grasses are well suited, and these soils provide excellent pasture where they are drained. They can be developed into excellent wildlife habitat.

Wetness is the main limitation to farming these soils, and they need drainage before they can be cropped. Most areas have been drained by surface ditches. If these ditches are not deep enough or spaced closely enough, however, the water table is not adequately lowered and the soils remain cold and wet in spring, which results in poor crop growth. Where installed, tile should be placed at a depth of 48 inches, preferably in the loamy material.

Crop residue should be returned to keep good tilth. These soils are susceptible to soil blowing because they are light and fine textured. Soil blowing can be controlled by use of cover crops, rough tillage, and field windbreaks.

Calcium content is adequate, but phosphorus and potassium content is generally low. Crops respond well to application of a balanced fertilizer.

CAPABILITY UNIT IVe–1

This unit consists of Buse-Barnes loams, 12 to 18 percent slopes, eroded. These are somewhat excessively drained to well drained, moderately eroded, calcareous, hilly soils. They are more than 60 inches deep and have an unrestricted root zone.

These soils are easily tilled and are permeable to roots and air. The surface layer has slow infiltration. Organic-matter content and nutrient supplying capacity are moderate. Available water capacity is high. A high concentration of lime results in poor soil structure. These soils have a thin surface layer, most of which has been removed by erosion on the steeper slopes and on hilltops. In these areas the calcareous subsoil is exposed, and the organic-matter content and nutrient supplying capacity are low.

Most of these soils are farmed, and corn, soybeans, and small grains are the main crops. These soils are suited to grasses, to trees, and to the development of wildlife habitat. Production of corn, soybeans, and small grains is often marginal, but production of grasses and legumes is fair.

Erosion is a severe limitation to farming these soils (fig. 5). Erosion generally occurs in spring, when the soil is not protected from the rains. Droughtiness is often a problem late in July or in August, because rainfall tends to run off rather than to infiltrate into the soils, and the soils seldom reach their available water capacity. Use of stubble mulching, cropping systems, and stripcropping helps to control erosion and to conserve moisture. Use of contour tillage is difficult because the slopes are short, irregular, and steep, but its use should be considered where slopes are suitable. Row crops are not suited to farming up and down the slope. Grassed waterways are needed wherever water collects and creates a hazard of gullying.

Crops grown on these soils should respond especially well to application of nitrogen and phosphorus. Phosphorus is "tied up" by the lime in the soils and is not available to plants. The availability of phosphorus and potassium is generally low in the eroded areas.

Figure 5.—**A gully cut in Buse-Barnes loams, 12 to 18 percent slopes, eroded.**

CAPABILITY UNIT IVe–2

Renshaw loam, 6 to 12 percent slopes, eroded, is the only soil in this unit. This is a somewhat excessively drained, strongly sloping to rolling soil that is underlain by sand and gravel at a depth of 12 to 24 inches.

This droughty soil is easily tilled and is readily permeable to roots, air, and water. Organic-matter content is moderate, but nutrient supplying capacity is low because of the limited root zone. Available water capacity is low.

This soil is best suited to earlier maturing crops because of the limited amount of available moisture. Small grains, soybeans, and corn are the main crops. The first cutting of hay is good, although the second crop generally is very poor. This soil is suited to grasses and trees and to the development of wildlife habitat.

Droughtiness and erosion are the main limitations to farming this soil. This soil does not contain adequate moisture for crop growth by midsummer. Soil blowing is a problem on fields left bare early in spring.

Farming should be on the contour, if practicable, because there is a hazard of erosion. If this soil must be farmed up and down the slope, the growing of row crops is not recommended because there is a hazard of erosion. Use of terraces is not suitable on this soil, since it exposes the coarse-textured substratum.

Return of crop residue and green manure helps to maintain the organic-matter content, to keep good soil tilth, and to insure the maximum available water capacity. This soil can be plowed in spring. If plowed in fall, it is generally left rough to reduce soil blowing and erosion. Use of stubble mulching and minimum tillage also helps to control erosion and to keep good tilth. Grassed waterways should be established where water collects and runs off.

Crops respond well to application of nitrogen and phosphorus.

CAPABILITY UNIT IVs–1

Hecla loamy sand, 0 to 3 percent slopes, is the only soil in this unit. This is a moderately well drained soil that is underlain by fine sand and medium sand, which provide an unrestricted root zone.

This soil is easily tilled and is permeable to roots, air, and water. Organic-matter content is moderate, but nutrient supplying capacity is low because of the nature of the parent material. Available water capacity is low.

This soil generally is farmed. Corn, soybeans, and small grains are the main crops. Early maturing crops make the best use of the limited available water. This soil is suited to grasses, legumes, and trees, and to the development of wildlife habitat.

Droughtiness is a severe limitation to farming, and the supply of moisture is inadequate for crop growth by mid-July. Soil blowing is a severe hazard where this soil is left unprotected in winter and spring. (fig. 6)

This soil generally is plowed in spring in order to protect it from soil blowing in winter and spring. Use of stubble mulching, cropping systems, minimum tillage, wind stripcropping, and field windbreaks helps to control erosion and to conserve soil moisture. Return of crop residue and plowing under a green-manure crop every 3 or 4 years help to maintain organic-matter content and to keep good soil tilth.

Crops respond well to application of nitrogen, phosphorus, and potassium.

CAPABILITY UNIT IVs-2

This unit consists of soils of the Maddock and Sioux series. These are well-drained and excessively drained, nearly level to rolling soils having slopes of 0 to 12 percent. They are sandy loam or loamy fine sand less than 12 inches deep. The Maddock soils are underlain by fine sand, and the Sioux soils are underlain by sand and gravel.

These soils are rapidly permeable to roots, air, and water. Organic-matter content is medium, but nutrient supplying capacity is low because of the nature of the parent material. Available water capacity is very low.

These soils generally are farmed, but they are poorly suited to crops. Corn, soybeans, small grains, and legumes are the main crops. Early maturing crops grow best, because the supply of moisture is limited. These soils are better suited to grasses, to trees, or to the development of wildlife habitat than to crops.

Droughtiness and low fertility are severe limitations to farming these soils. Since they have such a thin root zone, the supply of available nutrients and moisture is depleted by late in June. Erosion is a hazard on the more strongly rolling slopes when fields are bare.

Use of stubble mulching, minimum tillage, stripcropping, and field windbreaks helps to control erosion and to conserve moisture. Return of crop residue helps to maintain organic-matter content and to keep good soil tilth.

Crops respond well to application of nitrogen, phosphorus, and potassium.

***Figure 6.*—Area of Hecla loamy sand, 0 to 3 percent slopes, that has been subject to soil blowing.**

CAPABILITY UNIT IVs-3

This unit consists of soils of the Maddock and Torning series and of the Maddock series, loamy subsoil variant. These are well-drained and excessively drained soils having slopes of 0 to 6 percent. The surface layer is loamy fine sand and loamy sand that is underlain by fine sand, which provides an unrestricted root zone. The Torning soil is strongly calcareous, and the Maddock variant has a loam substratum at a depth of 2 to 3 feet.

These soils are easily tilled and are rapidly permeable to roots, air, and water. Organic-matter content is moderate. Nutrient supplying capacity is low. Available water capacity is low, but the Maddock variant has low to moderate available water capacity.

These soils are farmed intensively. Corn, soybeans, and small grains are the main crops. Early maturing crops make the best use of the limited amount of moisture available. These soils are suited to grasses, legumes, and trees, and to the development of wildlife habitat.

Droughtiness and soil blowing are the main limitations to farming. These soils generally do not contain adequate moisture for crop growth by mid-July. Soil blowing is a severe limitation on fields left bare in winter and spring.

Return of crop residue and plowing under a green-manure crop every 3 or 4 years help to maintain the organic-matter content, to keep good soil tilth, and to insure the maximum available water capacity of these soils. Use of stubble mulching, minimum tillage, wind stripcropping, and field windbreaks helps to control soil blowing and to reduce the evaporation and transpiration rates of the soils and plants. These soils generally are left in stubble over winter to prevent soil blowing, and then they are plowed in spring.

Crops respond well to application of nitrogen, phosphorus, and potassium.

CAPABILITY UNIT IVw-1

Fossum sandy loam is the only soil in this unit. This is a poorly drained, calcareous soil that has slopes of 0 to 2 percent and is underlain by sand. The root zone is determined by the depth to the water table. In spring the water table is within 2 feet of the surface, but by late in August it drops to about 4 feet.

Organic-matter content is high, but nutrient supplying capacity is low because of the nature of the parent material. Available water capacity is low. Both internal and surface drainage are slow.

This soil generally is farmed. Corn, soybeans, small grains, and legumes are commonly grown. This soil is suited to grasses, to trees, or to the development of wildlife habitat.

Soil blowing is a severe hazard in winter and spring if fields are left bare. Droughtiness sometimes occurs late in July and in August when the water table has dropped.

Use of stubble mulching, minimum tillage, wind stripcropping, and field shelterbelts helps to control erosion. Return of crop residue and plowing under a green-manure crop every 4 or 5 years help to maintain organic-matter content and to keep good soil tilth. This soil generally is left in stubble over winter to control soil blowing and to hold snow, and then in spring it is plowed. Disking this soil rather than plowing leaves the surface rough and resistant to soil blowing.

Crops respond well to application of nitrogen, phosphorus, and potassium. The high lime content of this soil causes the phosphorus to be "tied up" and therefore not available to plants. The high pH of the soil reduces the availability of nutrients such as potassium, iron, and zinc.

CAPABILITY UNIT IVw-2

This unit consists of soils of the Hamar and Venlo series. These are poorly drained and very poorly drained, sandy soils in wet depressions on the lake plain. The surface layer consists of fine sandy loam or loamy sand that is underlain by fine sand. The thickness of the root zone is determined by the depth to the water table, which generally is within 1 foot of the surface in spring but drops to about 4 feet by late in August.

Organic-matter content is high, but nutrient supplying capacity is low because of the nature of the parent material. Available water capacity is low.

Crops and trees generally are not well suited to these soils, but corn, soybeans, oats, grasses, and legumes are grown where they are drained. The undrained Venlo soil provides excellent wildlife habitat.

Wetness is the main limitation to farming these soils. The Venlo soil is in the wetter depressions and generally is ponded in spring. In places it is ponded throughout the year. The soils in this unit need additional drainage before they can be farmed safely. Many areas are now drained by open ditches, which remove the surface water early and permit annual cropping. Tile lines, where used, are often plugged by the sandy substratum.

Return of crop residue helps to maintain organic-matter content and to keep good soil tilth. Soil blowing is a problem on unprotected fields. Disking, rather than plowing, leaves crop residue on the surface, which reduces soil blowing. Use of minimum tillage and wind stripcropping also helps to control soil blowing.

Crops respond well to application of nitrogen and phosphorus.

CAPABILITY UNIT IVw-3

This unit consists of Muck and peat, shallow over sand. This is a very poorly drained organic soil that formed in shallow lakes. It is underlain by sand at a depth of 12 to 40 inches. The thickness of the root zone is determined by the depth to the water table.

Organic-matter content is very high, but nutrient supplying capacity is low because of the nature of the parent material. Available water capacity is high.

Corn and soybeans are the main crops, because this soil is slow to warm up in spring. Small grains grow well, but often the grain lodges and is not harvestable. Production of corn for silage is good, but corn for grain seldom matures. This soil provides excellent wildlife habitat. When it is drained, it makes excellent pastureland.

Wetness is the main limitation to farming. Where undrained, the water table is near the surface. Ponding commonly occurs for several weeks late in spring and early in summer. Late and early frosts and flooding are annual hazards. This fine-textured, light soil is susceptible to soil blowing. Soil blowing is controlled by use of cover crops, rough tillage, and field windbreaks. Crop residue should be returned to keep good soil tilth.

Most areas of this soil do not have sufficient drainage to be farmed. Use of deep, open ditches removes the surface water and permits cropping. Tile drainage can be installed, but care must be taken to insure that it will function. Tile placed in the sand can become plugged. Tile placed in the peat can settle as the peat decomposes and subsides.

This soil generally contains an adequate amount of calcium but is low in content of phosphorus and potassium. Crops respond well to application of nitrogen and phosphorus. This soil generally is calcareous, but pH is variable.

CAPABILITY UNIT Vs-1

This unit consists of soils of the Svea series. These are moderately well drained, stony and very stony or bouldery soils having slopes of 0 to 2 percent. They are loam in texture, are more than 60 inches deep, and have an unrestricted root zone.

Organic-matter content is high. Nutrient supplying capacity is high. Available water capacity is high.

These soils are too stony to be cultivated. They are all in grass that provides excellent pasture and hay. When these soils are pastured, they become compacted and more stones are exposed. This greatly reduces their value for growing hay, because use of haying equipment is difficult.

The stony soil can be cleared economically for cropland, but it is not economically feasible to clear the very stony soil. If the stony soil is cleared, it can be managed much as the soils in capability unit I-1.

Grass production is increased by application of nitrogen, phosphorus, and potassium. Control of weeds and brush and use of a grazing system also increase grass production.

CAPABILITY UNIT Vw-1

This unit consists of soils of the Flom and Parnell series. These are poorly drained and very poorly drained, stony and very stony, level and depressional soils. They are silty clay loam in texture and are more than 60 inches deep. The root zone is determined by the depth to the water table. The water table is generally within 2 feet of the surface in spring. In the depressional areas, water is generally ponded for several months of the year.

Organic-matter content and nutrient supplying capacity are high. Available water capacity is high.

These soils are well suited to pasture or meadow, but when they are pastured, they tend to become compacted and more boulders are exposed. This greatly reduces the value of the land for growing hay, since it becomes more difficult to use haying equipment. Control of weeds and brush, use of rotational grazing, and application of fertilizer increase grass production. Ponded areas of these soils make excellent wildlife habitat.

These soils are too stony to be cultivated, but it is economically feasible to clear the stony soil. The very stony soil, however, cannot economically be cleared. If the stony soil is cleared, it can be managed much as the soils in capability unit IIw-2.

CAPABILITY UNIT VIe-1

This unit consists of soils of the Buse series. These are somewhat excessively drained soils having slopes of 12 to 30 percent. They are loam in texture, are more than 60 inches deep, and have an unrestricted root zone. Stones or boulders occur on the surface of these soils, and in places they are very numerous.

Organic-matter content and nutrient supplying capacity are moderate. In some severely eroded areas, the topsoil has been completely removed and the organic-matter content and nutrient supplying capacity are low. Available water capacity is high.

These soils are best suited to grass. Production of crops is very poor. Some areas are farmed, and these have been subject to severe erosion.

Care must be taken not to overgraze these soils. Late in summer the soils generally become dry and the grasses are dormant. Permanent pasture can be improved by use of weed control, by rotational and restricted grazing, and by application of fertilizer.

Erosion is a severe hazard. The slopes are so steep that most of the rainfall runs off rather than into the soil. Generally these soils become droughty by midsummer because they seldom are at their maximum available water capacity.

CAPABILITY UNIT VIe-2

This unit consists of soils of the Barnes, Buse, and Fordville series. These are well-drained to somewhat excessively drained, stony or bouldery soils having slopes of 0 to 12 percent. They are of loamy texture, are more than 60 inches deep, and have an unrestricted root zone. The Fordville soil is underlain by sand and gravel at a depth of 24 to 40 inches.

Organic-matter content is high. Nutrient supplying capacity is moderate to high. Available water capacity generally is high, but it is moderate in the Fordville soil.

These soils are too bouldery to be cultivated (fig. 7), but it is economically feasible to clear the Fordville stony loam. The very stony soils cannot economically be cleared.

These soils are well suited to pasture or meadow. When they are pastured, they tend to become compacted and more stones are exposed. This lowers the value of the land for growing hay, since it becomes more difficult to use haying equipment. Control of weeds and brush, rotational grazing, and application of fertilizer increase production. Care should be taken to prevent overgrazing in mid-summer, when the grasses become semidormant.

CAPABILITY UNIT VIe-3

This unit consists of soils of the Renshaw and Fordville series. These are well-drained to somewhat excessively drained, stony and very stony or bouldery soils having slopes of 0 to 6 percent. They are loam in texture and are underlain by sand and gravel at a depth of 12 to 24 inches in the Renshaw soils and at a depth of 24 to 36 inches in the Fordville soils.

Organic-matter content is moderate to high. Nutrient supplying capacity is low to moderate. Available water capacity is low to moderate.

These soils are all in grass and provide good pasture and hay. In some areas the large number of stones hinders the operation of haying equipment. These soils are very stony, and it is not economically feasible to

Figure 7.—**Area of Barnes-Buse very stony loams, 2 to 12 percent slopes. These soils provide good grazing. Note the number and size of the exposed boulders.**

clear them for cropland. Droughtiness is common in midsummer. Care must be taken not to overgraze these soils during dry periods. Grass production is improved by control of weeds and brush, by use of rotational and controlled grazing, and by application of fertilizer.

CAPABILITY UNIT VIs–1

Sioux sandy loam, 12 to 25 percent slopes, is the only soil in this unit. This is an excessively drained soil that is less than 12 inches deep over sand and gravel.

Organic-matter content is moderate. Nutrient supplying capacity is low. Available water capacity is very low.

This soil is best suited to grass, and it provides fair pasture both early and late in the season. Pasture can be improved by use of restricted and rotational grazing, by weed and brush control, and by application of fertilizer.

In areas where this soil is farmed, erosion has removed the topsoil and exposed the gravelly underlying material. Erosion is also a hazard where this soil is overgrazed. Care should be taken to prevent overgrazing during dry summer months. Droughtiness is a very severe hazard.

CAPABILITY UNIT VIs–2

This unit consists of the Maddock-Dune land complex. These are well-drained to excessively drained, moderately and severely eroded, sandy soils having slopes of 0 to 12 percent. They are loamy fine sand in texture and are underlain by fine sand, which provides an unrestricted root zone.

These soils are loose and are rapidly permeable to roots, air, and water. Organic-matter content is moderate, but nutrient supplying capacity is low because of the nature of the parent material. Available water capacity is very low.

These soils are so highly erodible and unproductive that they are best suited to permanent grass. Use of rotational and restricted grazing, control of weeds, and application of fertilizer assure good grass production.

Special care must be taken to prevent overgrazing during dry periods.

Droughtiness is a very severe limitation. These soils generally do not contain adequate moisture for crop growth by mid-July. Soil blowing is a constant hazard because the soil is so loose. Dunes and drifts commonly occur.

CAPABILITY UNIT VIw-1

This unit consists of Alluvial land, frequently flooded, Rauville silty clay loam, and Sandy lake beaches. These are poorly drained and very poorly drained soils and land types that occur in frequently flooded positions next to streams and lakes. The Rauville soil generally is underlain by sand at a depth of more than 40 inches. Alluvial land, frequently flooded, is variable in texture, but generally it is loamy and contains layers of sand in the profile. It commonly is dissected by stream meanders and contains some small, sandy areas. Sandy lake beaches are sandy throughout.

The soil and land types in this unit are best suited to permanent vegetation. If they are used for pasture, it is important to control weeds and brush. If they are grazed when they are too wet, they become hummocky and of less value as pasture. Areas of the land types and of the soil in this unit may be suited to crops if major improvements are made in the channels of streams passing through them.

The lower lying areas, where water is ponded most of the year, are best suited to wildlife. They may be further improved as wildlife habitat by planting trees, shrubs, or water-tolerant grasses.

This unit is flooded too frequently to be safely cultivated or is too dissected by old stream meanders to be cultivated economically. Suitable outlets for drainage are lacking because of the position of the soils in this unit relative to nearby lakes and streams. Streambank stabilization may be needed in places where bank cutting is active.

CAPABILITY UNIT VIIe-1

Buse loam, 25 to 35 percent slopes, is the only soil in this unit. This is an excessively drained, calcareous soil that is more than 60 inches deep and has an unrestricted root zone.

Organic-matter content and nutrient supplying capacity are moderate. Available water capacity is high.

This soil provides fair pasture both early and late in the season, but care should be taken to prevent overgrazing and creation of an erosion hazard. Pasture can be improved by use of restricted grazing, by control of weeds and brush, and by application of fertilizer.

This soil is so steep that it should be kept under permanent vegetation. Erosion is the main hazard, and because the slopes are so steep, most of the rain runs off; therefore, this soil never reaches its available water capacity.

Predicted yields

Table 2 gives predicted average acre yields for the principal crops grown in Swift County under two levels of management. These predictions are based on records and observations of the Soil Conservation Service, the

TABLE 2.—*Predicted average yields per acre of principal crops under two levels of management*

[In columns A are average yields obtained under a medium level of management; in columns B are average yields obtained under a high level of management. Absence of a yield figure indicates crop is not suited to the soil or ordinarily is not grown on it]

Soil	Corn		Oats		Soybeans		Wheat		Corn for silage		Sugar beets		Barley		Alfalfa		Alfalfa-brome	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Animal-unit-days* [1]	*Animal-unit-days* [1]
Alluvial land, frequently flooded																		
Arveson loam	35	50	35	50	20	25	20	30	7	10	7	12	20	35	2.0	3.0	100	150
Barnes loam, 0 to 2 percent slopes	50	75	50	70	20	30	25	35	10	15	9	13	30	45	2.5	3.5	125	175
Barnes-Buse loams, 2 to 6 percent slopes, eroded	45	65	50	70	20	30	25	35	8	12	8	12	30	45	2.2	3.2	115	175
Barnes-Buse loams, 6 to 12 percent slopes, eroded	35	50	35	55	15	25	20	30	6	10			25	40	2.0	3.0	100	125
Barnes-Buse very stony loams, 2 to 12 percent slopes																		
Bearden silty clay loam, 0 to 2 percent slopes	50	70	50	70	19	25	23	35	10	15	10	13	35	45	2.3	3.7	115	185
Benoit loam	35	55	30	45	15	20	20	25	8	12			20	25	2.0	2.5	100	125
Blue Earth silt loam	40	65	40	65	19	25	20	35	6	17	8	15	15	45	1.5	3.5	75	175
Borup silt loam	40	60	40	70	23	25	23	35	10	15	10	13	30	45	2.0	3.0	100	150
Buse loam, 18 to 25 percent slopes																		
Buse loam, 25 to 35 percent slopes																		
Buse very stony loam, 12 to 30 percent slopes																		
Buse-Barnes loams, 2 to 6 percent slopes, eroded	40	55	35	50	14	20	18	28	7	10			25	35	2.0	3.0	100	150
Buse-Barnes loams, 6 to 12 percent slopes, eroded	35	45	25	40	8	18	15	25	6	9			20	30	2.0	3.0	100	150
Buse-Barnes loams, 12 to 18 percent slopes, eroded	20	35	15	25	5	15	10	20	5	8			15	25	1.5	2.0	75	100

See footnote at end of table.

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TABLE 2.—*Predicted average yields per acre of principal crops under two levels of management*—Continued

Soil	Corn		Oats		Soybeans		Wheat		Corn for silage		Sugar beets		Barley		Alfalfa		Alfalfa-brome	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Animal-unit-days* [1]	*Animal-unit-days* [1]
Clontarf sandy loam, 0 to 2 percent slopes	40	55	40	60	20	25	20	30	7	10	----	----	20	35	1.5	2.5	75	125
Colvin silty clay loam	45	70	45	70	19	27	23	35	10	15	12	13	30	45	2.2	3.7	110	185
Colvin silty clay loam, depressional	35	65	40	65	18	25	20	35	6	17	8	15	20	45	1.5	3.5	75	175
Darnen loam, 0 to 4 percent slopes	55	75	55	75	22	32	28	43	10	15	10	15	35	50	2.5	3.7	125	185
Doland silt loam, 0 to 2 percent slopes	50	65	50	70	20	27	25	35	10	15	8	11	35	45	2.2	3.3	110	165
Doland silt loam, 2 to 6 percent slopes	45	65	45	70	20	25	25	35	8	13	----	----	30	45	2.2	3.3	110	165
Edison very fine sandy loam, 0 to 2 percent slopes	45	60	45	65	20	25	25	35	8	12	6	9	25	40	1.5	2.5	75	125
Edison very fine sandy loam, 2 to 6 percent slopes	40	60	45	65	20	25	25	35	8	12	----	----	25	40	1.5	2.5	75	125
Embden fine sandy loam	40	55	35	50	15	20	18	25	7	9	----	----	20	30	----	----	----	----
Estelline silt loam, 0 to 2 percent slopes	40	60	45	65	18	24	22	34	8	12	6	9	30	45	1.5	2.5	75	125
Flandreau silt loam, 0 to 2 percent slopes	40	60	45	65	18	23	20	30	8	12	6	9	30	45	1.5	2.5	75	125
Flandreau silt loam, 2 to 6 percent slopes	35	55	45	60	18	22	20	30	8	12	6	9	30	45	1.5	2.5	75	125
Flom-Parnell stony silty clay loams	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Flom-Parnell very stony silty clay loams	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Fordville loam, 2 to 6 percent slopes	35	55	45	65	20	25	20	30	8	12	6	9	30	45	1.5	2.5	75	125
Fordville stony loam, 0 to 2 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Fossum sandy loam	35	50	35	50	12	18	15	20	6	10	6	9	20	25	1.0	1.5	50	75
Fulda loam, sand subsoil variant, 0 to 2 percent slopes	45	55	45	60	25	30	20	35	7	10	6	10	20	35	2.0	3.0	100	150
Fulda silty clay, 0 to 2 percent slopes	45	65	50	70	20	30	24	35	10	15	12	15	35	50	2.5	3.8	125	190
Fulda silty clay, sand subsoil variant, 0 to 2 percent slopes	45	60	50	70	25	30	20	35	10	15	8	11	25	40	2.0	3.0	100	150
Glyndon silt loam, 0 to 2 percent slopes	50	65	45	60	20	25	20	35	8	12	8	12	30	45	2.0	3.0	100	150
Hamar loamy sand	35	55	25	35	10	15	15	20	5	8	----	----	15	25	1.0	2.0	50	100
Hamar sandy loam	45	60	35	50	20	25	20	30	7	10	----	----	20	35	2.0	3.0	100	150
Hamerly loam, 0 to 3 percent slopes	50	65	50	65	18	25	23	35	10	15	10	13	35	45	2.2	3.5	110	175
Hantho silt loam, 0 to 2 percent slopes	55	70	50	70	25	30	25	35	10	15	10	13	30	45	2.5	3.5	125	175
Hattie clay, 6 to 12 percent slopes, eroded	30	40	35	45	8	15	15	25	6	9	----	----	20	30	2.0	3.0	100	150
Hattie-Nutley clays, 2 to 6 percent slopes	45	60	40	60	20	25	20	30	8	12	6	10	20	30	2.5	3.5	125	175
Hecla loamy sand, 0 to 3 percent slopes	25	40	25	40	10	15	15	20	5	8	----	----	15	25	1.0	1.5	50	75
Hegne clay	40	65	40	70	20	30	20	35	10	15	10	13	25	45	2.5	4.0	125	200
Lamoure silty clay loam	45	70	50	70	25	30	25	35	10	15	10	14	35	45	2.5	3.8	135	200
Lamoure-Rauville complex	35	65	40	65	25	30	20	30	10	15	----	----	20	35	2.5	4.0	125	200
La Prairie silty clay loam	50	75	50	75	25	30	20	35	10	15	9	13	25	30	2.5	3.0	125	150
Maddock loamy fine sand, 0 to 2 percent slopes	25	35	25	40	10	15	12	20	----	----	----	----	20	30	1.0	1.5	50	75
Maddock loamy fine sand, 2 to 6 percent slopes	25	35	25	35	8	12	12	20	----	----	----	----	20	30	1.0	1.5	50	75
Maddock loamy fine sand, 6 to 12 percent slopes	20	30	20	30	6	12	12	20	----	----	----	----	15	30	1.0	1.5	50	75
Maddock loamy sand, loamy subsoil variant, 0 to 3 percent slopes	35	50	40	50	15	20	25	35	----	----	----	----	30	45	1.0	2.0	50	100
Maddock sandy loam, 0 to 4 percent slopes	30	45	40	55	10	15	20	30	7	10	----	----	20	35	1.5	2.5	75	125
Maddock-Dune land complex	15	25	15	25	5	10	10	15	----	----	----	----	15	30	1.0	1.5	50	75
Malachy sandy loam, 0 to 2 percent slopes	45	55	35	50	18	23	25	35	7	10	----	----	25	40	1.7	2.8	85	140
Malachy sandy loam, loamy subsoil variant, 0 to 2 percent slopes	45	65	35	50	20	25	20	30	9	12	----	----	20	35	2.0	3.0	100	150
Marsh	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Marysland loam	40	55	45	70	20	25	23	35	10	15	10	13	30	45	2.0	3.0	100	150
Mayer loam	50	60	55	70	25	30	25	35	10	15	10	13	25	45	2.3	3.3	115	165
Mayer loam, depressional	35	65	40	65	18	25	20	35	6	17	8	15	20	45	1.5	3.5	75	175
McIntosh silt loam, 0 to 3 percent slopes	50	70	50	70	17	26	20	35	10	15	10	14	35	45	2.3	3.8	115	190

See footnote at end of table.

TABLE 2.—*Predicted average yields per acre of principal crops under two levels of management*—Continued

Soil	Corn		Oats		Soybeans		Wheat		Corn for silage		Sugar beets		Barley		Alfalfa		Alfalfa-brome	
	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B	A	B
	Bu.	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Tons*	*Tons*	*Bu.*	*Bu.*	*Tons*	*Tons*	*Animal-unit-days* [1]	*Animal-unit-days* [1]
Muck and peat	30	75	35	70	20	30	15	30	5	18	7	15	15	45	1.0	4.0	50	200
Muck and peat, calcareous	30	70	35	70	20	30	15	30	5	18	7	15	15	45	1.0	4.0	50	200
Muck and peat, calcareous, shallow	40	65	40	65	20	25	18	30	5	18	7	15	25	45	1.5	3.5	75	185
Muck and peat, shallow over loam	40	70	40	65	20	25	18	30	5	18	7	15	25	45	1.5	3.5	75	185
Muck and peat, shallow over sand	40	65	40	65	20	25	18	30	5	18	7	15	25	45	1.5	3.5	75	185
Nutley-Hattie clays, 0 to 2 percent slopes	50	65	45	65	20	25	25	35	8	12	8	12	20	30	2.5	3.5	125	175
Oldham silty clay loam	35	65	40	65	18	25	20	35	6	17	8	15	20	45	1.5	3.5	75	175
Parnell silty clay loam	35	75	40	70	20	28	20	35	6	17	8	15	25	45	1.5	3.5	75	175
Parnell and Flom soils	45	75	40	70	20	30	20	35	10	15	9	13	25	45	2.5	4.0	125	200
Perella silt loam	50	70	50	70	20	30	25	35	10	15	9	13	35	50	2.5	4.0	125	200
Perella silty clay loam, depressional	35	65	40	65	18	25	20	35	6	17	8	15	20	45	1.5	3.5	75	175
Rauville silty clay loam	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Renshaw loam, 0 to 2 percent slopes	35	50	35	45	15	20	15	20	7	10	----	----	20	30	1.5	2.0	75	100
Renshaw loam, 2 to 6 percent slopes	30	45	30	40	15	20	15	20	5	8	----	----	20	30	1.5	2.0	75	100
Renshaw loam, 6 to 12 percent slopes, eroded	25	35	25	35	10	15	15	20	5	8	----	----	15	20	1.5	2.0	75	100
Renshaw stony loam, 0 to 6 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Renshaw and Fordville very stony loams	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Rockwell loam	40	65	40	70	20	30	20	35	10	15	10	13	25	45	2.5	4.0	125	200
Rockwell fine sandy loam	40	60	35	50	20	25	20	30	7	10	9	14	20	35	2.5	3.5	125	175
Rothsay silt loam, 0 to 2 percent slopes	50	70	50	75	20	30	25	35	10	15	8	11	30	45	2.5	3.5	125	175
Rothsay silt loam, 2 to 6 percent slopes	45	65	45	70	20	30	25	35	8	13	----	----	30	45	2.5	3.5	125	175
Sandy lake beaches	25	40	35	50	18	20	15	20	6	10	----	----	15	20	1.0	1.5	50	75
Shakopee clay	45	60	50	70	25	30	20	35	10	15	8	11	25	40	2.0	3.0	100	150
Shible fine sandy loam, 0 to 2 percent slopes	45	55	45	60	20	25	25	35	8	12	6	9	25	40	1.5	2.5	75	125
Shible fine sandy loam, 2 to 6 percent slopes	45	55	45	60	20	25	25	35	8	12	----	----	25	40	1.5	2.5	75	125
Sioux sandy loam, 0 to 2 percent slopes	25	40	20	40	12	18	15	25	5	8	----	----	15	25	1.0	1.5	50	75
Sioux sandy loam, 2 to 6 percent slopes	20	35	20	40	10	15	15	25	5	8	----	----	15	25	1.0	1.5	50	75
Sioux sandy loam, 6 to 12 percent slopes	20	30	20	35	8	15	10	20	----	----	----	----	15	20	----	----	50	75
Sioux sandy loam, 12 to 25 percent slopes	15	25	15	25	5	10	10	20	----	----	----	----	----	----	----	----	50	75
Spottswood-Fordville loams, 0 to 2 percent slopes	40	60	45	65	20	25	20	30	8	12	6	9	30	45	1.5	2.5	75	125
Svea loam, 0 to 2 percent slopes	55	70	55	70	22	30	25	40	10	15	10	13	35	50	2.5	3.7	125	185
Svea loam, 2 to 4 percent slopes	50	60	50	70	22	30	25	35	10	15	8	12	30	45	2.5	3.5	125	175
Svea stony loam, 0 to 2 percent slopes	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Svea very stony loam	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----	----
Sverdrup sandy loam, 0 to 2 percent slopes	35	50	40	55	15	20	20	30	7	10	----	----	20	35	1.5	2.5	75	125
Sverdrup sandy loam, 2 to 6 percent slopes	35	50	40	55	15	20	20	30	7	10	----	----	20	35	1.5	2.5	75	125
Swenoda sandy loam, 0 to 2 percent slopes	45	65	30	50	20	25	20	30	9	12	----	----	20	35	2.0	3.0	100	150
Tara silt loam, 0 to 2 percent slopes	55	75	55	70	23	30	25	40	10	15	10	13	35	50	2.5	3.7	125	185
Torning loamy fine sand, 0 to 6 percent slopes	25	40	25	45	10	18	20	30	----	----	----	----	20	35	1.0	2.0	50	100
Vallers-Winger silty clay loams	40	70	45	70	20	30	25	35	10	15	9	13	35	50	2.5	4.0	125	200
Venlo fine sandy loam	35	60	35	50	20	25	15	30	6	10	----	----	15	25	1.0	2.5	50	125
Winger silty clay loam	45	70	45	70	17	26	23	35	10	15	12	16	30	45	2.3	3.8	115	190
Zell-Rothsay silt loams, 2 to 6 percent slopes	45	55	35	55	15	20	20	28	7	10	----	----	20	30	2.0	3.5	125	175
Zell-Rothsay silt loams, 6 to 12 percent slopes	40	50	30	45	10	15	16	24	5	8	----	----	15	25	2.0	2.5	100	125

[1] 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 season without injury to the sod.

Extension Service, the University of Minnesota, and the U.S. Census of Agriculture. They are also based on interviews with farmers. Under a medium level of management—

1. A planned cropping system generally is used, but seeding of grass-legume and green-manure crops occasionally fail where adequate attention is not given to cultural and management techniques.
2. Surface drainage and internal drainage are improved but not enough to provide optimum conditions for plant growth on soils that have restricted drainage.
3. A moderate amount of fertilizer is used, but a more adequate soil testing and fertilization program is needed.
4. All crop residue is returned to the soil either directly or through its use as bedding or for grazing.
5. Seedbed preparation is sometimes either inadequate or excessive and may be carried out when the soil is too wet or too dry.
6. Weed competition or insect damage frequently contributes to lowered crop yields.
7. Crop varieties, seed quality, and plant population may be adequate for soil and location.
8. Erosion control generally is practiced, but additional control measures may be needed.
9. Field operations usually are timely.

Under a high level of management—

1. Surface drainage and internal drainage provide optimum conditions for plant growth on soils that have restricted drainage.
2. Phosphorus, potassium, and nitrogen are applied according to soil tests and crop needs.
3. All crop residue is returned to the soil either directly or through use as bedding or for grazing.
4. Seedbeds are prepared as follows:
   (a) Fields are plowed in fall, but furrows are left rough over winter. Green-manure crops are plowed no earlier than October 1 of the seeding year; or
   (b) Seedbed preparation is limited to that which is necessary for crop production. Tillage is avoided when the soil is wet.
5. Weeds and insects are adequately controlled by cultural and chemical methods.
6. Crop varieties, seed quality, and plant population are as recommended for the particular soil and location.
7. Soil losses that result from soil blowing and water erosion are kept within allowable limits.
8. Field operations are carried out in a timely and efficient manner.

Table 3 gives predicted average acre yields for the principal plants grown for permanent pasture in Swift County. Predicted yields are for permanent pasture grown under two levels of management—medium and high. Under a medium level of management—

1. Fertilizer is applied infrequently and at rates that are too low for optimum forage yields.
2. Grazing is delayed in spring until grasses are 4 inches high, but pastures are frequently overgrazed later in the year.
3. Drainage of wet sites is inadequate for maximum production of forage species and may cause inefficient use of forage by grazing livestock.
4. Weeds and brush are partially controlled.

Under a high level of management—

1. Fertilizer is applied according to soil test recommendations and forage crop needs.
2. Pastures are not overgrazed or rotation grazing is practiced as needed for high forage yields.
3. Weeds and brush are adequately controlled.
4. Drainage is adequate for the forage species being produced and for efficient use of the forage by livestock.

TABLE 3.—*Predicted average acre yields of permanent pasture under two levels of management*

[Soils listed are those commonly used for pasture. In columns A are average yields obtained under a medium level of management; in columns B are average yields obtained under a high level of management. Absence of a yield figure indicates crop is not suited to the soil or ordinarily is not grown on it]

Soil	Bluegrass		Reed canarygrass	
	A	B	A	B
	Animal-unit-days [1]	*Animal-unit-days* [1]	*Animal-unit-days* [1]	*Animal-unit-days* [1]
Buse loam, 18 to 25 percent slopes	40	75		
Buse-Barnes loams, 6 to 12 percent slopes, eroded	75	100		
Mayer loam, depressional			150	225
Muck and peat, calcareous			100	175
Muck and peat, calcareous, shallow			100	175
Muck and peat, shallow over loam			100	175
Muck and peat, shallow over sand			100	175
Oldham silty clay loam			150	225
Parnell silty clay loam			150	225
Perella silty clay loam, depressional			150	225
Sioux sandy loam, 6 to 12 percent slopes	25	50		
Zell-Rothsay silt loams, 6 to 12 percent slopes	60	100		

[1] 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.

Field and Farmstead Windbreaks [2]

This subsection lists trees and shrubs that can be grown for field and farmstead windbreaks. The soils in the county 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 4. A discussion of the windbreak suitability groups follows.

[2] THOR K. BERGH, woodland conservationist, Soil Conservation Service, helped to prepare this subsection.

The total forest land in Swift County is about 2.4 percent of the land area. American elm, green ash, soft maple, basswood, bur oak, sugar maple, and cottonwood are some of the trees that commonly grow. Most trees planted in the county are planted for the purpose of establishing field and farmstead windbreaks.

Field windbreaks help to control soil blowing, to bring about a more uniform distribution of snow, and to reduce the moisture loss and damage caused by hot, dry winds (fig. 8). Control of soil blowing is especially important on the coarse-textured soils.

Farmstead windbreaks help to block off the cold northerly and westerly winds in winter; to reduce damage from cyclonic winds; to protect livestock in outdoor feedlots, which saves feed cost; to reduce heating costs; to reduce snow drifting; and to protect gardens and orchards. In addition, wildlife is benefited, the value of real estate is increased, and outdoor living is made more enjoyable.

***Figure 8.*—A one-row field windbreak on Spottswood-Fordville loams, 0 to 2 percent slopes. Trees are 4-year-old Siberian elms.**

Windbreak suitability groups

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" at the back of this survey.

The trees and shrubs suitable for field and farmstead windbreaks in Swift County are listed in table 4. Groups 3, 4, and 7 include poorly drained and very poorly drained soils and are therefore rated for both the undrained and drained condition. Performance of each species on soils of the first eight groups has been rated as *preferred*, *acceptable*, or *not recommended*. The 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 the windbreak suitability groups that follow tell how these soil characteristics affect the performance of the trees and shrubs. Suggestions about the preparation of sites for planting are also given.

TABLE 4.—*Performance ratings for various species of shrubs and trees*

[Performance ratings are: 1, preferred; 2, acceptable; and 3, not recommended. Groups 9 and 10 are not shown because they are too variable or too wet to be rated]

CONIFEROUS TREES

Species of shrubs and trees	Windbreak suitability groups										
	1	2	3		4		5	6	7		8
			Undrained	Drained	Undrained	Drained			Undrained	Drained	
Pine:											
Jack	2	1	3	2	3	3	2	1	3	2	2
Red	1	1	3	2	3	3	2	1	3	2	2
Scotch	2	2	3	2	3	3	2	2	3	2	2
Western yellow	1	1	3	1	3	2	1	1	3	1	2
White	1	2	3	2	3	3	3	3	3	2	2
Redcedar, eastern	1	1	3	2	3	2	1	1	3	1	1
Spruce:											
Black Hills	1	2	3	2	3	2	2	2	3	2	2
Colorado	1	2	3	2	3	2	2	2	3	1	2
White	2	1	3	2	3	2	2	1	2	1	1
White-cedar, northern	1	1	2	1	3	2	3	2	2	1	2

TABLE 4.—*Performance ratings for various species of shrubs and trees*—Continued

DECIDUOUS TREES

Species of shrubs and trees	Windbreak suitability groups										
	1	2	3		4		5	6	7		8
			Undrained	Drained	Undrained	Drained			Undrained	Drained	
Ash, green	1	2	2	1	2	1	1	2	1	1	2
Elm:											
American	1	2	2	2	3	2	1	2	2	1	2
Siberian	1	1	2	1	2	1	1	1	1	1	1
Hackberry	2	3	3	2	3	2	2	3	2	1	3
Honeylocust	2	2	3	2	3	2	1	2	3	2	1
Maple, soft	1	2	2	1	3	2	2	3	2	1	2
Poplar:											
Norway	1	2	1	1	2	1	1	3	1	1	2
Siouxland	1	2	1	1	2	1	1	3	1	1	2
Robusta	1	2	1	1	2	1	1	3	1	1	2
Willow, white	1	2	1	1	2	1	1	3	1	1	2
SMALL SHRUBS AND TREES											
Buffaloberry	1	1	2	1	3	2	1	1	2	1	2
Caragana	1	2	2	1	3	2	2	2	2	1	1
Crabapple, Siberian	1	1	3	2	3	2	1	1	2	1	1
Honeysuckle:											
Tartarian	1	1	2	2	2	1	1	2	2	2	2
White bella	1	1	2	1	2	1	1	2	2	1	1
Maackii	1	1	2	1	3	2	1	2	2	1	2
Zabelli	1	1	2	1	2	1	1	2	2	1	2
Lilac:											
Common	1	1	2	1	2	1	1	2	3	1	2
Villosa	1	1	2	1	3	2	1	2	3	2	1
Maple, Ginnala	1	2	2	1	3	2	1	3	2	1	2
Plum, American	1	1	2	1	3	2	1	2	2	1	1
Russian-olive	1	2	2	1	2	1	1	2	1	1	1
Willow:											
Laurel	1	2	1	1	2	1	2	3	1	1	2
Purple-osier	1	2	1	1	2	1	2	3	1	1	2

The names of the soil series represented are mentioned in the description of each suitability group, but the listing of the series name does not necessarily indicate that all the soils of a series are in the same suitability group. To find the suitability group of any given soil, refer to the "Guide to Mapping Units."

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.

WINDBREAK SUITABILITY GROUP 1

This group consists of soils of the Barnes, Darnen, Doland, Hantho, Nutley, La Prairie, Rothsay, Svea, and Tara series. These are moderately well drained and well drained soils that range in texture from loam to clay and are more than 60 inches deep. They formed in glacial till.

These soils have an unrestricted root zone. Soil texture, permeability, and drainage allow moisture to penetrate deeply and promote a uniform distribution of roots. Available water capacity is high. The surface layer is neutral, and the parent material is mildly alkaline.

Most of the soils in this group are nearly level to gently sloping, and soil limitations are slight. Some are more strongly sloping, and erosion is a hazard and moisture conditions are less favorable.

WINDBREAK SUITABILITY GROUP 2

This group consists of soils of the Estelline, Flandreau, Fordville, and Spottswood series, and of the Fulda series, sand subsoil variant. These are well-drained soils that are loam or silt loam in texture and are underlain by sand or gravel at a depth of 24 to 40 inches. These level to gently sloping soils occur on uplands and on stream terraces.

The upper layers of these soils provide a root zone that favors the growth of young plants, but the coarse-textured substratum restricts the roots of older trees and shrubs. Available water capacity is moderate. Reaction is neutral in the loamy upper layers and mildly alkaline in the coarse-textured substratum.

The soils in this group have lower available water capacity than do those in windbreak group 1. Use of moisture conserving measures will provide a better root environment for plants. In sloping areas trees can be planted on the contour. Control of weeds is important, since they consume much water in growth.

WINDBREAK SUITABILITY GROUP 3

This group consists of soils of the Flom, Fulda, Parnell, and Perella series, and of the Fulda series, sand subsoil variant. These are poorly drained to very poorly drained soils that range in texture from silt loam to silty clay and are more than 60 inches deep. They are in level and depressional areas throughout the county. Where these soils occur in potholes that do not have adequate surface drainage, they should be considered with the soils in windbreak group 9.

The root zone in these soils is determined by the depth to the water table, which is within 2 feet of the surface in spring where undrained. Surface water should be removed quickly in spring and the water table lowered by drainage in order to provide a thicker root zone. The available water capacity is high. The surface layer is neutral, and the parent material is mildly alkaline.

Where drained, these soils are well suited to trees and shrubs. Competition from weeds is severe.

WINDBREAK SUITABILITY GROUP 4

This group consists of soils of the Colvin, Hegne, Lamoure, Oldham, Rockwell, Vallers, and Winger series. These are poorly drained and very poorly drained, high-lime soils that range in texture from fine sandy loam to clay and are more than 60 inches deep. These soils are in level and depressional areas throughout the county. Where they occur in potholes that do not have adequate surface drainage, they should be considered with the soils in windbreak group 9.

The root zone in these soils is determined by the depth to the water table. If undrained, the water table is within 2 feet of the surface in spring. Surface water should be removed quickly in spring and the water table lowered by drainage in order to provide a thicker root zone.

Available water capacity is high. Reaction is moderately alkaline. These soils have a strongly calcareous surface layer that affects the growth of trees and shrubs by "tying up" plant nutrients. Young plants are often yellowish in color and grow slowly until their roots have penetrated the strongly calcareous layer, after which they have good color and grow well.

WINDBREAK SUITABILITY GROUP 5

This group consists of soils of the Bearden, Buse, Hamerly, Hattie, McIntosh, and Zell series. These are level to steep, moderately well drained to excessively drained, high-lime soils. They range in texture from loam to clay and are more than 60 inches deep.

Available water capacity is high. Reaction is mildly alkaline to moderately alkaline. These soils are limited by droughtiness, low fertility, and poor tilth. On the Hamerly soil, the surface layer is often eroded and has low organic-matter content.

The root zone of the soils in this group is restricted by the high content of lime in the upper part of the profile, which affects the growth of trees and shrubs by "tying up" plant nutrients. The young plants are often yellowish in color and are stunted until their roots have penetrated the calcareous layers. Use of moisture conserving practices such as weed control helps to increase plant survival.

WINDBREAK SUITABILITY GROUP 6

This group consists of soils of the Hecla, Maddock, Renshaw, Shible, Sverdrup, and Torning series, of Maddock-Dune land complex, and of the Maddock series, loamy subsoil variant. These are level to rolling, droughty, moderately well drained to somewhat excessively drained soils. The surface ranges in texture from loam to loamy sand and is underlain by sand or gravel at a depth of 12 to 24 inches. The Maddock series, loamy subsoil variant, is underlain by loamy material.

These soils have a very restricted root zone. Available water capacity is very low. Reaction generally is neutral, but the Torning soil is strongly calcareous. Trees planted on the soils in this group generally grow slowly and are stunted, and they generally are shorter lived than similar species planted on deeper soils.

Use of moisture conserving practices is needed to increase the survival rate of young plants. Where these soils are sloping, trees should be planted on the contour. Control of weeds is needed to reduce competition for available moisture. Mulching the soil between trees reduces evaporation.

Young plants should be protected from damage by soil blowing. A row of corn planted parallel to the young plants protects them from soil blowing.

WINDBREAK SUITABILITY GROUP 7

This group consists of soils of the Arveson, Benoit, Borup, Fossum, Hamar, Marysland, Mayer, Shakopee, and Venlo series and of Sandy lake beaches. These are poorly drained and very poorly drained soils. They are dominantly loam but range in texture from sand to clay and are underlain by sand and gravel at a depth of 12 to 36 inches. These are nearly level to depressional soils. Where they occur in potholes that do not have adequate surface drainage, they should be considered with the soils in group 9.

The root zone of these soils is restricted by the coarse-textured underlying material and by the depth to the water table. Where undrained, the water table is within

2 feet of the surface. Drainage is needed to remove surface water quickly in spring and to lower the water table in order to provide a thicker root zone.

Available water capacity is moderate. Reaction is neutral or mildly alkaline. Some of these soils contain an excessive amount of lime, which "ties up" plant nutrients. Young plants often are yellowish in color and grow slowly until a good root system has been established. Competition from weeds is severe.

WINDBREAK SUITABILITY GROUP 8

This group consists of soils of the Clontarf, Edison, Embden, Glyndon, Malachy and Swenoda series, and of the Malachy series, loamy subsoil variant. These are nearly level to gently sloping, well drained and moderately well drained soils. They range in texture from sandy loam to silt loam and are underlain by sand at a depth of 18 to 24 inches. The soils of the Malachy series, loamy subsoil variant, and the Swenoda series have medium-textured material at a depth of 20 to 36 inches.

These soils have an unrestricted root zone. Soil texture, permeability, and drainage allow deep penetration and uniform distribution of plant roots. Available water capacity is low. The water table is at a depth of 3 to 7 feet. Reaction ranges from neutral to moderately alkaline. Some of these soils have a limy surface layer that can slow the growth of young plants for a short time, but they soon develop a good root system.

Droughtiness and soil blowing are hazards for new plants. A row of corn planted parallel to the trees or shrubs reduces soil blowing. The mulching of the surface layer between the plants and the control of weeds help to conserve moisture.

WINDBREAK SUITABILITY GROUP 9

This group consists of soils of the Blue Earth, Rauville, and Sioux series, of Alluvial land, frequently flooded, of Marsh, and of Muck and peat. These are level to steep, very poorly drained to excessively drained soils and land types that range in texture from clay loam to sandy loam.

The Sioux are very droughty, gravelly soils, and the Blue Earth and Rauville are very wet peat or muck soils. They generally are not suited to trees or shrubs. Redcedar is best suited to the gravelly soils. White-cedar, willow, and possibly poplar can be grown on the peat and muck soils, although willows are the most suitable for windbreak plantings. Onsite investigations should be made to determine plant suitability before making decisions on land use.

WINDBREAK SUITABILITY GROUP 10

This group consists of soils of the Barnes, Buse, Flom, Fordville, Parnell, Renshaw, and Svea series. These are level to steep, somewhat excessively drained to poorly drained soils that are loam or clay loam in texture and are stony and very stony.

These soils are suited to the same trees and shrubs as those to which they are suited where not stony. Onsite investigation is needed to determine which trees can be planted by use of a tree planter and which trees must be planted by hand.

Wildlife and Recreation [3]

Swift County is crossed by several major highways that are used by tourists and is near large population centers. It is therefore in a good position to improve its economic growth by providing facilities for tourists and by developing recreation areas.

The hills in the northeastern part of the county offer sites for the establishment of short ski and toboggan runs, fish ponds, and vacation farms. The more nearly level areas of the county provide good to excellent pheasant and duck hunting and have potential for the development of guest hunting farms.

Community parks have been established in nearly all villages. Picnic shelters, fireplaces, ball diamonds, and parking facilities are available in most of these parks. Several State wildlife management areas are open to the public for hunting. The largest of these are the Danvers Slough and the Lac Qui Parle wildlife management areas.

The wildlife and recreation resources of Swift County can be grouped into eight areas. These areas conform generally to the soil associations, which are shown on the general soil map at the back of this survey. Suitability ratings of the areas for wildlife and recreation factors are given in table 5. Additional information on these resource areas follows.

[3] HANS G. UHLIG, biologist, Soil Conservation Service, helped to prepare this subsection.

TABLE 5.—*Wildlife and recreation resource areas*

[Suitability ratings: 1. excellent; 2. very good; 3. good; 4. fair; 5. poor]

Factor	Area 1	Area 2	Area 3	Area 4	Area 5	Area 6	Area 7	Area 8
Ducks	5	3	2	4	4	3	4	4
Pheasants	5	2	2	3	1	3	3	2
Geese	5	5	4	4	5	4	4	4
Squirrels	5	4	4	4	4	4	4	3
Cottontail rabbits	3	3	3	4	3	3	4	3
Deer	2	3	3	1	3	1	4	2
Vacation farms	2	3	4	5	5	5	5	4
Camping areas	2	3	4	5	5	5	5	3
Guest hunting farms	4	3	2	2	2	4	4	2
Ski and toboggan runs	2	4	4	5	5	5	5	4
Ponds	2	3	3	5	5	5	5	5
Dugout pits	5	5	3	2	2	2	5	5
Hiking trails	2	4	4	4	4	4	4	3

Area 1.—This area consists of soil association 1. It is hilly and is marked by many potholes and shallow ponds. The rough, scenic, contrasting topography of this area gives it good potential for development of recreation facilities such as vacation farms. Areas such as those along Mud Creek, at Camp Lake, and near Swift Falls would provide good campsites. Short ski and toboggan runs could be established on the longer steep slopes.

Deer are numerous in this area. Duck and pheasant hunting is generally considered poor because of the hilly topography, but some isolated fields and sloughs provide good hunting. Camp Lake provides good fishing.

Area 2.—This area consists generally of soil association 2. It is rolling and is marked by numerous potholes, marshes, and lakes. This area has good potential for the development of vacation farms. The varied landscape is suited to the development of riding and hiking trails. Good camping facilities can be developed in such areas as at Monson Lake, Frank Lake, and Skunk Lake.

Guest hunting farms could be established to provide additional income to farmers. Ample cover and nesting areas are provided by the diverse crops that are grown, by the numerous potholes, and by the marshes (fig. 9). This area is well suited to the building of farm ponds, which would provide additional hunting and fishing opportunities.

Area 3.—This area consists of soil association 3. It is nearly level to gently rolling, contains several shallow lakes, and is marked by many sloughs and potholes. This area has some potential for vacation farms in the more hilly area adjacent to the Pomme de Terre River. This hilly area has some slopes that could be used to develop ski and toboggan runs. Park areas can be developed along some of the lakes, especially along Lakes Hassel, Moore, Frovold, and Oliver.

The development of guest hunting farms should be considered for this area. The diverse crops grown and the many potholes, lakes, and sloughs provide ample cover and nesting areas. This area is well suited to the building of dugout pits and farm ponds (fig. 10), which could provide additional facilities for hunting and fishing.

Area 4.—This area consists mainly of soil associations 5, 6, 7, and 12. It is mainly level and is almost completely drained by the many deep county ditches that dissect it. Areas along the Chippewa River, Shakopee Creek, and the county ditches provide protective cover for deer. The area southwest of Appleton along the Minnesota River provides excellent hunting for deer. Dugout pits could easily be

***Figure 9.*—An undrained area of Parnell silty clay loam. Such areas provide excellent wildlife habitat.**

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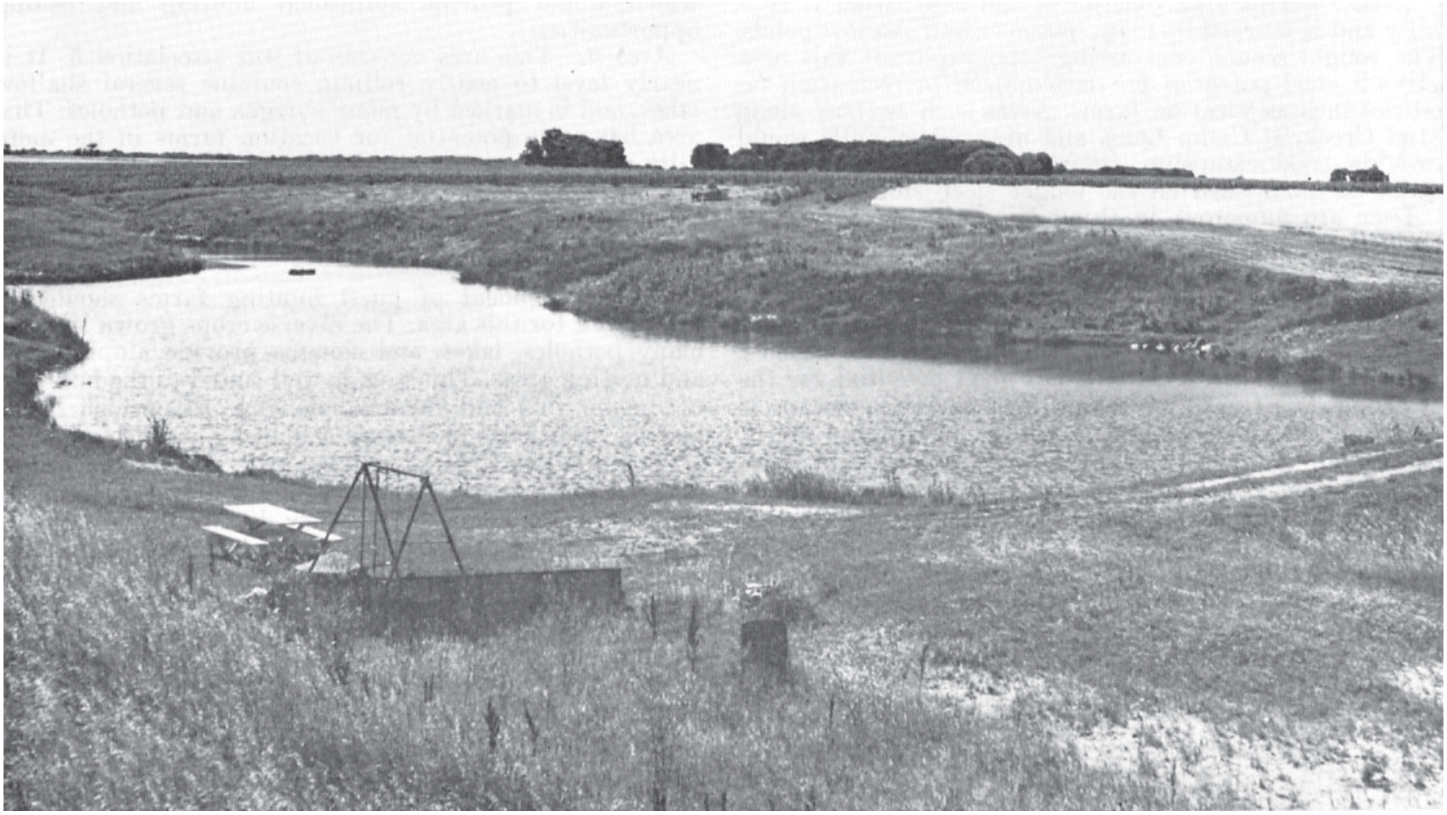

Figure 10.—**Farm pond on Barnes-Buse loams, 2 to 6 percent slopes, eroded. This pond is used for water conservation, recreation, and stock watering.**

constructed in the depressional areas, and these would be of great value for wildlife and would improve the hunting. Duck hunting generally is only fair, but it is good in the few remaining sloughs and along the East Branch Chippewa River. Pheasant hunting is good, but it would be better if more nesting areas were available.

Area 5.—This area consists of soil association 4. It is gently undulating and contains several large ditches and numerous potholes and sloughs. This area has excellent potential for the development of guest hunting farms to supplement the income of farmers. Protective cover, nesting areas, and food are all adequate for wildlife that would provide good hunting. Deer hunting is good in the sloughs and along the ditchbanks. Duck hunting is fair to good, although many of the sloughs and potholes dry up in fall and are not suitable as resting areas. Pheasant hunting is good, and the diverse crops and the many potholes provide adequate protective cover. The soils in this area are suitable for the construction of dugout pits in the depressional areas. Dugout pits would improve the duck hunting by providing some additional resting areas.

Area 6.—This area consists of soil association 8. It is level to nearly level, poorly drained, and contains several shallow lakes, sloughs, and wet depressions. This area is dissected from north to south by the Chippewa River and by two county ditches. Farming is less intensive because of soil limitations.

Duck hunting is good, particularly in the large sloughs and around the shallow lakes. Pheasant hunting is good because there is ample protective and nesting cover. A large deer herd normally winters in the Danvers slough area. The Chippewa River and the county ditches are natural routes for the movement of the deer. The poorly drained soils are ideal for the digging of watering pits, which are very beneficial to wildlife.

Area 7.—This area consists generally of soil associations 9 and 10. It is nearly level to sloping and well drained. This area contains only a few small sloughs, which generally are dry by midsummer. Some of it generally is left idle, and this provides good protective cover and nesting areas. Duck hunting is fair but is limited to the grain fields. Pheasant hunting is good because of the ample amount of protective cover. This area lies close to the Lac Qui Parle Goose Refuge. Goose hunting is occasionally good when the geese are feeding in the grain fields.

Area 8.—This area consists of soil association 11. It is nearly level to sloping and excessively drained to well drained. This area contains only a few sloughs, many of which are dry by midsummer. The area in the western part of the county is divided by the Pomme de Terre River. The area in the northeastern part of the county is dissected by the East Branch Chippewa River and by Mud Creek.

Duck hunting is only fair and is limited to the few sloughs and to the grain fields. Deer hunting is excellent in the wooded areas along the rivers and creeks.

Deer hunting is fair to good in the areas farther away from the streams. Much of this area is close enough to the Lac Qui Parle Goose Refuge to serve as a feeding area, and occasionally goose hunting is good in the area between Appleton and Holloway.

Engineering Uses of the Soils

Some soil properties are of special interest to engineers because they affect the construction and maintenance of highways, airports, and pipelines, the foundations of buildings, facilities for storing water, structures for controlling erosion, and systems for irrigation, drainage, and sewage disposal. Among the properties most important to engineers are permeability, shear strength, plasticity, compaction characteristics, drainage, shrink-swell characteristics, grain size, and pH. Also important are topography, depth to water table, and depth to bedrock or to sand and gravel.

The information in this section can be used to—

1. Make studies that will aid in selecting and developing sites for industrial, business, residential, and recreational areas.
2. Make preliminary estimates of the soil properties that affect the planning of agricultural drainage systems, farm ponds, irrigation systems, diversion terraces, and other structures for controlling water and conserving soil.
3. Make preliminary evaluations of soil and ground conditions that will aid in selecting locations for highways, airports, cables, and pipelines and in planning detailed investigations at the selected locations.
4. Estimate the size of drainage areas and the speed and volume of runoff from them for use in designing culverts and bridges.
5. Identify the soils along proposed highway routes so that preliminary estimates can be made for the thicknesses of flexible pavements.
6. Make preliminary evaluations of topography, surface drainage, internal drainage, depth to the water table, and other features that affect the design of embankments, subgrades, and pavements.
7. Correlate performance of engineering structures with soil mapping units and thus develop information for overall planning that will be useful in designing and maintaining the structures.
8. Determine the suitability of soils for use in cross-country movement of vehicles and construction equipment.
9. Supplement other published information such as maps, reports, and aerial photographs for the purpose of making engineering maps and reports that can be used readily by engineers.
10. Develop other preliminary estimates for construction purposes pertinent to the particular area.

The maps, soils descriptions, and other data in this survey are valuable in planning detailed engineering surveys. By using this information, an engineer can select soil mapping units and concentrate on the ones that are most suitable for the planned construction and in this manner reduce the number of soil samples needed for laboratory testing. It should be emphasized, however, that the interpretations in this subsection are not a substitute for the sampling and testing needed at a site chosen for a specific engineering work that involves heavy loads, or at a site where excavations are to be deeper than the depths of the layers here reported. Also, engineers and others should not assign specific values to estimated values.

The soil mapping units shown on the maps in this survey may include small areas of a different soil material. These included soils may be as much as 2 acres in size. They are too small to be mapped separately but may be important in engineering planning.

Much of the information in this subsection is given in tables 6, 7, and 8. Table 6 contains test data on soils in Swift County. In table 7 properties of the soils that are important to engineering are estimated. Table 8 indicates the suitability of soils for various engineering uses.

Additional information useful to engineers can be found in the sections, "Descriptions of the Soils" and "Formation and Classification of the Soils" as well as in other sections of this survey.

Some of the terms used by the scientist may be unfamiliar to the engineer, and some words—for example, soil, clay, silt, and sand—may have special meaning in soil science. These and other special terms used in the soil survey are defined in the Glossary at the back of this survey.

Engineering classification systems

Two systems for classifying soil material are generally used by engineers. One is the system approved by the American Association of State Highway Officials (AASHO) (*1*), and the other is the Unified system adopted by the United States Department of Defense (*8*). Both systems are used in this survey and are explained in the following paragraphs.

The AASHO system is used to classify soils according to those properties that affect use in highway construction. In this system, soil materials are classified in seven principal groups. These range from group A–1, consisting of gravelly soils, to group A–7, consisting of clayey soils. Soil material near a classification boundary is given a symbol for both classes; for example, A–2 or A–4. If laboratory data are available, some of these groups are subdivided into A–1–a, A–1–b, A–2–4, A–2–5, A–2–6, A–2–7, A–7–5, and A–7–6. Within each group, the relative engineering value of the soil material is indicated by a group index number. Group index numbers range from 0 for the best material to 20 for the poorest. For the soils tested, group index numbers are shown in table 6 in parentheses following the group symbol. The estimated AASHO classification of the soils in the county, without group index number, is given in table 7. Highly organic soils, such as peat and muck, are not included in the AASHO classification because their use as construction material or foundation material should be avoided.

TABLE 6.—*Engineering*

[Test performed by the Minnesota Department of Highways in cooperation with the U.S. Department of Commerce, Bureau of

Soil name and location	Parent material	Minnesota report No. SS63–	Depth	Moisture-density [1]	
				Maximum dry density	Optimum moisture
			Inches	*Lb. per cu. foot*	*Percent*
Barnes loam:					
SW¼SW¼ sec. 7, T. 121 N., R. 42 W. (Modal profile.)	Clay loam glacial till.	1792	0–8	97	23
		1793	8–17	97	22
		1794	30–54	105	18
SW¼SE¼ sec. 2, T. 122 N., R. 39 W. (More silty in upper part of solum than modal profile.)	Loam glacial till.	1798	0–8	96	23
		1799	16–22	106	16
		1800	27–35	113	15
SW¼SW¼ sec. 10, T. 121 N., R. 37 W. (Coarser textured than modal profile.)	Loam glacial till.	1795	0–8	102	19
		1796	15–22	111	14
		1797	30–60	117	12
Buse loam:					
NW¼NW¼SW¼ sec. 3, T. 121 N., R. 41 W. (Modal profile.)	Clay loam glacial till.	1774	0–6	92	25
		1775	6–18	102	21
		1776	18–60	107	18
NE¼SW¼NW¼ sec. 7, T. 122 N., R. 37 W. (Coarser textured than modal profile.)	Clay loam glacial till.	1780	0–7	110	16
		1781	7–14	112	16
		1782	14–40	114	13
SE¼NE¼NE¼ sec. 18, T. 121 N., R. 43 W. (Coarser textured substratum than modal profile.)	Loam glacial till.	1777	0–7	99	19
		1778	7–18	110	16
		1779	30–60	113	15
Colvin silty clay loam:					
NW¼SW¼SW¼ sec. 11, T. 120 N., R. 39 W. (Modal profile.)	Lacustrine silts.	1801	0–6	86	32
		1802	6–12	93	25
		1803	16–28	104	18
SW¼SW¼NE¼ sec. 30, T. 120 N., R. 39 W. (Finer textured than modal profile.)	Lacustrine silts.	1804	0–9	87	29
		1805	9–18	105	24
		1806	25–36	94	25
NW¼SW¼NE¼ sec. 22, T. 120 N., R. 40 W. (Coarser textured than modal profile.)	Lacustrine silts.	1807	0–7	84	27
		1808	17–22	103	20
		1809	29–40	110	14
Doland silt loam:					
NE¼NE¼NW¼ sec. 23, T. 122 N., R. 42 W. (Modal profile.)	Loam glacial till of silt-capped ground moraine.	1819	0–8	92	24
		1820	15–20	102	17
		1821	26–54	118	13
SE¼NE¼SE¼ sec. 13, T. 121 N., R. 38 W. (Coarser textured surface layer than modal profile.)	Loam glacial till of silt-capped ground moraine.	1825	0–8	92	25
		1826	13–19	97	22
		1827	24–54	99	24
NW¼NW¼ sec. 34, T. 122 N., R. 41 W. (Finer textured substratum than modal profile.)	Clay loam glacial till of silt-capped ground moraine.	1822	0–7	90	25
		1823	16–22	98	23
		1824	31–54	108	17
Hamerly loam:					
NE¼NW¼ sec. 7, T. 121 N., R. 42 W. (Modal profile.)	Clay loam glacial	1828	0–8	88	25
		1829	12–23	104	20
		1830	23–54	109	18
SW¼SW¼SW¼ sec. 20, T. 122 N., R. 41 W. (Contains more silt than modal profile.)	Clay loam glacial till.	1834	0–6	86	29
		1835	9–13	93	26
		1836	19–60	116	14
NE¼NW¼ sec. 1, T. 120 N., R. 38 W. (Coarser textured than modal profile.)	Loam glacial till.	1831	0–8	96	21
		1832	8–19	101	19
		1833	32–60	116	13

See footnotes at end of table.

test data

Public Roads (BPR), in accordance with standard procedures of the American Association of State Highway Officials (AASHO) (*1*)]

Mechanical analysis [2]										Liquid limit	Plasticity index	Classification	
Percentage passing sieve—						Percentage smaller than—						AASHO	Unified [3]
2-in.	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	97	91	72	59	42	22	17	38	9	A-4(7)	ML or OL
		100	99	96	81	77	47	25	21	39	10	A-4(8)	ML
100	99	96	94	87	64	58	47	31	23	35	11	A-6(6)	ML-CL
	100	99	99	93	78	70	43	25	18	39	7	A-4(8)	OL or ML
	100	97	94	86	68	62	47	22	16	34	10	A-4(7)	ML-CL
100	99	94	88	76	52	49	38	24	18	30	8	A-4(3)	ML-CL
	100	99	96	87	59	51	34	18	14	40	12	A-6(6)	OL or ML
	100	97	94	85	53	48	34	23	18	[4] NP	NP	A-4(4)	ML
100	98	91	86	76	49	44	32	20	15	27	7	A-4(3)	SM-SC
	100	95	90	80	55	49	36	18	11	NP	NP	A-4(4)	OL or ML
100	98	95	91	75	50	53	44	29	21	36	10	A-4(4)	ML-CL
100	99	95	92	84	60	54	42	28	21	32	10	A-4(5)	ML-CL
100	95	89	85	77	48	43	32	18	13	29	4	A-4(3)	SM
	100	96	92	84	54	49	38	25	17	29	8	A-4(4)	ML-CL
100	99	96	92	83	52	44	34	20	13	23	4	A-4(3)	ML
	100	96	93	85	59	53	39	21	15	36	7	A-4(5)	OL or ML
	100	97	93	84	62	57	42	25	19	29	8	A-4(5)	ML-CL
	100	95	92	86	68	60	44	21	15	24	4	A-4(7)	ML-CL
			100	95	87	80	57	33	28	57	14	A-7-5(13)	OH
			100	99	94	89	68	39	32	54	18	A-7-5(14)	OH
		100	99	98	91	81	60	37	27	41	15	A-7-6(10)	ML-CL
			100	98	91	88	75	49	37	55	16	A-7-5(13)	OH
			100	99	95	91	78	61	47	53	24	A-7-6(16)	MH-CH
			100	99	92	86	77	60	40	58	29	A-7-6(19)	MH-CH
			100	98	86	82	53	30	23	54	15	A-7-5(13)	OH
				100	90	87	58	34	29	37	11	A-6(8)	ML-CL
				100	94	84	41	21	14	28	6	A-4(8)	ML-CL
			100	98	89	81	54	27	19	43	9	A-5(9)	OL
			100	97	89	83	44	25	20	36	8	A-4(8)	ML
	100	96	90	78	50	45	33	18	14	28	8	A-4(3)	SC
			100	97	86	71	46	22	18	46	12	A-7-5(10)	OL
			100	99	93	86	60	29	22	38	10	A-4(8)	ML
100	99	97	96	92	79	77	67	43	24	38	14	A-6(10)	ML-CL
			100	96	82	69	50	22	15	44	9	A-5(9)	OL
			100	98	92	85	53	28	25	36	8	A-4(8)	ML
100	99	95	92	84	61	55	46	28	19	36	14	A-6(7)	CL
	100	98	96	89	66	57	38	16	6	52	14	A-7-5(10)	OH
100	99	95	92	85	65	62	51	29	16	37	10	A-4(6)	ML
100	98	93	90	83	60	55	44	28	26	35	13	A-6(6)	ML-CL
		100	99	93	77	73	50	25	20	47	8	A-5(9)	OL
			100	97	88	81	60	36	29	42	15	A-7-6(10)	ML-CL
	100	98	95	88	64	58	40	22	15	25	6	A-4(6)	ML-CL
		100	99	95	75	65	45	28	25	41	12	A-7-6(9)	ML
		100	97	93	72	66	42	25	22	37	13	A-6(9)	ML-CL
	100	96	92	83	56	50	37	23	18	25	7	A-4(4)	ML-CL

TABLE 6.—*Engineering*

Soil name and location	Parent material	Minnesota report No. SS63–	Depth	Moisture-density [1]	
				Maximum dry density	Optimum moisture
			Inches	*Lb. per cu. foot*	*Percent*
Maddock loamy fine sand: SE¼SE¼SW¼ sec. 5, T. 120 N., R. 43 W. (Modal profile.)	Wind-shifted outwash sand.	1810	0–12	110	14
		1811	17–22	115	12
		1812	22–64	110	14
SE¼SE¼NE¼ sec. 8, T. 120 N., R. 43 W. (Thinner surface layer than modal profile.)	Wind-shifted outwash sand.	1813	0–9	115	12
		1814	20–32	115	12
		1815	32–54	111	12
SW¼SE¼SW¼ sec. 7, T. 120 N., R. 42 W. (Thicker surface layer than modal profile.)	Wind-shifted outwash sand.	1816	0–9	104	16
		1817	14–20	108	15
		1818	25–33	109	14
Marysland loam: SE¼SW¼SW¼ sec. 4, T. 121 N., R. 40 W. (Modal profile.)	Outwash sand.	1783	0–9	66	49
		1784	12–18	94	25
		1785	31–40	111	12
SW¼NW¼SW¼ sec. 23, T. 121 N., R. 41 W. (Finer textured than modal profile.)	Outwash sand.	1789	0–7	102	20
		1790	18–23	105	17
		1791	30–54	112	12
SW¼SW¼ sec. 4, T. 122 N., R. 40 W. (Coarser textured than modal profile.)	Outwash sand.	1786	0–6	89	27
		1787	13–22	115	14
		1788	27–54	111	15

[1] Based on AASHO Designation: T 99–57, Method C.
[2] Mechanical analyses according to the AASHO Designation: T 88–57. Results by this procedure frequently may differ somewhat from results obtained by the soil survey procedure of the Soil Conservation Service (SCS). In the AASHO procedure, the fine material is analyzed by the hydrometer method and the various grain-size fractions are calculated on the basis of all the material, including that coarser than 2 millimeters in diameter. In the SCS soil survey procedure, the fine material is analyzed by the pipette method and the material

TABLE 7.—*Engineering*

[Alluvial land, frequently flooded (Af) and Marsh (Mo) are so variable that their properties were not rated. An asterisk in the first column different properties and limitations, and for this reason it is necessary to follow carefully the instructions for referring to

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification
			USDA texture
	Feet	*Inches*	
Arveson: Av	2–5	0–12	Loam
		12–17	Sandy loam
		17–20	Sandy loam
		20–60	Fine sand
*Barnes: BaA, BbB2, BbC2, BcC. For Buse part of BbB2, BbC2, and BcC, see Buse series.	10+	0–10	Loam
		10–20	Loam
		20–50	Loam
Bearden: BdA	4–8	0–9	Silty clay laom
		9–18	Silty clay laom
		18–60	Silty clay loam
Benoit: Be	2–4	0–13	Loam
		13–18	Loam
		18–23	Sandy loam
		23–60	Gravel

test data—Continued

Mechanical analysis [2]										Liquid limit	Plasticity index	Classification	
Percentage passing sieve—						Percentage smaller than—						AASHO	Unified [3]
2-in.	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	94	23	20	14	6	5	NP	NP	A-2-4(0)	SM
--------	--------	--------	100	94	20	------	------	------	------	NP	NP	A-2-4(0)	SM
--------	--------	--------	100	94	16	------	------	------	------	NP	NP	A-2-4(0)	SM
--------	--------	--------	100	91	15	------	------	------	------	NP	NP	A-2-4(0)	SM
--------	--------	--------	100	83	14	------	------	------	------	NP	NP	A-2-4(0)	SM
--------	--------	--------	100	85	12	------	------	------	------	NP	NP	A-2-4(0)	SP-SM
--------	--------	--------	100	97	28	18	13	6	5	NP	NP	A-2-4(0)	SM
--------	--------	--------	100	98	31	20	12	6	4	NP	NP	A-2-4(0)	SM
--------	--------	--------	100	99	27	17	14	10	9	NP	NP	A-2-4(0)	SM
--------	--------	--------	100	89	66	58	39	27	21	72	16	A-7-5(12)	OH
--------	--------	--------	100	87	57	57	49	40	35	40	10	A-4(4)	ML or OL
--------	--------	--------	100	67	8	------	------	------	------	NP	NP	A-3(0)	SP-SM
--------	--------	--------	100	96	52	46	32	20	16	36	9	A-4(3)	ML
--------	--------	--------	100	97	53	47	40	30	25	32	12	A-6(4)	CL
--------	--------	--------	100	97	24	15	9	9	9	NP	NP	A-2-4(0)	SM
--------	--------	--------	100	86	58	50	40	24	18	49	11	A-7-5(6)	ML
--------	--------	--------	100	82	40	37	32	26	24	30	11	A-6(1)	SC
--------	100	99	98	54	7	------	------	------	------	NP	NP	A-3(0)	SP-SM

coarser than 2 millimeters in diameter is excluded from calculations of grain-size fractions. The mechanical analyses used in this table are not suitable for naming textural classes for soils.

[3] SCS and BPR have agreed to consider that all soils having plasticity indexes within 2 points from A-line are to be given a borderline classification. Examples of borderline classifications thus obtained are ML-CL, SM-SC, and MH-CH.

[4] Nonplastic.

properties

indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in such mapping units may have other series that appear in the first column of this table. The symbol < means less than; the symbol > means more than]

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 200 (0.074 mm)	*Inches per hour*	*Inches per inch of soil*	*pH value*	
OL or ML	A-4	95-100	90-100	60-75	0. 63-2. 0	0. 14-0. 18	7. 4-7. 8	Low.
SC	A-6	95-100	90-100	36-50	0. 63-2. 0	0. 12-0. 16	7. 9-8. 4	Low.
SM	A-2	95-100	90-100	15-25	2. 0-6. 3	0. 06-0. 08	7. 9-8. 4	Low.
SM	A-2	95-100	90-100	10-20	>6. 3	0. 04	7. 4-7. 8	Low.
OL or ML	A-4	95-100	85-100	50-80	0. 63-2. 0	0. 14-0. 18	6. 6-7. 3	Low to moderate.
CL	A-4	95-100	85-100	50-80	0. 63-2. 0	0. 14-0. 18	6. 6-7. 3	Low to moderate.
CL	A-4	95-100	85-100	50-80	0. 63-2. 0	0. 14-0. 18	7. 9-8. 4	Low to moderate.
OL or ML	A-6	95-100	90-100	85-95	0. 2-0. 63	0. 19-0. 21	7. 4-7. 8	Moderate.
CL	A-6	95-100	90-100	85-95	0. 2-0. 63	0. 19-0. 21	7. 9-8. 4	Moderate.
CL	A-6	95-100	90-100	85-95	0. 2-0. 63	0. 19-0. 21	7. 4-7. 8	Moderate.
OL or ML	A-4	95-100	90-100	50-70	0. 63-2. 0	0. 14-0. 18	7. 4-7. 8	Low.
SC or CL	A-4	90-100	80-95	48-70	0. 63-2. 0	0. 14-0. 18	7. 9-8. 4	Low.
SM	A-2	70-90	40-50	12-25	2. 0-6. 3	0. 10-0. 14	7. 9-8. 4	Low.
GW-GM	A-1	40-50	25-40	5-12	>6. 3	0. 02	7. 4-7. 8	Low.

TABLE 7.—*Engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification: USDA texture
	Feet	*Inches*	
Blue Earth: Bh	0–4	0–14	Silt loam
		14–40	Silt loam and silty clay loam
		40–60	Silty clay loam
Borup: Bm	2–5	0–36	Silt loam and very fine sandy loam
		36–60	Very fine sand
*Buse: BnE, BnF, BoE, BuB2, BuC2, BuD2	10+	0–7	Loam
For Barnes part of BuB2, BuC2, and BuD2, see Barnes series.		7–60	Loam
Clontarf: ClA	3–6	0–22	Sandy loam
		22–29	Loamy sand
		29–60	Sand
Colvin:			
Co	2–5	0–6	Silty clay loam
		6–12	Silty clay loam
		12–60	Silty clay loam
Cv	0–3	0–8	Silty clay loam
		8–48	Silty clay loam
Darnen: DaB	8–15	0–38	Loam
		38–60	Loam
Doland: DlA, DlB	10+	0–11	Silt loam
		11–26	Silt loam and loam
		26–54	Loam
Edison: EdA, EdB	10+	0–14	Very fine sandy loam
		14–21	Loamy fine sand
		21–34	Loam
		34–60	Fine sandy loam and loamy fine sand
Embden: Em	5–10	0–47	Fine sandy loam and sandy loam
Estelline: EsA	8–15	0–15	Silt loam
		15–36	Silt loam
		36–60	Fine sand
Flandreau: FlA, FlB	10+	0–10	Silt loam
		10–23	Silt loam
		23–31	Loam and fine sandy loam
		31–48	Fine sand
*Flom: Fm, Fn	2–6	0–22	Silty clay loam
For Parnell part of Fm and Fn, see Parnell series.		22–30	Loam
		30–54	Clay loam
Fordville: FoB, FrA	8–15	0–14	Loam
		14–32	Loam
		32–60	Sand and gravel
Fossum: Fs	2–4	0–8	Sandy loam
		8–21	Loamy sand and medium sand
		21–60	Fine sand
Fulda: FvA	2–6	0–15	Silty clay
		15–22	Silty clay
		22–60	Silty clay
Fulda, sand subsoil variant:			
FuA	5–10	0–8	Loam
		8–26	Clay and clay loam
		26–30	Sandy loam
		30–48	Fine sand
FwA	4–8	0–14	Silty clay and clay
		14–34	Clay
		34–60	Sand

properties—Continued

Classification—Continued		Percentage passing sieve—			Perme-ability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 200 (0.074 mm)				
					Inches per hour	*Inches per inch of soil*	*pH value*	
OL	A–4	95–100	90–100	70–90	0. 63–2. 0	0. 18–0. 23	7. 4–7. 8	Low.
ML	A–4	95–100	90–100	70–90	0. 63–2. 0	0. 18–0. 23	7. 4–7. 8	Low.
CL	A–6	95–100	90–100	85–95	0. 2–0. 63	0. 19–0. 21	7. 4–7. 8	High.
ML	A–4	95–100	90–100	70–90	0. 63–2. 0	0. 18–0. 23	7. 4–7. 8	Low.
SM	A–4 or A–2	95–100	90–100	30–50	>6. 3	0. 06–0. 08	7. 4–7. 8	Low.
OL or ML	A–4	90–100	85–100	50–80	0. 63–2. 0	0. 14–0. 18	7. 4–7. 8	Low to moderate.
CL	A–4	90–100	85–100	50–80	0. 63–2. 0	0. 14–0. 18	7. 9–8. 4	Low to moderate.
SM	A–2 or A–4	95–100	90–100	20–45	2. 0–6. 3	0. 10–0. 14	6. 6–7. 3	Low.
SM	A–2	95–100	90–100	15–25	>6. 3	0. 04–0. 06	6. 6–7. 3	Low.
SM	A–2	95–100	90–100	5–12	>6. 3	0. 02–0. 04	6. 6–7. 3	Low.
OH	A–7	95–100	90–100	80–90	0. 2–0. 63	0. 19–0. 21	7. 4–7. 8	High.
MH	A–7	95–100	90–100	85–95	0. 2–0. 63	0. 19–0. 21	7. 9–8. 4	High.
CL	A–6	95–100	90–100	85–95	0. 2–0. 63	0. 19–0. 21	7. 4–7. 8	Moderate to high.
OH	A–7	95–100	90–100	70–90	0. 2–0. 63	0. 19–0. 21	7. 9–8. 4	High.
CL	A–6 or A–7	95–100	90–100	85–95	0. 2–0. 63	0. 19–0. 21	7. 9–8. 4	High.
OL	A–4	95–100	90–100	60–80	0. 63–2. 0	0. 14–0. 18	6. 6–7. 3	Low.
ML	A–4	95–100	90–100	60–80	0. 63–2. 0	0. 14–0. 18	7. 4–7. 8	Low.
OL	A–5	95–100	95–100	80–90	0. 63–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
ML	A–4	95–100	95–100	80–90	0. 63–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
ML	A–4	95–100	90–100	60–80	0. 63–2. 0	0. 18–0. 23	7. 4–7. 8	Low.
ML	A–4	95–100	90–100	50–80	0. 63–2. 0	0. 10–0. 14	6. 6–7. 3	Low.
SM	A–2	95–100	90–100	20–30	>6. 3	0. 06–0. 08	6. 6–7. 3	Low.
ML	A–4	95–100	85–95	60–75	0. 63–2. 0	0. 14–0. 18	6. 6–7. 3	Low.
SM	A–4	95–100	90–100	35–50	>6. 3	0. 08–0. 12	7. 4–7. 8	Low.
SM	A–2 or A–4	95–100	95–100	25–40	2. 0–6. 3	0. 10–0. 14	6. 6–7. 3	Low.
OL	A–4	95–100	90–100	80–90	0. 63–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
ML	A–4	95–100	90–100	80–90	0. 63–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
SP–SM	A–2 or A–3	95–100	90–100	5–12	>6. 3	0. 04	7. 4–7. 8	Low.
OL	A–4	95–100	95–100	85–95	0. 63–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
ML	A–4	95–100	95–100	85–95	0. 63–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
ML–CL	A–4	95–100	90–100	50–80	0. 63–2. 0	0. 14–0. 18	7. 4–7. 8	Low.
SP–SM	A–2 or A–3	95–100	90–100	5–12	>6. 3	0. 04	7. 4–7. 8	Low.
OL	A–7	95–100	90–100	85–95	0. 2–0. 63	0. 19–0. 21	6. 6–7. 3	High.
CL	A–6	95–100	90–100	60–75	0. 63–2. 0	0. 14–0. 18	7. 4–7. 8	Low to moderate.
CL	A–6	95–100	90–100	70–80	0. 63–2. 0	0. 16–0. 18	7. 4–7. 8	Moderate.
ML	A–4	90–95	85–95	50–75	0. 63–2. 0	0. 14–0. 18	6. 6–7. 3	Low.
CL	A–4	90–95	85–95	50–75	0. 63–2. 0	0. 14–0. 18	6. 6–7. 3	Low.
GW	A–1	40–50	25–40	3–5	>6. 3	0. 02	7. 4–7. 8	Low.
SM	A–2	95–100	90–100	25–35	2. 0–6. 3	0. 10–0. 14	7. 4–7. 8	Low.
SM	A–2	95–100	90–100	15–25	>6. 3	0. 04–0. 06	7. 9–8. 4	Low.
SP–SM	A–2 or A–3	95–100	90–100	5–12	>6. 3	0. 04	7. 9–8. 4	Low.
OH or MH	A–7	95–100	90–100	85–95	<0. 05	0. 15–0. 18	6. 6–7. 3	Very high.
CH	A–7	95–100	90–100	85–95	<0. 05	0. 15–0. 18	6. 6–7. 3	Very high.
CL	A–7	95–100	90–100	85–95	<0. 05	0. 15–0. 18	7. 4–7. 8	Moderate.
OL or ML	A–4 or A–6	95–100	90–100	60–80	0. 63–2. 0	0. 14–0. 18	6. 6–7. 3	Moderate.
CH	A–7	95–100	90–100	75–90	<0. 05	0. 15–0. 18	6. 6–7. 3	Very high.
SM	A–2 or A–4	95–100	90–100	15–40	2. 0–6. 3	0. 10–0. 14	6. 6–7. 3	Low.
SP–SM	A–2 or A–3	95–100	90–100	5–12	>6. 3	0. 04	6. 6–7. 3	Low.
OH or MH	A–7	95–100	95–100	90–95	<0. 05	0. 15–0. 18	6. 6–7. 3	Very high.
CH	A–7	95–100	95–100	75–95	<0. 05	0. 15–0. 18	6. 6–7. 3	Very high.
SP–SM	A–2 or A–3	95–100	95–100	5–12	>6. 3	0. 02–0. 04	7. 4–7. 8	Low.

TABLE 7.—*Engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification: USDA texture
	Feet	*Inches*	
Glyndon: GdA	8–15	0–7 7–32 32–60	Silt loam Silt loam Very fine sand
Hamar: Ha, Hc	2–4	0–30 30–54	Loamy sand and sand Loamy sand
Hamerly: HdA	5–10	0–8 8–32 32–60	Loam Loam Loam
Hantho: HhA	5–10	0–12 12–15 15–60	Silt loam Silt loam Silt loam and silty clay loam
*Hattie: HtC2, HuB For Nutley part of HuB, see Nutley series.	10+	0–7 7–12 12–48	Clay loam Clay loam Clay loam and clay
Hecla: HvA	3–6	0–14 14–66	Loamy sand Sand
Hegne: Hy	2–5	0–12 12–25 25–60	Clay Silty clay Silty clay loam
*Lamoure: Lm, Lr For Rauville part of Lr, see Rauville series.	3–5	0–26 26–60	Silt loam Silty clay loam
La Prairie: Ls	8–15	0–17 17–60	Silty clay loam Silty clay loam and clay loam
*Maddock: McA, McB, McD, MdB, Mk Properties of Dune land in unit Mk are too variable to rate.	10+	0–17 17–50	Loamy fine sand Fine sand
Maddock, loamy subsoil variant: MbA	10+	0–6 6–17 17–60	Loamy fine sand Fine sand Loam
Malachy: MmA	3–7	0–26 26–34 34–60	Sandy loam Loamy sand Medium sand
Malachy, loamy subsoil variant: MnA	3–6	0–25 25–33 31–60	Sandy loam and loamy sand Sand Silty clay loam
Marysland: Mp	2–5	0–12 12–27 27–60	Loam and sandy loam Loam and sandy loam Sand
Mayer:			
Mr	2–5	0–13 13–33 13–60	Loam Loam and clay loam Sand and gravel
Ms	0–3	0–26 26–32 32–60	Loam Silt loam Sand
McIntosh: MtA	4–8	0–9 9–22 22–60	Silt loam Silt loam Loam
Muck and peat: Mu	0–3		Peat or muck
Muck and peat, calcareous: Mv	0–3		Peat or muck
Muck and peat, calcareous, shallow: Mw	0–3	0–18 18–40	Muck Loam

properties—Continued

Classification—Continued		Percentage passing sieve—			Perme-ability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 200 (0.074 mm)				
					Inches per hour	*Inches per inch of soil*	*pH value*	
ML	A–4	95–100	90–100	70–90	0. 63–2. 0	0. 18–0. 23	7. 4–7. 8	Low.
ML	A–4	95–100	90–100	70–90	0. 63–2. 0	0. 18–0. 23	7. 9–8. 4	Low.
SM	A–2	95–100	90–100	20–35	>6. 3	0. 04–0. 08	7. 9–8. 4	Low.
SM	A–2	95–100	90–100	15–30	>6. 3	0. 06–0. 08	6. 6–7. 3	Low.
SM	A–2	95–100	90–100	15–30	>6. 3	0. 06–0. 08	7. 4–7. 8	Low.
ML	A–4	95–100	95–100	55–80	0. 63–2. 0	0. 14–0. 18	7. 4–7. 8	Low to moderate.
CL or ML	A–4 or A–6	95–100	95–100	55–80	0. 63–2. 0	0. 14–0. 18	7. 9–8. 4	Low to moderate.
CL or ML	A–4 or A–6	95–100	95–100	55–65	0. 63–2. 0	0. 14–0. 18	7. 4–7. 8	Low to moderate.
OL or ML	A–5 or A–4	95–100	90–100	75–90	0. 63–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
ML	A–4	95–100	90–100	75–90	0. 63–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
ML	A–4 or A–6	95–100	90–100	75–90	0. 63–2. 0	0. 18–0. 23	7. 4–7. 8	Low.
ML	A–4	95–100	95–100	70–80	0. 2–0. 63	0. 16–0. 18	6. 6–7. 3	High.
CL	A–6 or A–7	95–100	95–100	70–80	0. 2–0. 63	0. 16–0. 18	7. 4–7. 8	High.
CH	A–7	95–100	95–100	75–95	<0. 05	0. 15–0. 18	7. 4–7. 8	High.
SM	A–2	95–100	90–100	15–30	>6. 3	0. 04–0. 06	6. 6–7. 3	Low.
SP–SM	A–2 or A–3	95–100	90–100	5–12	>6. 3	0. 02–0. 04	6. 6–7. 3	Low.
OH or MH	A–7	95–100	90–100	90–95	<0. 05	0. 15–0. 18	7. 4–7. 8	Very high.
CH	A–7	95–100	90–100	90–96	<0. 05	0. 15–0. 18	7. 9–8. 4	Very high.
CH	A–7	95–100	90–100	90–95	0. 2–0. 63	0. 15–0. 18	7. 4–7. 8	High.
CL or ML	A–4	95–100	95–100	70–90	0. 63–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
CL	A–7	95–100	95–100	90–95	0. 2–0. 63	0. 19–0. 21	7. 4–7. 8	Moderate.
CL	A–6	95–100	90–100	85–95	0. 2–0. 63	0. 19–0. 21	6. 6–7. 3	Moderate.
CL	A–6	95–100	90–100	85–95	0. 2–0. 63	0. 19–0. 21	6. 6–7. 3	Moderate.
SM	A–2	95–100	90–100	20–30	>6. 3	0. 06–0. 08	6. 6–7. 7	Low.
SP–SM or SM	A–2	95–100	90–100	15–25	>6. 3	0. 04	6. 6–7. 3	Low.
SM	A–2	95–100	90–100	15–25	>6. 3	0. 06–0. 08	6. 6–7. 3	Low.
SP–SM	A–2 or A–3	95–100	90–100	5–12	>6. 3	0. 04	6. 6–7. 3	Low.
ML	A–4	95–100	90–100	50–75	0. 63–2. 0	0. 14–0. 18	6. 6–7. 3	Low.
SM	A–2 or A–4	95–100	90–100	25–40	2. 0–6. 3	0. 10–0. 14	7. 4–7. 8	Low.
SM	A–2	95–100	90–100	15–25	>6. 3	0. 06–0. 08	7. 4–7. 8	Low.
SP–SM	A–2 or A–3	95–100	90–100	5–15	>6. 3	0. 02–0. 04	7. 4–7. 8	Low.
SM	A–2 or A–4	95–100	90–100	25–40	2. 0–6. 3	0. 10–0. 14	7. 4–7. 8	Low.
SP–SM	A–2 or A–3	95–100	90–100	5–12	>6. 3	0. 02–0. 04	7. 4–7. 8	Low.
CL	A–4 or A–6	95–100	90–100	70–80	0. 2–0. 63	0. 16–0. 18	7. 9–8. 4	Low to moderate.
OL or ML	A–4	85–100	85–95	50–65	0. 63–2. 0	0. 14–0. 18	7. 4–7. 8	Low.
ML	A–6	85–100	85–95	50–60	0. 63–2. 0	0. 14–0. 18	7. 9–8. 4	Low to moderate.
SP–SM	A–2 or A–3	65–100	50–95	5–12	>6. 3	0. 02–0. 04	7. 4–7. 8	Low.
OL	A–4	95–100	90–100	60–70	0. 63–2. 0	0. 14–0. 18	6. 6–7. 3	Low to moderate.
CL	A–4 or A–6	95–100	90–100	50–80	0. 63–2. 0	0. 14–0. 18	7. 4–7. 8	Low to moderate.
GP–GM	A–2	40–50	25–40	3–5	>6. 3	0. 04	7. 4–7. 8	Low.
CL	A–4	95–100	90–100	50–80	0. 63–2. 0	0. 14–0. 18	7. 4–7. 8	Low to moderate.
ML	A–4	95–100	90–100	70–85	0. 63–2. 0	0. 18–0. 23	7. 4–7. 8	Low.
SP–SM	A–2	95–100	90–100	5–12	>6. 3	0. 02–0. 04	7. 4–7. 8	Low.
OL	A–5 or A–4	95–100	90–100	80–95	0. 63–2. 0	0. 18–0. 23	7. 4–7. 8	Low.
ML	A–4	95–100	90–100	80–95	0. 63–2. 0	0. 18–0. 23	7. 9–8. 4	Low.
CL	A–6	95–100	90–100	60–80	0. 63–2. 0	0. 14–0. 18	7. 4–7. 8	Low to moderate.
Pt	----------	----------	----------	----------	----------	0. 25	6. 6–7. 3	Low.
Pt	----------	----------	----------	----------	----------	0. 25	7. 4–7. 8	Low.
Pt	----------	----------	----------	----------	----------	0. 25	7. 4–7. 8	Low.
ML	A–4	95–100	85–95	50–80	0. 63–2. 0	0. 14–0. 18	7. 4–7. 8	Low.

TABLE 7.—*Engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification
			USDA texture
	Feet	*Inches*	
Muck and peat, shallow over loam: Mx	0–3	0–18	Muck
		18–40	Loam
Muck and peat, shallow over sand: My	0–3		
*Nutley: NhA	5–10	0–7	Clay
For Hattie part of NhA, see Hattie series.		7–15	Clay
		15–27	Clay
		27–60	Silty clay loam
Oldham: Om	0–3	0–36	Silty clay loam
		36–54	Silt loam
*Parnell: Pa, Pf	0–3	0–24	Silty clay loam
For Flom part of Pf, see Flom series.		24–40	Silty clay
		40–60	Silty clay loam
Perella:			
Pr	2–6	0–14	Silt loam
		14–28	Silt loam
		28–54	Silt loam
Ps	0–3	0–10	Silty clay loam
		10–25	Silty clay loam
		25–54	Silt loam
Rauville: Ra	0–2	0–50	Silty clay loam
		50–60	Gravelly loam
*Renshaw: ReA, ReB, ReC2, RhB, Rk	8–15	0–16	Loam
For Fordville part of Rk, see Fordville series.		16–60	Sand and gravel
Rockwell: Rm, Rn	2–5	0–12	Loam
		12–24	Loam
		24–34	Loamy sand
		34–60	Loam and silt loam
Rothsay: RoA, RoB	10+	0–13	Silt loam
		13–22	Silt loam
		22–60	Silt loam
Sandy lake beaches: Sa	(1)	(1)	(1)
Shakopee: Se	3–6	0–7	Clay
		7–17	Clay
		17–38	Silty clay
		38–60	Fine sand
Shible: SfA, SfB	10+	0–10	Fine sandy loam
		10–24	Fine sandy loam and sandy loam
		24–42	Loamy fine sand
		42–54	Fine sand
Sioux: SsA, SsB, SsC, SsE	10+	0–8	Sandy loam
		8–48	Gravel
*Spottswood: StA	8–15	0–8	Loam
For Fordville part of StA, see Fordville series.		8–24	Loam
		24–30	Sandy loam
		30–60	Sand and gravel
Svea: SuA, SuB, SvA, Sw	5–10	0–16	Loam
		16–60	Loam
Sverdrup: SxA, SxB	10+	0–16	Sandy loam
		16–55	Sand

See footnotes at end of table.

properties—Continued

Classification—Continued		Percentage passing sieve—			Perme-ability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 200 (0.074 mm)				
					Inches per hour	*Inches per inch of soil*	*pH value*	
Pt						0. 25	6. 6–7. 3	Low.
CL or ML	A–4	95–100	85–95	50–80	0. 63–2. 0	0. 14–0. 18	7. 4–7. 8	Low.
						0. 20	7. 4–7. 8	Low.
OL or ML	A–7	95–100	95–100	70–80	0. 2–0. 63	0. 19–0. 21	6. 6–7. 3	High.
CH	A–7	95–100	95–100	85–95	<0. 05	0. 15–0. 18	6. 6–7. 3	High.
CH	A–7	95–100	90–100	85–95	<0. 05	0. 15–0. 18	7. 4–7. 8	High.
CL	A–7	95–100	90–100	80–90	0. 2–0. 63	0. 19–0. 21	7. 9–8. 4	High.
OL	A–6 or A–7	95–100	95–100	85–95	0. 2–0. 63	0. 19–0. 21	7. 8–8. 4	High.
ML	A–4	95–100	95–100	70–90	0. 63–2. 0	0. 18–0 23	7. 8–8. 4	Low.
OH or MH	A–6	95–100	95–100	85–95	0. 2–0. 63	0. 19–0. 21	6. 6–7. 3	High.
CH	A–7	95–100	95–100	85–95	<0. 05	0. 15–0. 18	6. 6–7. 3	High.
CL	A–6 or A–7	95–100	95–100	85–95	0. 2–0. 63	0. 19–0. 21	6. 6–7. 3	High.
OL–ML	A–4	95–100	90–100	70–90	0. 63–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
ML	A–4	95–100	90–100	70–90	0. 63–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
ML	A–4	95–100	90–100	70–90	0. 63–2. 0	0. 18–0. 23	7. 4–7. 8	Low.
OH–MH	A–7	95–100	90–100	85–95	0. 2–0. 63	0. 19–0. 21	6. 6–7. 3	High.
ML or CL	A–6 or A–7	95–100	90–100	85–95	0. 2–0. 63	0. 19–0. 21	6. 6–7. 3	High.
ML	A–4	95–100	90–100	70–90	0. 2–0. 63	0. 18–0. 23	7. 4–7. 8	Low.
OH	A–7	95–100	90–100	85–95	0. 2–0. 63	0. 19–0. 21	7. 4–7. 8	High.
SM	A–2 or A–4	80–100	70–90	25–45	2. 0–6. 3	0. 06–0. 08	7. 4–7. 8	Low.
ML	A–4	90–95	85–95	60–75	0. 63–2. 0	0. 14–0. 18	6. 6–7. 3	Low to moderate.
GW	A–1	40–50	25–40	3–5	>6. 3	0. 02	7. 4–7. 8	Low.
ML	A–4	95–100	85–95	55–75	0. 63–2. 0	0. 14–0. 18	7. 4–7. 8	Low to moderate.
ML	A–4 or A–6	95–100	85–95	55–75	0. 63–2. 0	0. 14–0. 18	7. 9–8. 4	Low to moderate.
SM	A–2	95–100	90–100	15–25	>6. 3	0. 04–0. 06	7. 4–7. 8	Low.
ML	A–4	95–100	90–100	60–75	0. 63–2. 0	0. 14–0. 18	7. 4–7. 8	Low.
OL or ML	A–4	95–100	95–100	80–95	0. 63–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
ML	A–4	95–100	95–100	80–95	0. 63–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
ML	A–4	95–100	95–100	80–95	0. 63–2. 0	0. 18–0. 23	7. 4–8. 4	Low.
(1)	(1)	(1)	(1)	(1)	>6. 3	0. 04–0. 08	7. 4–7. 8	Low.
OH or MH	A–7	95–100	90–100	90–95	<0. 05	0. 15–0. 18	7. 4–7. 8	Very high.
CH	A–7	95–100	90–100	75–95	<0. 05	0. 15–0. 18	7. 8–8. 4	Very high.
CH	A–7	95–100	90–100	75–95	<0. 05	0. 15–0. 18	7. 4–7. 8	Very high.
SM	A–2	95–100	90–100	10–20	>6. 3	0. 04	7. 4–7. 8	Low.
SM or ML	A–4	95–100	90–100	40–55	2. 0–6. 3	0. 12–0. 16	6. 6–7. 3	Low.
SM or ML	A–4	95–100	90–100	40–55	2. 0–6. 3	0. 12–0. 16	6. 6–7. 3	Low.
SM	A–2	95–100	90–100	15–35	>6. 3	0. 06–0. 08	6. 6–7. 3	Low.
SM	A–2	95–100	90–100	10–20	>6. 3	0. 04	7. 4–7. 8	Low.
SM	A–2 or A–4	95–100	90–100	25–40	2. 0–6. 3	0. 10–0. 14	6. 6–7. 3	Low.
GW	A–1	35–45	20–30	3–5	>6. 3	0. 02	7. 4–7. 8	Low.
CL	A–4	90–95	85–95	50–75	0. 63–2. 0	0. 14–0. 18	6. 6–7. 3	Low.
CL	A–4	90–95	85–95	50–75	0. 63–2. 0	0. 14–0. 18	6. 6–7. 3	Low.
SM	A–2 or A–4	90–95	85–95	25–40	0. 63–2. 0	0. 10–0. 14	7. 4–7. 8	Low.
GW	A–1	40–50	25–40	3–5	>6. 3	0. 02	7. 4–7. 8	Low.
OL or ML	A–4	95–100	85–95	50–80	0. 63–2. 0	0. 14–0. 18	7. 4–7. 8	Low to moderate.
CL	A–4	95–100	85–95	50–80	0. 63–2. 0	0. 14–0. 18	7. 4–7. 8	Low to moderate.
SM	A–2 or A–4	95–100	90–100	25–45	2. 0–6. 3	0. 10–0. 14	6. 6–7. 3	Low.
SM or SP–SM	A–2 or A–3	85–95	85–90	5–20	>6. 3	0. 02–0. 04	7. 4–7. 8	Low.

TABLE 7.—*Engineering*

Soil series and map symbols	Depth to seasonal high water table	Depth from surface	Classification: USDA texture
	Feet	*Inches*	
Swenoda: SyA	3–6	0–17	Sandy loam
		17–36	Loamy sand and sandy loam
		36–60	Silt loam
Tara: TaA	5–10	0–13	Silt loam
		13–17	Silt loam
		17–24	Silt loam
		24–60	Loam
Torning: ToB	10+	0–12	Loamy fine sand
		12–60	Fine sand
*Vallers: Va. For Winger part of Va, see Winger series.	2–6	0–11	Silty clay loam
		11–20	Clay loam
		20–54	Loam
Venlo: Ve	0–2	0–16	Fine sandy loam
		16–36	Loamy fine sand
		36–60	Fine sand
Winger: Ws	2–6	0–10	Silty clay loam
		10–21	Silty clay loam
		21–26	Silty clay loam
		26–60	Loam
*Zell: ZrB, ZrC. For Rothsay part of ZrB and ZrC, see Rothsay series.	10+	0–10	Silt loam
		10–60	Silt loam

[1] Variable.

TABLE 8.—*Engineering*

[An asterisk in the first column indicates that at least one mapping unit in this series is made up of two or more kinds of soil. The soils in for referring to other series that appear

Soil series and map symbols	Suitability as a source of— Topsoil [1]	Sand	Gravel	Road fill [2]	Limitations for septic tank filter fields	Susceptibility to frost action
Alluvial land, frequently flooded: Af.	Fair	Poor	Poor	Poor to good: high water table.[3]	Severe: subject to frequent flooding.	High
Arveson: Av	Good	Suitable for fine sand: high water table.	Poor	Good: good shear strength; low compressibility; fair stability; fair compaction; good bearing capacity.	Severe: high water table; pollution hazard.	High
*Barnes: BaA, BbB2, BbC2. For Buse part of BbB2 and BbC2, see Buse series.	Good	Not suitable	Not suitable	Fair: fair shear strength; medium compressibility; fair compaction; fair bearing capacity.	Slight: moderate permeability.	Low

See footnotes at end of table.

properties—Continued

Classification—Continued		Percentage passing sieve—			Permeability	Available water capacity	Reaction	Shrink-swell potential
Unified	AASHO	No. 4 (4.7 mm)	No. 10 (2.0 mm)	No. 200 (0.074 mm)				
					Inches per hour	*Inches per inch of soil*	*pH value*	
SM	A–2 or A–4	95–100	95–100	20–40	2. 0–6. 3	0. 10–0. 14	6. 6–7. 3	Low.
SM	A–2	95–100	95–100	15–25	>6. 3	0. 04–0. 06	6. 6–7. 3	Low.
ML–CL	A–4	95–100	95–100	60–90	0. 63–2. 0	0. 18–0. 23	7. 8–8. 4	Low.
OL or ML	A–5 or A–4	95–100	90–100	80–95	0. 63–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
ML–CL	A–4	95–100	90–100	80–95	0. 63–2. 0	0. 18–0. 23	6. 6–7. 3	Low.
ML–CL	A–4	95–100	90–100	80–95	0. 63–2. 0	0. 18–0. 23	7. 4–7. 8	Low.
CL	A–4 or A–6	95–100	90–100	55–80	0. 63–2. 0	0. 14–0. 18	7. 4–7. 8	Low to moderate.
SM	A–2	95–100	90–100	20–35	>6. 3	0. 06–0. 08	6. 6–7. 3	Low.
SM or SP–SM	A–2 or A–3	95–100	90–100	5–30	>6. 3	0. 04	7. 8–8. 4	Low.
OL or ML	A–7	95–100	90–100	85–95	0. 2–0. 63	0. 18–0. 21	7. 4–7. 8	Moderate.
CL	A–6	95–100	90–100	70–80	0. 2–0. 63	0. 16–0. 18	7. 9–8. 4	Moderate.
CL	A–4	95–100	90–100	50–75	0. 63–2. 0	0. 16–0. 18	7. 4–7. 8	Low to moderate.
SM	A–2 or A–4	95–100	90–100	25–40	2. 0–6. 3	0. 12–0. 16	6. 6–7. 3	Low.
SM	A–2	95–100	90–100	15–25	>6. 3	0. 06–0. 08	6. 6–7. 3	Low.
SM or SP–SM	A–2 or A–3	95–100	90–100	5–15	>6. 3	0. 02–0. 04	6. 6–7. 3	Low.
OH or MH	A–7	95–100	90–100	85–95	0. 2–0. 63	0. 18–0. 22	7. 4–7. 8	Moderate.
ML–CL	A–6	95–100	90–100	85–95	0. 2–0. 63	0. 18–0. 22	7. 9–8. 4	Moderate.
ML–CL	A–6	95–100	90–100	85–95	0. 2–0. 63	0. 18–0. 22	7. 4–7. 8	Moderate.
CL	A–6	95–100	90–100	60–80	0. 63–2. 0	0. 14–0. 18	7. 4–7. 8	Low to moderate.
OL or ML	A–4	95–100	90–100	80–90	0. 63–2. 0	0. 18–0. 23	7. 4–7. 8	Low.
ML	A–4	95–100	90–100	80–90	0. 63–2. 0	0. 18–0. 23	7. 9–8. 4	Low.

interpretations

such mapping units may have different properties and limitations, and for this reason it is necessary to follow carefully the instructions in the first column of this table]

Soil features affecting—					
Highway location	Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
	Reservoir area	Embankment			
Subject to frequent flooding.	Subject to frequent flooding; subject to piping.	(3)	Drainage outlets inadequate.	(4)	Frequent flooding; deposition in channels.
High water table; fair compaction.	High water table; good location for dugout pits.	Fair stability and compaction; subject to piping in substratum; high water table.	Surface drainage needed; ditch banks unstable; subject to piping in substratum; tile lines susceptible to plugging.	(4)	Sandy; highly erodible.
Fair compaction; stable.	Moderate permeability; nearly impervious if compacted.	Fair stability; slow permeability if compacted.	(4)	Irregular, complex slopes.	Stable material; highly calcareous; steep in places; occasional stones or boulders.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as a source of—				Limitations for septic tank filter fields	Suscepti-bility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
*Barnes—Continued						
BcC For Buse part of BcC, see Buse series.	Not suitable.	Generally not suitable: gravelly or sandy in places.	Not suitable	Poor: very stony; poor workability.	Severe: stones and boulders hinder construction; hazard of seepage on downslope surfaces of more than 12 percent slope.	Low
Bearden: BdA	Good	Not suitable	Not suitable	Poor to fair: fair shear strength; medium compressibility; fair workability; poor bearing capacity; poor compaction characteristics.	Moderate: moderately slow permeability.	High
Benoit: Be	Good	Fair in substratum: high water table.	Good: high water table.	Fair: good bearing capacity and workability.	Severe: high water table; pollution hazard.	High
Blue Earth: Bh	Good	Not suitable	Not suitable	Poor: fair shear strength; very poor bearing capacity; poor compaction characteristics.	Severe: high water table.	High
Borup: Bm	Good	Suitable for very fine sand; high water table.	Not suitable	Poor to depth of 2 feet; fair shear strength; medium compressibility; very poor bearing capacity; poor compaction characteristics. Fair to good at a depth below 2 feet: low compressibility.	Severe: high water table; pollution hazard.	High
*Buse: BnE, BnF	Fair	Not suitable	Not suitable: pockets of gravel in places.	Fair: fair shear strength; medium compressibility; fair compaction; fair bearing capacity.	Severe: steep; moderate permeability; hazard of seepage on downslope surface.	Low
BoE	Not suitable.	Not suitable: gravelly or sandy areas in places.	Not suitable: gravelly or sandy areas in places.	Poor: very stony; poor workability.	Severe: stones and boulders hinder construction.	Low
BuB2, BuC2, BuD2 For Barnes part of BuB2, BuC2, and BuD2, see Barnes series.	Fair	Not suitable	Not suitable	Fair: fair shear strength; medium compressibility; fair compaction; fair bearing capacity.	Slight: moderate permeability; hazard of seepage on downslope surface on slopes of more than 12 percent.	Low
Clontarf: ClA	Fair	Suitable for fine and medium sand.	Poor	Good: good shear strength; low compressibility; good bearing capacity; good compaction.	Moderate: moderately rapid permeability; occasional high water table; pollution hazard.	Low

See footnotes at end of table.

interpretations—Continued

Soil features affecting—					
Highway location	Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
	Reservoir area	Embankment			
Numerous stones and boulders.	Stony [3]	Stoniness may hinder construction; fair stability; fair shear strength.	(4)	Stoniness may hinder construction; steep in places.	Stony; generally not needed if used for grassland.
Fair stability; medium compressibility.	Compaction needed; nearly impervious if compacted.	Fair stability; moderately slow permeability.	(4)	(4)	Stable; generally favorable features.
High water table; good bearing capacity; fair stability.	High water table; good location for dugout pits.	Fair stability and compaction; piping hazard; high water table.	Surface drainage needed; gravelly substratum makes tile drainage difficult.	(4)	Depth of excavation depends on depth to substratum; very pervious in substratum; difficult to vegetate; high water table.
High content of organic matter; high water table.	High water table; location good for dugout pits.	High content of organic matter; poor stability; high water table.	Surface and subsurface drainage needed.	(4)	Generally not needed; high water table.
Silty; poor stability and compaction; medium compressibility.	High water table; good location for dugout pits.	Poor stability and compaction; piping hazard; fair stability in substratum; high water table.	Surface drainage needed; subject to piping in substratum; tile lines susceptible to plugging.	(4)	Depth of excavation depends on depth to substratum; very pervious in substratum; difficult to vegetate; high water table.
Stable; steep; stones and boulders in places; fair stability.	Moderate permeability; slow permeability if compacted.	Fair stability; slow permeability if compacted.	(4)	Steep in most places.	Steep in most places.
Numerous stones and boulders.	Stony [3]	Stoniness hinders construction in places.	(4)	Stoniness hinders construction in places.	Stony; generally not needed if used for grassland.
Fair compaction; fair stability.	Moderate permeability; slow permeability if compacted.	Fair stability; slow permeability if compacted.	(4)	Irregular, complex slopes; not suited to slopes of more than 12 percent.	Stable material; highly calcareous; steep; occasional stones or boulders.
Cuts and fills subject to erosion; good compaction.	Material too porous to hold water.	Fair stability; good compaction; moderately rapid permeability if compacted; piping hazard.	(4)	(4)	Sandy; highly erodible; very pervious in substratum.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as a source of—				Limitations for septic tank filter fields	Suscepti-bility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
Colvin: Co	Good	Not suitable	Not suitable	Poor to fair: fair shear strength; medium compressibility; poor bearing capacity; fair compaction.	Severe: high water table; moderately slow permeability.	High
Cv	Good	Not suitable	Not suitable	Poor: high water table; fair shear strength; medium compressibility; poor bearing capacity; fair compaction.	Severe: high water table; flooding hazard; moderately slow permeability.	High
Darnen: DaB	Good	Not suitable	Not suitable	Poor: poor stability; poor compaction; fair shear strength; poor bearing capacity.	Moderate: slight overflow hazard.	Low
Doland: DlA, DlB	Good	Not suitable	Not suitable	Poor to fair: silty to depth of 2 feet; fair shear strength; fair workability; fair bearing capacity.	Slight: moderate permeability.	Low
Edison: EdA, EdB	Fair	Suitable in substratum for fine and very fine sand.	Not suitable	Good: loamy layer at depth of 2 feet; fair shear strength; fair compaction; good bearing capacity.	Slight: very porous	Low
Embden: Em	Good	Poor to depth of 40 inches.	Not suitable	Good: good shear strength; good bearing capacity; fair workability.	Slight: very porous	Low
Estelline: EsA	Good	Good at depth of 2 to 3 feet.	Good at depth of 2 to 3 feet.	Poor to depth of 30 inches: poor bearing capacity: fair shear strength. Good in substratum: good shear strength; good bearing capacity.	Slight: very porous; pollution hazard.	Low
Flandreau: FlA, FlB	Good	Good at depth of 2 to 3 feet.	Poor	Poor to depth of 30 inches: poor bearing capacity; fair shear strength. Good in substratum: good shear strength; fair bearing capacity.	Slight: very porous; pollution hazard.	Low
*Flom: Fm For Parnell part of Fm, see Parnell series.	Good: stony.	Generally not suitable: gravelly or sandy in places.	Generally not suitable: gravelly or sandy in places.	Poor: numerous stones and boulders.	Severe: high water table; moderately slow permeability; numerous boulders.	High

See footnotes at end of table.

interpretations—Continued

Soil features affecting—					
Highway location	Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
	Reservoir area	Embankment			
Poor stability and compaction; medium compressibility; high water table.	Slow permeability if compacted; high water table; location fair for dugout pits.	Poor stability; slow permeability if compacted; medium compressibility; high water table.	Moderately slow permeability; seasonal high water table; surface and subsurface drainage needed.	(4)	High water table; drainage needed before construction.
Poor stability; fair compaction; medium compressibility; high water table.	High water table; location good for dugout pits.	Poor stability; fair compaction; moderately slow permeability; piping hazard; high water table.	Moderately slow permeability; wet, depressional areas; tile drainage with surface inlets needed.	(4)	Very poorly drained; drainage needed before construction.
Poor compaction and compressibility; high organic-matter content.	Moderate permeability; substratum nearly impervious if compacted.	Poor stability; poor compaction; piping hazard.	(4)	Features generally favorable; can be used as outlet.	Features generally favorable; more than 2 percent slope in places.
Good stability and compaction in substratum; medium compressibility.	Moderate permeability; nearly impervious if compacted.	Silty; subject to piping; moderate permeability; good compaction and stability in substratum.	(4)	Features generally favorable.	Features generally favorable; small pockets of sand exposed in places.
Fair stability and compaction; medium compressibility.	Material too porous to hold water.	Fair stability and compaction; pervious if compacted; piping hazard.	(4)	Depth to sandy substratum within depth of channeling in places.	Low in fertility, erodible, and droughty in the sandy substratum
Fair stability; fair to good compaction; slight compressibility.	Rapid permeability; piping hazard.	Fair stability; fair to good compaction; moderate permeability if compacted; piping hazard.	(4)	(4)	Features generally favorable; droughty in places.
Poor stability, poor compaction, and medium compressibility in surface layer; fair stability in substratum.	Porous material	Piping hazard in silty material; porous sand in substratum; moderate permeability.	(4)	Sandy substratum at depth of 2 to 3 feet.	Depth of excavation depends on depth to substratum; very pervious in substratum; difficult to vegetate; droughty and low in fertility in places.
Poor stability, poor compaction, and medium compressibility in surface layer; fair stability in substratum.	Material too porous to hold water.	Poor stability and compaction; piping hazard; porous sand in substratum.	(4)	Sandy substratum at depth of 2 to 3 feet.	Depth of excavation depends on depth to substratum; very pervious in substratum; difficult to vegetate; droughty and low in fertility in places.
Numerous stones and boulders.	Numerous boulders [3]	Numerous boulders hinder construction in places.	Numerous boulders [3]	(4)	(4).

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as a source of—				Limitations for septic tank filter fields	Suscepti-bility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
*Flom—Continued						
Fn. For Parnell part of Fn, see Parnell series.	Good: many stones.	Generally not suitable: gravelly or sandy in places.	Generally not suitable: gravelly or sandy in places.	Poor: numerous stones and boulders; poor workability.	Severe: high water table; moderately slow permeability; numerous boulders.	High.
Fordville:						
FoB	Good	Good: sand and gravel at depth of 2 to 3 feet.	Good: sand and gravel at depth of 2 to 3 feet.	Good in substratum: excellent shear strength; good bearing capacity; good compaction.	Slight: rapid permeability in substratum; pollution hazard.	Low.
FrA	Not suit-able.	Good: many boulders, sand, and gravel at depth of 2 to 3 feet.	Good: numerous boulders. Gravel at depth of 2 to 3 feet.	Good: numerous boulders; good in substratum.	Slight: rapid permeability in substratum; numerous boulders; pollution hazard.	Low.
Fossum: Fs	Fair	Fair: fine sand; high water table.	Not suitable	Good: good shear strength; good bear-ing capacity; high water table.	Severe: high water table; pol-lution hazard.	High.
Fulda: FvA	Fair	Poor	Not suitable	Poor: poor shear strength; high com-pressibility; fair to poor compaction; poor bearing capac-ity; high water table.	Severe: high water table; very slow permeability.	High.
Fulda, sand subsoil variant:						
FuA	Fair	Good: sand at depth of 2 to 3 feet.	Not suitable	Poor to depth of sub-stratum; good in substratum; good shear strength; good bearing capacity; fair compaction characteristics.	Slight: rapid per-meability in sub-stratum; pollu-tion hazard.	High.
FwA	Fair	Good: sand at depth of 2 to 3 feet.	Not suitable	Poor to depth of sub-stratum; good in substratum; good shear strength; good bearing capacity; fair compaction characteristics.	Moderate: high water table; rapid permeability in substratum; pol-lution hazard.	High.

See footnotes at end of table.

interpretations—Continued

Soil features affecting—					
Highway location	Farm ponds: Reservoir area	Farm ponds: Embankment	Agricultural drainage	Terraces and diversions	Waterways
Numerous stones and boulders.	Numerous boulders [3]	Numerous boulders hinder construction in places.	Numerous boulders [3]	(4)	(4).
Fair stability; very low compressibility; good bearing capacity.	Porous material	Fair to good stability and compaction to depth of 24 to 36 inches; very stable in substratum; highly porous.	(4)	Sand and gravel substratum at depth of 24 to 36 inches.	Depth of excavation depends on depth to substratum; very pervious in substratum; difficult to vegetate; low in fertility and droughty in places.
Numerous stones and boulders.	Stony [3]	Stoniness hinders construction in places; porous substratum.	(4)	Numerous boulders, sand, and gravel in substratum at depth of 24 to 36 inches.	Generally not needed if used for grassland.
Fair stability; fair to good compaction; slight compressibility; high water table.	High water table; location good for dugout pits.	Fair stability; fair to good compaction; rapid permeability; piping hazard; high water table.	Surface drainage needed; piping hazard in substratum; ditchbanks unstable; tile should be blinded to prevent plugging.	(4)	Generally not needed; level; poorly drained.
High water table; poor stability; very slow permeability.	High water table; good location for dugout pits; very slow permeability.	Fair to poor compaction; poor stability; cracks on drying; very slow permeability; high water table.	Very slow permeability; surface-ditch and tile drainage needed.	(4)	Drainage needed before construction.
Poor stability and compaction, and medium compressibility to depth of substratum; fair stability in substratum.	Substratum too porous to hold water.	Poor stability; poor compaction; cracks on drying in material extending to depth of substratum; subject to piping and rapid permeability in substratum.	(4)	(4)	Depth of excavation depends on depth to substratum; very pervious substratum; difficult to vegetate.
Poor stability and compaction and medium compressibility to depth of substratum; fair stability in substratum.	High water table; fair location for dugout pits.	Poor stability; poor compaction; cracks on drying in material to depth of substratum; subject to piping and rapid permeability in substratum.	Very slow permeability; subsoil material flows; tile should be blinded to prevent plugging.	(4)	Depth of excavation depends on depth to substratum; very pervious substratum; difficult to vegetate.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as a source of—				Limitations for septic tank filter fields	Suscepti-bility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
Glyndon: GdA	Good	Very fine sand.	Not suitable	Poor to depth of substratum: fair shear strength; poor bearing capacity. Good in substratum: good bearing capacity.	Slight: rapid permeability in substratum; pollution hazard.	Low
Hamar: Ha, Hc	Poor	Poorly graded sands; high water table.	Not suitable	Good: high water table; good shear strength; good bearing capacity.	Severe: high water table; pollution hazard.	High
Hamerly: HdA	Good	Not suitable	Not suitable	Fair: fair shear strength and bearing capacity; good compaction; medium compressibility.	Slight: moderate permeability.	Moderate
Hantho: HhA	Good	Not suitable	Not suitable	Poor: fair shear strength; poor bearing capacity; medium workability.	Slight: moderate permeability.	Moderate
*Hattie:						
HtC2	Fair	Not suitable	Not suitable	Poor: poor shear strength; fair bearing capacity; high shrink-swell potential; poor workability.	Severe: very slow permeability.	Low
HuB For Nutley part of HuB, see Nutley series.	Fair	Not suitable	Not suitable	Poor: poor shear strength; fair bearing capacity; high shrink-swell potential; poor workability.	Severe: slow permeability.	Low
Hecla: HvA	Poor	Poorly graded sands.	Not suitable	Good: good shear strength; good bearing capacity; low compressibility.	Moderate: high water table; rapid permeability in substratum.	Low
Hegne: Hy	Fair	Not suitable	Not suitable	Poor: poor shear strength; poor workability and bearing capacity.	Severe: high water table; very slow permeability.	High

See footnotes at end of table.

interpretations—Continued

Soil features affecting—					
Highway location	Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
	Reservoir area	Embankment			
Poor stability, poor compaction, and medium compressibility in silty material; fair stability and good compaction in substratum.	Material too porous to hold water.	Poor stability, poor compaction, and piping hazard in silty material; rapid permeability in substratum.	(4)	(4)	Depth of excavation depends on depth to substratum; very pervious in substratum; difficult to vegetate; droughty and low in fertility in places.
Fair stability; fair compaction; slight compressibility; high water table.	High water table; good location for dugout pits.	Fair stability and compaction; rapid permeability; piping hazard; high water table.	Surface drainage needed; subject to piping in substratum; ditchbanks unstable.	(4)	Generally not needed; level surface; poorly drained.
Good stability and compaction; medium compressibility.	Moderate permeability; nearly impervious if compacted.	Good stability and compaction; moderate permeability.	(4)	Undulating topography.	Stable material; highly calcareous.
Poor stability and compaction; medium compressibility.	Piping hazard; moderately pervious to nearly impervious if compacted.	Poor stability and compaction; moderate permeability and piping hazard in silty material.	(4)	(4)	Features generally favorable.
Fair stability and compaction; high compressibility.	Very slow permeability; nearly impervious if compacted; high shrink-swell potential.	Fair stability and compaction; very slow permeability; cracks on drying.	(4)	Suited to slopes of not more than 12 percent; clayey subsoil; very slow permeability; construction difficult.	Stable material; fine textured; calcareous; steep.
Fair to poor stability and compaction; high compressibility.	Slow permeability; nearly impervious if compacted; high shrink-swell potential.	Good stability and compaction; slow permeability; cracks on drying.	(4)	Clayey subsoil; slow permeability; construction difficult.	Stable material; fine textured.
Cuts or fills subject to erosion; fair to good compaction.	Too porous to hold water.	Fair stability and fair to good compaction; rapid permeability; subject to piping.	(4)	(4)	High rate of infiltration; hazard of erosion if not covered; droughty; low fertility.
Fair to poor stability and compaction; high compressibility.	High water table; good location for dugout pits; very slow permeability.	Fair to poor stability; very slow permeability; cracks on drying; high water table.	Very slow permeability; surface and subsurface drainage needed.	(4)	Drainage needed before construction; high water table.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as a source of—				Limitations for septic tank filter fields	Suscepti-bility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
*Lamoure:						
Lm	Good	Not suitable	Not suitable	Poor: fair shear strength; poor bearing capacity; high water table.	Severe: high water table.	High
Lr For Rauville part of Lr, see Rauville series.	Fair	Not suitable	Not suitable	(3, 4)	Severe: frequently flooded.	High
La Prairie: Ls	Good	Not suitable	Not suitable	Poor: fair shear strength; poor bearing capacity; fair workability.	Moderate: moderately slow permeability; high water table.	Moderate
Maddock:						
McA, McB, McD, MdB	Fair to poor.	Good	Not suitable	Good: good shear strength; good bearing capacity; fair workability.	Slight: rapid permeability; pollution hazard.	Low
Mk	Poor	Good	Not suitable	Good: good shear strength; good bearing capacity; fair workability.	Slight: rapid permeability.	Low
MbA	Poor	Good	Not suitable	Good to depth of substratum: good shear strength and bearing capacity; fair workability. Poor in substratum: poor bearing capacity; fair shear strength.	Slight: moderate permeability in substratum.	Low
Malachy:						
MmA	Good	Good	Not suitable	Good: fair shear strength; fair bearing capacity; fair workability.	Moderate: high water table; rapid permeability; pollution hazard.	Low
MnA	Good	Not suitable	Not suitable	Good: fair shear strength; fair bearing capacity; fair workability.	Moderate: high water table; moderately slow permeability in silty clay loam layer.	Low

See footnotes at end of table.

interpretations—Continued

Soil features affecting—					
Highway location	Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
	Reservoir area	Embankment			
Fair stability and compaction; medium to high compressibility; high water table.	High water table; good location for dugout pits.	Fair stability and compaction; moderately slow permeability; high water table.	Surface and subsurface drainage needed; moderately slow permeability; outlets difficult to obtain.	(4)	High water table; subject to overflow in places.
High water table; flooding hazard.	High water table; good location for dugout pits.	(3, 4)	Suitable outlets needed; hazard of overflow.	(4)	Generally not needed; high water table; subject to flooding.
Fair to good stability and compaction; medium to high compressibility.	Moderately slow permeability; nearly impervious if compacted.	Fair stability and compaction.	(4)	(4)	Most features generally favorable; stable; subject to high water table in places.
Fair stability; fair compaction; slight compressibility.	Material too porous to hold water.	Fair stability and compaction; moderate permeability if compacted; piping hazard.	(4)	Sandy material; highly erodible; difficult to vegetate.	High rate of infiltration; hazard of erosion if not covered; droughty low in fertility.
Fair stability; fair compaction; slight compressibility.	Material too porous to hold water.	Fair stability; fair compaction; piping hazard.	(4)	Not suited; irregular, short slopes; highly erodible.	High rate of infiltration; hazard of erosion if not covered; droughty low in fertility.
Fair stability; fair compaction; slight compressibility.	Porous in surface layer; fair compaction in substratum and moderate permeability if compacted.	Fair stability and compaction; moderate permeability if compacted; piping hazard.	(4)	Sandy material; highly erodible; difficult to vegetate.	High rate of infiltration; hazard of erosion if not covered; droughty low in fertility.
Fair stability; fair to good compaction; slight compressibility.	Material too porous to hold water.	Fair stability and compaction; moderate permeability; piping hazard.	(4)	(4)	High rate of infiltration; subject to soil blowing; difficult to vegetate.
Fair stability; fair to good compaction; slight compressibility.	Material too porous to hold water.	Fair stability, fair compaction, moderate permeability in surface layer; poor stability, poor compaction, moderately slow permeability in subsoil; piping hazard.	(4)	(4)	High rate of infiltration; subject to soil blowing; difficult to vegetate.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as a source of—				Limitations for septic tank filter fields	Suscepti-bility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
Marsh: Mo.[5]						
Marysland: Mp	Good	Good at depth of 2 to 3 feet; high water table.	Good at depth of 2 to 3 feet; high water table.	Fair to depth of substratum: fair shear strength; fair bearing capacity. Good in substratum: good bearing capacity; medium compressibility; high water table.	Severe: high water table; rapid permeability; pollution hazard.	High
Mayer:						
Mr	Good	Good: mixed sand and gravel; high water table.	Good: mixed sand and gravel; high water table.	Poor to depth of substratum: fair shear strength; fair bearing capacity. Good in substratum: good bearing capacity; medium compressibility; high water table.	Severe: high water table; rapid permeability; pollution hazard.	High
Ms	Good	Fair: mixed sand and gravel; high water table.	Fair: mixed sand and gravel; high water table.	Poor in loamy surface layer: fair shear strength; medium compressibility; fair to good compaction. Good in substratum: good shear strength; slight compressibility; fair to good compaction; high water table.	Severe: high water table; frequent flooding; pollution hazard.	High
McIntosh: MtA	Good	Not suitable	Not suitable	Fair: fair shear strength; poor bearing capacity; medium compressibility; fair workability.	Slight: moderate permeability.	High
Muck and peat:						
Mu	Poor	Not suitable	Not suitable	Not suitable: organic soils.	Severe: high water table.	High
Mv	Poor	Not suitable	Not suitable	Not suitable: organic soils.	Severe: high water table.	High
Mw	Poor	Not suitable	Not suitable	Not suitable: organic soils.	Severe: high water table.	High

See footnotes at end of table.

interpretations—Continued

Soil features affecting—					
Highway location	Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
	Reservoir area	Embankment			
High water table; fair to good stability to depth of substratum; fair to good compaction; medium compressibility and fair stability in substratum.	High water table; good location for dugout pits.	Fair stability, fair compaction, and moderate permeability in loam; very porous and subject to piping in substratum; high water table.	Surface drainage needed; subject to piping in substratum; fine material may flow into and plug tile.	(4)	Drainage needed before construction; depth of excavation depends on depth to substratum; difficult to establish plant cover on pervious substratum.
High water table; fair stability; fair compaction; medium compressibility.	High water table; good location for dugout pits.	Very stable and highly pervious in substratum; high water table.	Surface and subsurface drainage needed; tile drainage requires blinding in gravelly subsoil.	(4)	Drainage needed before construction; depth of excavation depends on depth to substratum; difficult to establish plant cover on pervious substratum.
Fair stability; high water table.	High water table; good location for dugout pits.	Fair stability, fair to good compaction, and moderate permeability to depth of substratum; fair stability and highly pervious in substratum; high water table.	Wet, depressional areas; drainage outlets generally difficult to obtain; tile should be blinded to prevent plugging.	(4)	Depressional; high water table.
Fair stability and compaction; medium compressibility.	Moderate permeability; nearly impervious if compacted.	Fair stability and compaction; moderate permeability.	(4)	(4)	Stable material; calcareous.
Organic soils; high water table.	High water table; good location for dugout pits.	High organic-matter content.	Surface and subsurface drainage needed; control of water table in drained areas needed.	(4)	(4).
Organic soils; high water table.	High water table; good location for dugout pits.	High organic-matter content.	Surface and subsurface drainage needed; control of water table in drained areas needed.	(4)	(4).
Organic soils; high water table.	High water table; good location for dugout pits.	High organic-matter content.	Surface and subsurface drainage needed; place tile in mineral material; control of water table in drained areas needed.	(4)	(4).

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as a source of—				Limitations for septic tank filter fields	Suscepti-bility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
Muck and peat—Continued Mx	Poor	Not suitable	Not suitable	Not suitable: organic soils.	Severe: high water table.	High
My	Poor	Not suitable	Not suitable	Not suitable: organic soils; high water table.	Severe: high water table.	High
*Nutley: NhA For Hattie part, see Hattie series.	Fair	Not suitable	Not suitable	Poor: poor shear strength; fair bearing capacity; high shrink-swell potential; poor workability.	Severe: very slow permeability in substratum.	Moderate
Oldham: Om	Good	Not suitable	Not suitable	Poor: fair shear strength; poor bearing capacity; high water table.	Severe: high water table; frequent flooding.	High
*Parnell: Pa	Good	Not suitable	Not suitable	Poor: poor shear strength; fair to poor bearing capacity; poor workability; high water table.	Severe: high water table; frequent flooding.	High
Pf For Flom part of Pf, see Flom series.	Good	Not suitable	Not suitable	Poor: poor shear strength; fair to poor bearing capacity; poor workability; high water table.	Severe: high water table; very slow permeability.	High
Perella: Pr	Good	Not suitable	Not suitable	Poor: fair shear strength; poor bearing capacity; medium compressibility; fair workability.	Severe: high water table; moderate permeability.	High
Ps	Good	Not suitable	Not suitable	Poor: fair shear strength; fair to poor bearing capacity; poor workability; high water table.	Severe: high water table; frequent flooding.	High

See footnotes at end of table.

interpretations—Continued

Soil features affecting—					
Highway location	Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
	Reservoir area	Embankment			
Organic soils; high water table.	High water table; good location for dugout pits.	High organic-matter content.	Surface and sub-surface drainage needed; place tile in mineral material; control of water table in drained areas needed.	(4)	(4).
Organic soils; high water table.	High water table; good location for dugout pits.	High organic-matter content.	Surface drainage needed; subject to piping in substratum; hazard of tile plugging.	(4)	(4).
Fair to poor stability and compaction; high compressibility.	Very slow permeability; nearly impervious if compacted; high shrink-swell potential.	Fair to poor stability and compaction; very slow permeability; cracks on drying.	(4)	(4)	Stable, fine-textured material.
Fair stability and compaction; medium to high compressibility; high water table.	High water table; good location for dugout pits.	Fair stability and compaction; subject to piping; moderately slow permeability; high water table.	Wet; depressional; moderately slow permeability; surface drainage and tile drainage with surface inlets needed.	(4)	Drainage needed before construction.
Fair stability and compaction; medium to high compressibility; high water table.	High water table; good location for dugout pits.	Fair stability and compaction; very slow permeability; high water table.	Occupy wet depressional areas; very slow permeability; surface drainage and tile drainage with surface inlets needed.	(4)	Drainage needed before construction.
Fair stability and compaction; medium to high compressibility; high water table.	High water table; very slow permeability.	Fair stability and compaction; very slow permeability; high water table.	Surface and subsurface drainage needed; very slow permeability; seasonal high water table.	(4)	Drainage needed before construction; high water table.
Poor stability and compaction; medium compressibility; high water table.	Poorly drained; moderate permeability; nearly impervious if compacted.	Poor stability and compaction; moderate permeability; piping hazard; high water table.	Moderate permeability; seasonal high water table; surface drainage needed.	(4)	Drainage needed before construction; high water table.
Poor to fair stability and compaction; medium compressibility; high water table.	High water table; good location for dugout pits.	Fair stability; fair compaction; high water table.	Surface and subsurface drainage needed; moderately slow permeability; depressional; tile drainage with surface inlets needed.	(4)	Drainage needed before construction.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as a source of—				Limitations for septic tank filter fields	Suscepti-bility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
Rauville: Ra	Good	Not suitable	Not suitable	Poor: fair shear strength; fair to poor bearing capacity; poor workability; high water table.	Severe: frequent flooding.	High
*Renshaw: ReA, ReB, ReC2	Good	Fair at depth of 1 to 2 feet; mixed sand and gravel.	Good at depth of 1 to 2 feet; mixed sand and gravel.	Fair to depth of 20 inches; excellent in substratum; good bearing capacity; good shear strength.	Slight: rapid permeability; pollution hazard.	Low
RhB	Many stones.	Fair: numerous boulders; sand and gravel at depth of 1 to 2 feet.	Good: numerous boulders; sand and gravel at depth of 1 to 2 feet.	Poor: numerous boulders.	Slight: numerous boulders; pollution hazard.[3]	Low
Rk. For Fordville part of Rk, see Fordville series.	Stony	Fair: numerous boulders; sand and gravel at depth of 1 to 2 feet.	Good: numerous boulders; sand and gravel at depth of 1 to 2 feet.	Poor: numerous boulders.	Slight to numerous boulders; pollution hazard.[3]	Low
Rockwell: Rm, Rn	Good	Not suitable	Not suitable	Fair to depth of substratum: good shear strength; fair bearing capacity; poor in substratum; poor bearing capacity.	Severe: high water table.	High
Rothsay: RoA, RoB	Good	Not suitable	Not suitable	Poor: fair shear strength; poor bearing capacity; fair workability.	Moderate: moderate permeability.	High
Sandy lake beaches: Sa	Poor	Poor: high water table.	Not suitable	Poor: high water table.	Severe: high water table; frequent flooding.	High
Shakopee: Se	Fair	Fair at depth of 2 to 3 feet.	Not suitable	Poor to depth of substratum; good in substratum; good shear strength; good bearing capacity; fair compaction.	Severe: high water table; rapid permeability in substratum; pollution hazard.	High

See footnotes at end of table.

interpretations—Continued

Soil features affecting—					
Highway location	Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
	Reservoir area	Embankment			
Fair stability and compaction; medium compressibility; fair shear strength; high water table; flooding frequent.	High water table; good location for dugout pits.	Fair stability and compaction; subject to piping; highly pervious in substratum; high water table.	Depends on suitability of outlet.	(4)	Frequent flooding; deposition in channels.
Good stability and compaction and slight compressibility in substratum.	Material too porous to hold water.	Good stability and compaction to depth of 20 inches; very stable and highly pervious in substratum.	(4)	Shallow depth to sand and gravel substratum; difficult to vegetate.	Depth of excavation depends on depth to substratum; substratum is very porous and difficult to vegetate; droughty and low in fertility in places.
Numerous boulders in surface layer; good compaction, slight compressibility, and very stable in gravelly material.	Material too porous to hold water.	Good stability and compaction to depth of 20 inches; very stable and highly pervious in substratum; numerous boulders.	(4)	Numerous boulders; shallow depth to sand and gravel substratum.	Generally not needed if used for grassland.
Numerous boulders in surface layer; good compaction, slight compressibility, and very stable in gravelly material.	Material too porous to hold water.	Good stability and compaction to depth of 20 inches; very stable and highly pervious in substratum; numerous boulders.	(4)	Numerous boulders; shallow depth to sand and gravel substratum.	Generally not needed if used for grassland.
Fair stability and compaction; medium compressibility; high water table.	High water table; moderate permeability.	Fair stability and compaction; subject to piping; high water table.	Surface and subsurface drainage needed; fine material flows if wet; tile should be blinded or placed in loamy substratum.	(4)	Drainage needed before construction.
Fair stability and compaction; medium compressibility; fair shear strength.	Piping hazard; moderate permeability if compacted.	Fair stability and compaction; moderate permeability; piping hazard.	(4)	Generally favorable features; moderate permeability.	Generally favorable features; stable material; small pockets of sand are exposed in places.
Variable material; high water table; frequent flooding.	High water table; good location for dugout pits.	Fair stability and compaction; piping hazard; rapid permeability; high water table.	Outlets difficult to obtain; high water table.	(4)	Difficult to vegetate.
Fair stability and compaction; high compressibility; poor shear strength; poorly graded sands in substratum.	High water table; good location for dugout pits.	Fair stability and compaction; highly impervious; cracks on drying; subject to piping in substratum; high water table.	Very slow permeability; surface drainage needed; subject to piping in subsoil; tile needs blinding.	(4)	Depth of excavation depends on depth to substratum; substratum is very pervious and difficult to vegetate; drainage needed.

TABLE 8.—*Engineering*

Soil series and map symbols	Suitability as a source of—				Limitations for septic tank filter fields	Suscepti-bility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
Shible: SfA, SfB	Fair	Good: fine sand.	Not suitable	Good: fair shear strength; good bearing capacity; fair workability.	Slight: rapid permeability in substratum; pollution hazard.	Low
Sioux: SsA, SsB, SsC, SsE	Poor	Good: mixed sand and gravel.	Good: mixed sand and gravel.	Excellent: good shear strength; good bearing capacity; good workability.	Slight: rapid permeability; pollution hazard; hazard of seepage on downslope surfaces of more than 12 percent slope.	Low
*Spottswood: StA. For Fordville part, see Fordville series.	Good	Good at depth of 2 to 3 feet: mixed sand and gravel.	Good at depth of 2 to 3 feet: mixed sand and gravel.	Fair to depth of substratum: fair shear strength and bearing capacity. Excellent in substratum: good shear strength and bearing capacity.	Slight: rapid permeability in substratum; pollution hazard.	Low
Svea:						
SuA, SuB	Good	Not suitable	Not suitable	Fair: fair shear strength; medium compressibility; fair compaction; fair bearing capacity.	Slight: moderate permeability.	Moderate
SvA	Fair: numerous boulders.	Not suitable	Not suitable	Fair: fair shear strength; medium compressibility; fair stability and compaction; good bearing capacity; numerous boulders.	Slight: numerous boulders.[3]	Moderate
Sw	Poor: numerous boulders.	Not suitable	Not suitable	Fair: fair shear strength; medium compressibility; fair stability and compaction; good bearing capacity; numerous boulders.	Slight: numerous boulders.[3]	Moderate
Sverdrup: SxA, SxB	Good	Good	Poor	Good: fair shear strength; good bearing capacity; fair workability.	Slight: rapid permeability in substratum; pollution hazard.	Low
Swenoda: SyA	Fair	Not suitable	Not suitable	Good to depth of substratum: fair bearing capacity; fair shear strength. Poor in substratum: fair shear strength; poor bearing capacity.	Slight: moderate permeability in substratum.	Moderate

See footnotes at end of table.

interpretations—Continued

Soil features affecting—					
Highway location	Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
	Reservoir area	Embankment			
Fair stability; fair to good compaction; slight compressibility.	Material too porous to hold water.	Fair stability and compaction; moderately rapid permeability; piping hazard.	(4)	Depth to sandy substratum within depth of channeling in places.	High rate of infiltration; droughty; low in fertility.
Stable; low compressibility; good shear strength; pervious if compacted.	Material too porous to hold water.	Very stable; good compaction; highly pervious.	(4)	Very shallow depth to gravel substratum; difficult to vegetate.	Depth of excavation depends on depth to substratum; substratum is very pervious and difficult to vegetate; droughty; low in fertility.
Good compaction; fair shear strength to depth of 2 to 3 feet. Very stable, good compaction, and very slight compressibility in substratum.	Material too porous to hold water.	Fair stability to depth of 2 to 3 feet; very stable and highly pervious in substratum.	(4)	(4)	Depth of excavation depends on depth to substratum; substratum very pervious and difficult to vegetate; droughty; low in fertility.
Fair stability; fair to good compaction.	Moderate permeability; nearly impervious if compacted.	Fair stability; fair to good compaction; moderate permeability; medium compressibility.	(4)	Generally favorable features; moderate permeability.	Generally favorable features; stable material; stones or boulders in places.
Stable material; fair to good compaction; numerous boulders.	Moderate permeability; nearly impervious if compacted; numerous boulders.	Fair stability and compaction; medium compressibility; numerous boulders.	(4)	Generally favorable features except for numerous boulders.	Generally not needed if used for grassland; numerous boulders.
Stable material; fair to good compaction; numerous boulders.	Moderate permeability; nearly impervious if compacted; numerous boulders.	Fair stability and compaction; medium compressibility; numerous boulders.	(4)	Generally favorable features except for numerous boulders.	Generally not needed if used for grassland; numerous boulders.
Fair stability; fair compaction; slight compressibility.	Material too porous to hold water.	Fair stability and compaction; piping hazard; moderately rapid permeability.	(4)	Sandy substratum within depth of channeling in places; highly erodible; difficult to vegetate.	High rate of infiltration; slopes without cover subject to erosion; droughty; low in fertility.
Fair stability and compaction; slight compressibility; fair shear strength.	Material too porous to hold water.	Fair stability and compaction.	(4)	(4)	High rate of infiltration; droughty; low in fertility.

TABLE 8.—*Engineerin*

Soil series and map symbols	Suitability as a source of—				Limitations for septic tank filter fields	Suscepti-bility to frost action
	Topsoil [1]	Sand	Gravel	Road fill [2]		
Tara: TaA	Good	Not suitable	Not suitable	Fair: fair shear strength; poor bearing capacity; fair workability.	Slight: moderate permeability.	High
Torning: ToB	Poor	Good: fine and very fine sand.	Not suitable	Good: good shear strength; good bearing capacity; fair workability.	Slight: rapid permeability; pollution hazard.	Low
*Vallers: Va For Winger part, see Winger series.	Good	Not suitable	Not suitable	Poor: fair shear strength; fair bearing capacity; fair workability.	Severe: high water table; moderately slow permeability.	High
Venlo: Ve	Poor	Good: high water table.	Not suitable	Poor: high water table; good shear strength; good bearing capacity.	Severe: high water table; flooding hazard; pollution hazard.	High
Winger: Ws	Good	Not suitable	Not suitable	Poor: fair shear strength; fair bearing capacity; fair workability.	Severe: high water table; moderately slow permeability.	High
*Zell: ZrB, ZrC For Rothsay part, see Rothsay series.	Fair	Not suitable	Not suitable	Poor: fair shear strength; poor bearing capacity; fair workability.	Moderate: moderate permeability; steep in places; hazard of seepage on downslope surfaces of more than 12 percent.	Low

[1] Refers to surface layer only.
[2] Refers to the substratum or underlying material unless otherwise specified.
[3] Properties of the soil materials are variable. Each site should be checked.

interpretations—Continued

Soil features affecting—					
Highway location	Farm ponds		Agricultural drainage	Terraces and diversions	Waterways
	Reservoir area	Embankment			
Fair stability and compaction; medium compressibility; fair shear strength.	Piping hazard; moderate permeability.	Silty; fair stability and compaction; moderate permeability; piping hazard.	(4)	Generally not needed.	Features generally favorable; material stable.
Fair stability; fair compaction; slight compressibility; good shear strength.	Material too porous to hold water.	Fair stability and compaction; rapid permeability; piping hazard.	(4)	Sandy; highly erodible; difficult to vegetate.	Sandy, erodible substratum has low fertility; droughty.
High water table; fair stability and compaction; medium compressibility; fair shear strength.	High water table; fair location for dugout pits; moderately slow permeability.	Fair stability and compaction; good resistance to piping; high water table.	Moderately slow permeability; seasonal high water table; surface and subsurface drainage needed.	(4)	Drainage needed before construction; high water table in places; highly calcareous.
Fair stability; fair compaction; slight compressibility; good shear strength; high water table.	High water table; good location for dugout pits.	Fair stability; subject to piping; high water table.	Wet; depressional; difficult to obtain outlets; surface drainage needed; ditchbanks unstable; subject to piping in substratum; material may flow into and plug tile.	(4)	High water table.
High water table; fair stability and compaction; medium compressibility; fair shear strength.	High water table; moderately slow permeability.	Fair stability and compaction; slow permeability if compacted; high compressibility; high water table.	Moderately slow permeability; seasonal high water table; surface and subsurface drainage needed.	(4)	Drainage needed before construction; high water table in places; calcareous.
Poor stability and compaction; medium compressibility: fair shear strength.	Piping hazard; moderate permeability if compacted.	Poor stability and compaction; moderate permeability; subject to piping.	(4)	Slopes of not more than 12 percent are suitable; short slopes in most places.	Generally short slopes; steep; generally high runoff velocity; calcareous.

[4] Practice generally is not applied to this soil.
[5] No interpretations provided. Check each site.

Some engineers prefer to use the Unified soil classification system. In this system, soils are identified according to their textural and plasticity qualities and are grouped according to their performance as engineering construction materials. Soil materials are divided into 15 classes; eight classes are for coarse-grained material, six classes are for fine-grained material, and one class is for highly organic material. Soils that have characteristics of two classes are designated by symbols for both classes; for example, CH or MH. The classes range from GW, consisting of well-graded gravels or gravel-sand mixtures with little or no fines, to Pt, consisting of peat and other highly organic soils. The soils of the county have been classified only in the SW, SP, SP–SM, SM, ML, ML–CL, CL, OL, CH, OH, GM, GW, GP, and Pt classes. The classification of the soils tested according to the Unified system is given in table 6.

Engineering test data

Soil samples from seven important soils series in Swift County were tested by standard procedures to help evaluate the soils for engineering purposes. The samples were taken from 21 locations, and only selected layers of each soil were sampled. Tests made were for moisture-density relationships, grain-size distribution, liquid limit, and plasticity index. The results of the tests and the classification of each sample, according to both the AASHO and Unified systems, are given in table 6.

The engineering classifications in table 6 are based on data obtained by mechanical analysis and by tests to determine liquid limits and plastic limits. The mechanical analysis was made by combined sieve and hydrometer methods.

In the moisture-density, or compaction, test a sample of the soil material is compacted several times with a constant compactive effort, each time at a successively higher moisture content. The moisture content increases until the optimum moisture content is reached. After that the density decreases with increase in moisture content. The highest density obtained in the compaction test is termed "maximum density." Moisture-density data are important in construction, for as a rule, optimum stability is obtained if the soil is compacted to about the maximum dry density at approximately the optimum moisture content.

Mechanical analysis shows the percentage, by weight, of soil particles that would pass sieves of specified sizes. Sand and coarser materials do not pass through the No. 200 sieve, but silt and clay do. Clay is the part passing through the No. 200 sieve that is smaller than 0.002 millimeter in diameter. The material intermediate in size between that held on the No. 200 sieve and that having a diameter of 0.002 millimeter is called silt.

The tests for the liquid limit and plastic limit measure the effect of water on the consistence of the soil material. As the moisture content of a clayey soil increases from a very dry state, the material changes from a semisolid to a plastic state. As the moisture content is further increased, the material changes from a plastic to a liquid state. The *plastic limit* is the moisture content at which the soil material passes from a semisolid to a plastic state. The *liquid limit* is the moisture content at which the soil material passes from a plastic to a liquid state. The *plasticity index* is the numerical difference between the liquid limit and the plastic limit. It indicates the range in moisture content within which a soil material is in a plastic condition.

Engineering properties

In table 7 the soil series of the county and the symbols for mapping units are listed, and certain characteristics that are significant to engineering are described. The estimated classification according to the AASHO and Unified classification systems is given for each important layer. These estimates are based on soil test data in table 6, on information in the rest of the survey, and on experience with similar soils in this and other counties. Because bedrock is at a great depth in this county and is not significant to engineering, it is not mentioned in table 7.

Permeability of the soil as it occurs in place was estimated. The estimates are based on the structure and porosity of the soil as it occurs in place and on permeability tests on undisturbed cores of similar material.

Available water capacity, given in inches of water per inch of soil depth, refers to approximate amount of capillary water in the soil when the soil is wet to field capacity. When the soil is at the wilting point of common plants, this same amount of water will wet the soil material to a depth of 1 inch without deeper percolation. Data are needed on representative soils from undisturbed soil samples or from field measurements if reliable estimates of water capacity are to be made.

Reaction, as shown in the table, is the estimated range in pH values for each major horizon as determined in the field. It indicates the acidity or alkalinity of the soils. Soil reaction in a range of 6.6 to 7.3 is called neutral; a lower pH range indicates acidity, and a higher range indicates alkalinity.

The shrink-swell potential refers to the change in volume of the soil that results from a change in moisture content. It is estimated on the basis of the amount and type of clay in the soil layers. In general soils classified as A–7 and CH have high shrink-swell potential. Clean sands and gravels and those having a small amount of nonplastic to slightly plastic fines have low shrink-swell potential, as do most other nonplastic to slightly plastic soil materials.

Engineering interpretations

Table 8 rates the soils according to their suitability as a source of topsoil, sand, gravel, and road fill. It also gives soil features that affect the use of soils for sewage disposal systems, highway location, farm ponds, and agricultural engineering.

The suitability ratings for topsoil, sand, and gravel apply only to the survey area. Some soils are rated fair or poor as a source of topsoil because they are eroded, low in content of organic matter, or low in natural fertility, or because they have a surface layer that is sticky and difficult to work. The soils rated as good sources of sand will need further examination if material meeting certain gradation requirements is required.

Ratings for suitability of the soils as road fill apply only to materials below the surface layer. Generally, the soils were rated according to their AASHO classification.

Sandy soils A–1, A–2, or A–3 are good; loamy soils A–4 or A–5 are fair; clayey soils A–6 or A–7 are poor; and organic soils are poor. The significant soil features affecting the suitability for road fill are also rated.

The suitability of soils for septic tank filter fields is important if residential and industrial developments must depend on septic tank disposal systems. In table 8 the soil limitations have been rated as slight, moderate, or severe. Among the features that affect the use of a soil for a septic tank filter field are slope, permeability, seepage, depth to the water table, presence of stones and boulders, and the hazard of flooding. It should be noted that soil variations may occur within a short distance, and in order to predict the suitability of a specific site, onsite inspection and evaluation may be needed. Although soils that have rapid permeability have slight limitation for filter fields, it should be noted that a contamination hazard exists to water supplies, streams, ponds and lakes if seepage from the filter fields enters the water source.

In rating soils for susceptibility to frost action the texture of the surface layer and subsoil were the main features considered. Layers that contain a high percentage of silt are the most susceptible to frost action. Frost boils or heaves are a serious problem in Swift County. Frost heaving is caused by ice crystals developing in the soil. In this process water in thin films moves toward the ice crystal, freezes at the edge of it, and causes it to increase in size. Silt-size particles will support a continual flow of films of water, but particles the size of sand are too large to support this flow. Frost heaves result in spring from differential thawing of soil material in place or at construction sites where materials with different expansion rates are used. The high water table of many soils also is a contributing factor to frost heaving.

The features considered for highway location were those that affect the overall performance of the soil for the location of highways. The evaluation for the entire soil profile was based on undisturbed soil without artificial drainage. It was assumed that the surface layer is removed in construction and used for topsoil. Engineers interested in highway location also should refer to the ratings for road fill and to susceptibility to frost action.

Good sites for farm ponds are available in the county. Deep drainageways that have steep side slopes, such as those in Buse soils, make good reservoir areas. The seepage rate in Buse soils is slow, and the glacial till that underlies these soils is suitable for use in embankments. Before selecting a site for a pond, borings should be made in the reservoir area to determine if underlying sand or gravel layers are present. The soil features for road fill also apply to embankments.

Dugout pits are common in Swift County. They are used for watering livestock and irrigating crops. Good locations for dugout pits are in the very poorly drained depressional soils. The soil should have a high water table that is easily exposed by digging the pit. Poorly drained and very poorly drained soils that are underlain by a sand or gravel substratum are well suited to dugout pits because a more constant water level is maintained by the unrestricted lateral movement of water in the porous substratum. Examples of soils that have a sand substratum are those of the Marysland, Arveson, and Venlo series. Dugout pits constructed in medium-textured or fine-textured soils such as Perella, depressional phase, or those of the Parnell or Oldham series also should be located where they will catch and hold runoff.

To best grow crops, soils that are wet and have poor natural drainage require some form of artificial drainage. Both surface and subsurface drainage are needed on the very poorly drained depressional soils such as the Parnell, Oldham, and Perella, depressional phase. Poorly drained soils such as the Colvin, Flom, Hegne, and Vallers can be cultivated year after year after the surface has been artificially drained. However, lower crop yields are common on these soils in seasons when rainfall is greater than normal, and tile drainage is needed to adequately lower the water table and eliminate wetness. Many poorly drained soils, such as the Marysland and Arveson, have a sand substratum. Special precautions are required where tile is installed in these soils because there is a hazard of ditchbank cave-in and of the sand flowing into and plugging the tile. Suitable drainage outlets often are difficult to obtain, particularly in bottom lands.

Irrigation is not used extensively in the survey area, and soil features affecting it are not given. Crops grown on soils northeast of Appleton and in the Pomme de Terre River valley have responded well to irrigation. Well-drained soils in these areas, such as the Renshaw, Fordville, and Spottswood, are underlain by sand and gravel and seem to have a sufficient supply of underground water at a depth of about 20 feet.

Terraces provide water management and erosion control on slopes of less than 12 percent. Where slopes are irregular, such as on the Barnes-Buse soils, cutting and filling generally are needed for good alinement of terraces. Uniform slopes having a loessal silt surface, such as on the Doland and Rothsay soils, generally are well suited to parallel terraces. Compaction is likely to be a problem in the terrace channel if terraces are constructed in spring. If terraces are constructed in fall, compaction is less severe because freezing and thawing before the next growing season improves soil structure. Diversion terraces mainly are used on slopes of more than 12 percent.

Grassed waterways provide drainageways that safely remove excess water and reduce the loss of soil. Among the soil features affecting grassed waterways are fertility, slope, drainage, erodibility, depth to the subsoil or substratum, soil reaction, depth to the water table, and the hazard of flooding. On wet soils such as the Flom, Parnell, Oldham, and Vallers, artificial drainage is needed before waterways can be constructed.

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 Swift County, and particular emphasis is placed 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; 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 the 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 Swift County are formed in the glacial drift and modified glacial drift of the Mankato Substage of the Wisconsin Glaciation. The Mankato glacier covered Swift County about 8,000 years ago. When it receded it left behind a thick mantle of glacial drift. Melt water from the glacier flowed out over much of the county and modified the glacial drift to lacustrine and outwash sediments.

Glacial till.—About 30 percent of the soils in Swift County formed in glacial till. The parent material is about the same today as it was when the glacier deposited it. The soils that formed in the glacial till are a mixture of sand, silt, and clay, and they are mainly loam in texture. Small pebbles and stones are distributed throughout the profile. The principal glacial till soils are the Buse, Barnes, Svea, Hamerly, Flom, and Parnell series.

The Buse and Barnes soils commonly occur in the steep, hilly terminal moraine areas that are scattered throughout the county. The largest terminal moraine area occurs in the northeastern part of the county in Kerkhoven Township, in Camp Lake Township, and in part of Hayes Township. It is called the Alexandria Moraine Complex and is thought to have been the foremost edge of one of the major lobes of the last glaciation.

In the western part of the county is a low range of hills that make up the Big Stone Moraine. This moraine runs through Shible, Hegbert, Fairfield, and Tara Townships. In Tara Township, however, this moraine is barely noticeable. Many smaller terminal moraine areas may be found throughout the county.

Modified glacial outwash.—Outwash and lacustrine soils occur in a large, nearly level basin that occupies most of Clontarf, Marysland, Six Mile Grove, Torning, Westbank, Swenoda, and Cashel Townships. These soils were deposited by melt water from the glacier as it receded northward. Soil materials carried in suspension began to settle out as the velocity of the water decreased. Sandy material was deposited near River Warren in the area of Appleton, and silty material was deposited farther east, where the water was more nearly still. Additional melt water flowed into this water-filled basin from the valleys of the present Chippewa and Pomme de Terre Rivers. Large, deltoid areas occur adjacent to each of these rivers at the point where they enter the basin.

At the county line of Swift and Pope Counties, the Chippewa River widened considerably and slowed down. As the stream moved more slowly, material carried in suspension began to settle out. Coarse-textured, sandy material was deposited in an area 3 to 8 miles wide located from the county line in the north to the upper part of Swenoda Township. Marysland, Arveson, and Hecla soils commonly occur in this area. From this area south into Chippewa County is a nearly level area in which silts and clays were deposited. These deposits range in thickness from a few inches to several feet. The soils in this area are mainly those of the Colvin, Bearden, and Perella series.

Another large, level area northeast of Appleton was formed when the waters of the Pomme de Terre River spread out and deposited gravel and sand over an area about 7 miles long and 4 miles wide. At one time the Pomme de Terre River carried a large amount of melt water from glaciers that had receded to the north. These waters eroded a uniform channel that is 1 to 1½ miles wide and 75 feet deep. When the stream reached an area near Section 17 of Moyer Township, it became less restricted, spread out, and deposited the sand and gravel it carried. The Renshaw and Fordville soils commonly occur in this area.

Buried soils.—Buried soils commonly occur in much of the outwash area near Appleton. The presence of these buried soils indicates that on at least two occasions this outwash area was flooded and that after the first period of flooding the water drained away and soil development occurred. After this, a second flooding eroded soils from the higher positions in the landscape and deposited them in the lower positions.

North of Appleton is an area of about six sections of buried soils. Buried soils also occur in the Arveson-Marysland-Hecla association.

Outwash.—About 35 percent of the acreage in Swift County formed in outwash material, which is glacial till that has been reworked and deposited by moving water. Soils that formed in outwash material are high in content of sand and gravel. They often have a loamy surface layer underlain by sandy or gravelly parent material. The main outwash soils are those of the Renshaw, Spottswood, Marysland, Arveson, and Mayer series.

Lacustrine deposits.—About 25 percent of the acreage in Swift County formed in lacustrine deposits. These soils are dominantly silty clay loam in texture and contain a small amount of sand or gravel. The main soils that formed in lacustrine deposits are those of the Colvin, Bearden, Hegne, and Perella series.

Loess.—Loess consists of silty material that was carried to its present location by the wind. A thin mantle of loess covers much of the glacial till in Swift County. It is generally about 2 feet thick but ranges from a few inches to more than 6 feet. The most extensive area of loess is in the Tara-Barnes-Hamerly association in Tara and Marysland Townships.

Alluvium.—The soils that formed in alluvium occur in small areas adjacent to the rivers and streams in the county. These deposits are relatively recent, and the soils show little development.

Climate

Climate is an active factor in soil formation. It affects the physical, chemical, and biological relationships in the soil profile, primarily through the influence of precipitation and temperature. The amount of water that filters through the soil at a given point depends upon the amount and intensity of rainfall, relative humidity, length of the frost-free period, soil permeability, and physiography. Water dissolves minerals, supports biological activity, and transports mineral and organic residue through the profile. Temperature influences the kinds and growth of organisms and the speed of physical and chemical reactions in the soils.

Plant and animal life

Plants and animals are active factors in the soil forming processes. Bacteria, fungi, earthworms, and other forms of animal life aid in the breakdown of parent materials and in the decomposition of organic matter. Vegetation affects soil formation by leaving residue in the soil and by transferring plant nutrients from the subsoil to the surface horizon. The kinds of plants and animals that live on and in the soil are determined by the climate, the parent material, relief, and the age of the soil.

The soils in Swift County formed under native grasses. Tall prairie grasses were best adapted to the well-drained soils. The more rank wetland grasses grew on the poorly drained soils. Organic matter, in the form of dead grass, was added to the soil, and this was decomposed by micro-organisms and other forms of animal life and by the chemicals in the soil. Because most soils in the county have been subject to little leaching, a large amount of organic matter has accumulated in the surface layer and given it a very dark color.

Relief

Relief, through its effect upon drainage, aeration, and erosion, is an important factor in the formation of soils. Maximum profile development takes place in well-drained, gently sloping soils.

In Swift County the effect of relief is most evident in the rolling to hilly morainic areas, mainly in the northeastern corner of the county. Here, the steep slopes and hilltops are occupied by soils that have a thin A horizon and are directly underlain by the calcareous parent material. Because these soils are so steep, vegetation has been sparse, erosion has been active, and the supply of moisture has been deficient because rainfall was lost through runoff. For these reasons, no B horizon has formed in these soils. Buse soils are an example of these soils.

On the lower slopes, where soil development has been greater, the soils have a thick, black A horizon, a brownish B horizon, and a greater depth to lime. Barnes soils are an example.

Soils that formed in depressional areas have a thick, dark surface layer because they are high in content of organic matter. The color and mottling of these soils are affected by the poor drainage. Flom and Parnell soils are examples.

Soils that formed in nearly level to gently undulating areas have a water table within a few feet of the surface. They have a thin, black, calcareous surface layer underlain by a thick, grayish, strongly calcareous horizon. While these soils were forming, moisture evaporated from the ground surface, which caused concentration of lime in the surface layer. Hamerly soils are an example.

Time

The soils in Swift County are all young. The processes of soil formation began about 8,000 years ago, when the glaciers receded. Soils formed in the glacial till in a relatively short time, because most of the soil material deposited by the glacier consisted of reworked drift carried by earlier glaciers. Thus, the weathering of minerals had already begun at the time of deposition.

The soils that formed in glacial till have distinct A, B, and C horizons. The development of horizons is less distinct in the poorly drained soils, since a high or fluctuating water table has modified the effect of time. Bottomland soils that occur near rivers and smaller streams show little development, because the soil material is very young.

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 relationship 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 of soils to specific fields and other tracts of land.

Thus in classification, soils are placed in narrow categories that are used in detailed soil surveys so that knowledge about the soils can be organized and used in managing farms, fields, and woodland; in developing rural areas; in engineering work; and in many other ways. Soils are placed in broad classes to facilitate study and comparison in large areas, such as countries and continents.

Two systems of classifying soils have been used in the United States in recent years. The older system was adopted in 1938 (*3*) and later revised (*5*). The system currently used was adopted by the National Cooperative Soil Survey in 1965. It is under continual study (*4*, *6*). Therefore, readers interested in developments of the current system should search the latest literature available. The soil series of Swift County are placed in some categories of the current system in table 9.

The current system of classification has six categories. Beginning with the broadest, these categories are order, suborder, great group, subgroup, family, and series. In this system the criteria used as a basis for classification are soil properties that are observable and measurable. The properties are chosen, however, so that the soils of similar origin are grouped together. The classes of the current system are briefly defined in the paragraphs that follow.

ORDER: Ten soil orders are recognized. They are Entisols, Vertisols, Inceptisols, Aridisols, Mollisols, Spodosols, Alfisols, Ultisols, Oxisols, and Histosols. The properties used to differentiate these soil orders are those that tend to give broad climatic groupings of soils. Two exceptions, Entisols and Histosols, occur in many different kinds of climate. Table 9 shows the three soil orders in Swift County—Mollisols, Histosols, and Entisols. Mollisols have a thick, soft, friable surface layer that has been darkened by organic matter. Histosols are soils that formed in organic matter. Entisols are recent soils that lack genetic horizons or have only the beginnings of such horizons.

SUBORDER: Each order is subdivided into groups (suborders) primarily on the basis of those soil characteristics that seem to produce classes having the greatest genetic similarity. The suborders narrow the broad climatic range permitted in the orders. The soil properties used to separate suborders are mainly those that reflect either the presence or absence of waterlogging or soil differences produced through the effects of climate or vegetation.

GREAT GROUP: Soil suborders are separated into great groups on the basis of uniformity in the kinds and sequence of major soil horizons and other features. The horizons used to make separations are those in which clay, iron, or humus have accumulated or those that have pans that interfere with growth of roots or movement of water. The features used are the self-mulching properties of clays, soil temperature, major differences in chemical composition (mainly calcium, magnesium, sodium, and potassium), and the like. The great group is not shown separately in table 9, because the name of the great group is the last word in the name of the subgroup.

SUBGROUP: Great groups are divided into subgroups, one representing the central (typic) segment of the group, and others, called intergrades, that have properties of the group and also one or more properties of another great group, suborder, or order. Subgroups may also be made in those instances where soil properties intergrade outside of the range of any other great group, suborder, or order. The names of subgroups are derived by placing one or more adjectives before the name of the great group.

FAMILY: Families are separated within a subgroup primarily on the basis of properties important to the growth of plants or behavior of soils when used for engineering. Among the properties considered are texture, mineralogy, reaction, soil temperature, permeability, thickness of horizons, and consistence.

SERIES: The series is a group of soils that have major horizons that, except for texture of the surface layer, are similar in important characteristics and in arrangement in the profile. Among these characteristics are color, structure, reaction, consistence, and mineralogical and chemical composition.

TABLE 9.—*Classification of soils*

Series	Current system			1938 system
	Family	Subgroup	Order	Great soil group
Arveson	Coarse-loamy, mixed, frigid	Typic Calciaquolls	Mollisols	Solonchak soils (calcium carbonate).
Barnes	Fine-loamy, mixed	Udic Haploborolls	Mollisols	Chernozems.
Bearden	Fine-silty, mixed, frigid	Aeric Calciaquolls	Mollisols	Solonchak soils (calcium carbonate).
Benoit	Fine-loamy over sandy or sandy-skeletal, mixed, frigid.	Typic Calciaquolls	Mollisols	Solonchak soils (calcium carbonate).
Blue Earth	Fine-silty, mixed, calcareous, mesic	Cumulic Haplaquolls	Mollisols	Humic Gley soils.
Borup	Coarse-silty, mixed, frigid	Typic Calciaquolls	Mollisols	Solonchak soils (calcium carbonate).
Buse	Fine-loamy, mixed	Udorthentic Haploborolls	Mollisols	Regosols.
Clontarf	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols	Solonchak soils (calcium carbonate).
Colvin	Fine-silty, mixed, frigid	Typic Calciaquolls	Mollisols	Solonchak soils (calcium carbonate).
Darnen	Fine-loamy, mixed	Pachic Udic Haploborolls	Mollisols	Chernozems.
Doland	Fine-loamy, mixed	Udic Haploborolls	Mollisols	Chernozems.
Edison	Coarse-silty, mixed	Udic Argiborolls	Mollisols	Chernozems.
Embden	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols	Alluvial soils.
Estelline	Fine-silty over sandy or sandy-skeletal, mixed.	Pachic Udic Haploborolls	Mollisols	Chernozems.

See footnotes at end of table.

TABLE 9.—*Classification of soils*—Continued

Series	Current system			1938 system
	Family	Subgroup	Order	Great soil group
Flandreau	Fine-loamy, mixed, mesic	Udic Haplustolls	Mollisols	Chernozems.
Flom	Fine-loamy, mixed, frigid	Typic Haplaquolls	Mollisols	Humic Gley soils.
Fordville	Fine-loamy over sandy or sandy-skeletal, mixed.	Pachic Udic Haploborolls	Mollisols	Chernozems.
Fossum	Sandy, mixed, frigid	Typic Haplaquolls	Mollisols	Chernozems or Solonchak soils (calcium carbonate).
Fulda, [1]	Fine, montmorillonitic, frigid	Typic Haplaquolls	Mollisols	Humic Gley soils.
Fulda, sand subsoil variant.	Clayey over sandy or sandy-skeletal, montmorillonitic, frigid.	Cumulic Haplaquolls	Mollisols	Humic Gley soils.
Glyndon	Coarse-silty, mixed, frigid	Aeric Calciaquolls	Mollisols	Solonchak soils (calcium carbonate).
Hamar [1]	Sandy, mixed, frigid	Typic Haplaquolls	Mollisols	Humic Gley soils.
Hamerly	Fine-loamy, mixed, frigid	Aeric Calciaquolls	Mollisols	Solonchak soils (calcium carbonate).
Hantho	Coarse-silty, mixed	Pachic Udic Haploborolls	Mollisols	Chernozems.
Hattie	Montmorillonitic	Udertic Haploborolls	Mollisols	Regosols.
Hecla	Sandy, mixed, frigid	Pachic Udic Haploborolls	Mollisols	Regosols or Chernozems.
Hegne	Fine, montmorillonitic, frigid	Typic Calciaquolls	Mollisols	Solonchak soils (calcium carbonate).
Lamoure	Fine-silty, mixed, calcareous, frigid	Cumulic Haplaquolls	Mollisols	Humic Gley soils.
La Prairie	Fine-loamy, mixed	Cumulic Udic Haploborolls	Mollisols	Chernozems.
Maddock	Sandy, mixed	Udorthentic Haploborolls	Mollisols	Regosols or Chernozems.
Maddock, loamy subsoil variant.	Sandy over loamy, mixed	Fluventic Haploborolls	Mollisols	Chernozems.
Malachy	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols	Chernozems or Solonchak soils (calcium carbonate).
Malachy, loamy subsoil variant.	Sandy over loamy, mixed	Pachic Udic Haploborolls	Mollisols	Chernozems or Solonchak soils (calcium carbonate).
Marysland	Fine-loamy over sandy or sandy-skeletal, mixed, frigid.	Typic Calciaquolls	Mollisols	Solonchak soils (calcium carbonate).
Mayer [1]	Fine-loamy over sandy or sandy-skeletal, mixed, calcareous, mesic.	Typic Haplaquolls	Mollisols	Humic Gley soils.
McIntosh	Fine-silty, mixed, frigid	Aeric Calciaquolls	Mollisols	Solonchak soils (calcium carbonate).
Muck and peat	(2)	(2)	Histosols	Organic soils.
Nutley	Fine, montmorillonitic, frigid	Udertic Haploborolls	Mollisols	Chernozems.
Oldham	Fine-silty, mixed, calcareous, frigid	Cumulic Haplaquolls	Mollisols	Humic Gley soils.
Parnell	Fine, montmorillonitic, frigid	Typic Agriaquolls	Mollisols	Humic Gley soils.
Perella	Fine-silty, mixed, frigid	Typic Haplaquolls	Mollisols	Humic Gley soils.
Rauville	Fine-silty, mixed, calcareous, frigid	Cumulic Haplaquolls	Mollisols	Humic Gley soils.
Renshaw	Fine-loamy over sandy or sandy-skeletal, mixed.	Udic Haploborolls	Mollisols	Chernozems.
Rockwell	Coarse-loamy, mixed, frigid	Typic Calciaquolls	Mollisols	Solonchak soils (calcium carbonate).
Rothsay	Coarse-silty, mixed	Udic Haploborolls	Mollisols	Chernozems.
Shakopee	Clayey over sandy or sandy-skeletal, montmorillonitic, frigid.	Typic Calciaquolls	Mollisols	Solonchak soils (calcium carbonate).
Shible	Coarse-loamy, mixed	Udic Argiborolls	Mollisols	Chernozems.
Sioux	Sandy-skeletal, mixed	Udorthentic Haploborolls	Mollisols	Regosols.
Spottswood	Fine-loamy over sandy or sandy-skeletal, mixed.	Pachic Udic Haploborolls	Mollisols	Chernozems.
Svea	Fine-loamy, mixed	Pachic Udic Haploborolls	Mollisols	Chernozems.
Sverdrup	Sandy, mixed	Udic Haploborolls	Mollisols	Chernozems.
Swenoda	Coarse-loamy, mixed	Pachic Udic Haploborolls	Mollisols	Solonchak soils (calcium carbonate).
Tara	Fine-silty, mixed	Pachic Udic Haploborolls	Mollisols	Chernozems.
Torning	Coarse-loamy, mixed, calcareous, frigid	Typic Udorthents	Entisols	Regosols.
Vallers	Fine-loamy, mixed, frigid	Typic Calciaquolls	Mollisols	Solonchak soils (calcium carbonate).
Venlo [1]	Sandy, mixed, frigid	Typic Haplaquolls	Mollisols	Humic Gley soils.
Winger	Fine-silty, mixed, frigid	Typic Calciaquolls	Mollisols	Solonchak soils (calcium carbonate).
Zell	Coarse-silty, mixed	Udorthentic Haploborolls	Mollisols	Regosols.

[1] This soil is a taxadjunct of the series, because it lacks distinct or prominent mottles in the horizon immediately beneath the mollic epipedon.
[2] Not classified in lower categories.

425-738—73——8

General Nature of the County

This section provides general information about Swift County. It discusses the geology, physiography and drainage, climate, farming, and other subjects of general interest.

Geology

Swift County is covered by glacial drift and modified glacial drift of the late Wisconsin Glaciation. Glacial ice covered Swift County about 8,000 years ago. When it receded it left a mantle of glacial drift ranging in thickness from about 150 feet in the southwestern part of the county to more than 300 feet in the northeastern part.

The glacial till material was deposited mainly in the northeastern and northwestern parts of the county and occurs mainly in undulating to rolling areas. In the northeastern part of the county, however, is a series of hilly terminal moraines that form part of the Alexandria Moraine Complex.

Throughout the central and southern parts of the county, the glacial drift has been modified to outwash and lacustrine and alluvial deposits by the action of water. Melt water from the glacier carried soil material into the part of Swift County that forms a basin. The outwash deposits occur at the mouths of streams, and the lacustrine deposits are in the broad level areas beyond the outwash. Additional information related to the geology of Swift County can be found in the section "Formation and Classification of the Soils".

Physiography and Drainage

Swift County is a rectangle 42 miles long and 18 miles wide. The Minnesota River cuts off about 3 square miles of Appleton Township in the southwestern corner of the county. Most of Swift County is nearly level to undulating, but the northeastern corner and other small areas throughout the county are steep and hilly.

The highest elevations, about 1,150 feet above sea level, are in Kerkhoven and Camp Lake Townships and in the northeastern part of Hayes Township. The lowest elevation, 934 feet above sea level, is at the mouth of the Pomme de Terre River. The mean elevation of the county is about 1,075 feet.

In the central and southern parts of the county is a large basin that is generally nearly level but in small areas is undulating and sloping. Nearly all of this basin is at an elevation of less than 1,050 feet. The basin slopes toward the southwest, however, and drainage water is intercepted by streams that flow south through valleys that are about 1,000 feet in elevation.

Swift County lies entirely within the drainage basin of the Minnesota River. It is further divided into two major drainage basins, those of the Pomme de Terre and the Chippewa Rivers. The Pomme de Terre River drains the western quarter of the county. It flows through Fairfield, Moyer, and Appleton Townships and enters the Minnesota River about 3 miles southwest of the city of Appleton. The Pomme de Terre River has only two small tributaries, and both of these are in Fairfield Township. One serves as an outlet for Lake Griffin, located 6 miles west of the river. The other tributary drains potholes and sloughs in the northeastern corner of the township.

Two rather large tributaries enter the Chippewa River as it flows through Swift County. The East Branch of the Chippewa River joins the main stream just north of the city of Benson, and Shakopee Creek enters the Chippewa River 8 miles southwest of Benson. The Chippewa River and its tributaries drain the eastern three-fourths of Swift County.

The Minnesota River lies in the postglacial bottom land of the glacial River Warren. The River Warren was formed by water that flowed rapidly from glacial Lake Agassiz, which lay further to the north. The amount of water carried by the River Warren was evidently very great, as is suggested by the size of the valley that remains. The valley is from 1 to 2 miles wide and has been cut to a depth of 100 to 150 feet.

Marsh Lake lies in the valley of the glacial River Warren and is an expansion of the Minnesota River produced by the damming effect of the delta of the Pomme de Terre River where it empties into the Minnesota River. An artificial dam has been constructed at the outlet of Marsh Lake to further control its level.

Climate [4]

Swift County has a continental climate. Summers are warm, winters are cold, and the maximum precipitation is in the summer months. Swift County lies in a belt where there is considerable interaction between the cold, dry air from the north and the warm, moist air from the south, so there are marked daily changes in the climate. Temperature and precipitation data are given in table 10.

The climate is generally uniform throughout the county, but there is some variability in the minimum temperature and in the amount of precipitation in summer. On calm, clear nights, the temperatures in low-lying areas is a few degrees lower than in other areas. Rainfall from showers in the warm months varies considerably from place to place, but seasonal totals are about the same in all areas.

The average temperature in December, January, and February is about 15° F. Most winters will have at least 2 days when the temperature drops to 20° below zero or lower; these low temperatures occur when cold, continental air masses spread over the area. The average temperature in June, July, and August is about 70°. Days when the temperature reaches 100° occur infrequently.

The wide range of temperature to be expected is shown in table 10. These columns show the probability of very high and very low temperatures. For example, during July it can be expected that 2 years in 10 will have at least 4 days with a temperature of 100° or higher. At the other extreme, 2 years in 10 January will have at least 4 days with a temperature of 22° or more below zero.

[4] By DONALD A. HAINES, climatologist for Minnesota National Weather Service, U.S. Department of Commerce.

TABLE 10.—*Temperature and precipitation*

Month	Temperature				Precipitation				
	Average daily maximum	Average daily minimum	Two years in 10 will have at least 4 days with—		Average total	One 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—		Less than—	More than—		
	°F.	*°F.*	*°F.*	*°F.*	*Inches*	*Inches*	*Inches*	*Number*	*Inches*
January	23	2	44	−22	0.7	0.2	1.6	25	8
February	27	5	46	−17	.8	.1	2.1	25	9
March	38	18	59	−5	1.3	.4	2.9	19	11
April	56	33	76	20	2.2	.6	4.0	3	4
May	70	45	87	30	2.8	.6	5.5	0	----------
June	79	55	92	44	4.1	1.6	6.9	0	----------
July	86	60	100	49	2.8	.9	5.3	0	----------
August	83	58	97	47	3.6	.9	7.3	0	----------
September	74	48	91	33	2.0	.7	3.7	0	----------
October	62	36	80	20	1.4	.1	2.8	[1]	----------
November	41	21	61	−6	1.1	.1	2.4	9	2
December	28	8	43	−14	.8	.2	1.6	17	5
Year	56	33	------------	------------	23.6	15.1	30.2	98	5

[1] Less than 0.5 day.

About 18 inches of precipitation, or about 75 percent of the annual total, falls during the period April through September. Precipitation of 0.01 inch or more can be expected about 95 days per year. Rainfall of about 1 inch per hour can be expected once in 2 years. There is about a 40 percent probability of receiving 1 inch of rain per week in the latter part of June, and this decreases to about 20 percent by the latter part of August.

The first measurable snowfall comes in October in 1 year in 4, and the last snow of the season falls in mid-April. The average number of days with a snow cover of 1 inch or more and average depth can be found in table 10.

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 a certain temperature occurring in spring and fall is shown in table 11. For example, 5 years out of 10, or 50 percent of the time, a temperature of 32°F. or lower can be expected to occur in spring later than May 15. In fall the probability is 50 percent that a temperature of 32° or lower will occur earlier than September 25 (*2*).

During a typical year, there are about 98 clear days, 110 partly cloudy days, and 157 cloudy days. The average windspeed is about 10 miles per hour, and the winds are northerly in winter and southerly in summer. The humidity at noon averages about 60 percent and ranges from 50 percent in August to 73 percent in February.

About 40 thunderstorms occur each year, some accompanied by hail and damaging winds. During the period 1933-62, 29 hailstorms were reported in the county. Tornadoes are infrequent, and only two were reported during the period 1916-62.

TABLE 11.—*Probabilities of last freezing temperature 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. 24	May 8	May 22	May 29	June 6	June 14	--------
2 years in 10 later than	Apr. 7	Apr. 20	May 3	May 17	May 24	May 31	June 10	--------
5 years in 10 later than	Mar. 28	Apr. 11	Apr. 22	May 6	May 15	May 21	May 31	June 19
Fall:								
1 year in 10 earlier than	Oct. 21	Oct. 12	Sept. 30	Sept. 20	Sept. 12	Sept. 3	Aug. 20	--------
2 years in 10 earlier than	Oct. 26	Oct. 16	Oct. 6	Sept. 25	Sept. 16	Sept. 7	Aug. 26	--------
5 years in 10 earlier than	Nov. 6	Oct. 26	Oct. 17	Oct. 5	Sept. 25	Sept. 18	Sept. 7	July 22

Settlement

Swift County was named after Henry Swift, who was governor of Minnesota in 1863. It was a part of Chippewa County until 1870, when it was established by legislative act.

The first white settlers arrived in Swift County in 1861 and settled in what is now Hayes Township. Most of the early settlers remained near streams or lakes, where wood and water were available. The first settlers were mainly Scandinavians and Germans, followed by the Irish and French. Members of these ethnic groups still make up most of the population of Swift County.

The population of Swift County continued to increase until 1950, but since then it has declined. In 1950 the population was 16,230, but by 1960 it had dropped to 15,170. In the same period, the population of Benson, the largest town, increased from 3,398 to 3,678.

Farming

In Swift County farms are decreasing in number and increasing in size. In 1940 there were 1,876 farms in the county, but by 1965 the number had decreased to 1,360. During this same period, the average size of farms increased from 241 acres to 310 acres.

Corn is the main crop grown in Swift County. Soybeans and oats are also important crops. Of the acreage planted to crops in 1966, 114,900 was in corn; 78,300 was in soybeans; and 46,100 was in oats. In addition, 22,800 acres was planted to alfalfa, 12,700 acres to flax, 7,800 acres to wheat, and 3,900 acres to sugar beets.

Livestock production in Swift County has increased with the increase in population and the development of local markets. In 1966 there were in the county 45,100 cattle, 8,700 milk cows, 36,900 hogs, and 6,600 sheep.

Since about 1940 the number of milk cows in Swift County has decreased. During the past decade, however, the number of beef cattle has increased. Poultry production is of minor importance, but the production of turkeys has increased during the last decade. Along with the increase in corn production during the past 50 years, the production of hogs has increased.

Transportation and Markets

The Burlington Northern railroad crosses the eastern part of the county and serves the towns of Kerkhoven, Murdock, De Graff, Benson, and Clontarf. A branch line of this railroad extends southwest from Benson and serves Danvers, Holloway, and Appleton. The Chicago, Milwaukee, St. Paul and Pacific railroad crosses the southwestern corner of the county and serves Appleton.

U.S. Highway 12 crosses Swift County from east to west, and U.S. Highway 59 crosses it from north to south. A system of hard-surfaced roads spaced about 4 miles apart has been built. Gravelled county and township roads serve the rest of the farms.

Grain elevators are located in most towns. Livestock is taken by truck to the south part of St. Paul. Creameries are located in Kerkhoven, Benson, and Appleton. The creameries in Appleton also operate milk drying plants. An alfalfa dehydrating plant is located in Benson.

Community Facilities

High schools are located at Kerkhoven, Murdock, Benson, and Appleton. Elementary schools are located at De Graff, Clontarf, and Danvers. A parochial elementary school is located at Benson. Hospitals, airports, golf courses, and swimming pools are located at both Benson and Appleton. There is a radio station at Benson, and an educational television station at Appleton.

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Glossary

Alluvium. Soil material, such as sand, silt, or clay, that has been deposited on land by streams.

Available water capacity (also termed available moisture capacity). The capacity of soils to hold water available for use by most plants. It is commonly defined as the difference between the amount of soil water at field capacity and the amount at wilting point. It is commonly expressed as inches of water per inch of soil.

Calcareous soil. A soil containing enough calcium carbonate (often with magnesium carbonate) to effervesce (fizz) visibly when treated with cold, dilute hydrochloric acid.

Clay. As a soil separate, the mineral soil particles less than 0.002 millimeter in diameter. As a soil textural class, soil material that is 40 percent or more clay, less than 45 percent sand, and less than 40 percent silt.

Colluvium. Soil material, rock fragments, or both, moved by creep, slide, or local wash and deposited at the base of steep slopes.

Concretions. Grains, pellets, or nodules of various sizes, shapes, and colors consisting of concentrations of compounds, or of soil grains cemented together. The composition of some concretions is unlike that of the surrounding soil. Calcium carbonate and iron oxide are examples of material commonly found in concretions.

Consistence, soil. The feel of the soil and the ease with which a lump can be crushed by the fingers. Terms commonly used to describe consistence are—

Loose.—Noncoherent when dry or moist; does not hold together in a mass.

Friable.—When moist, crushes easily under gentle pressure between thumb and forefinger and can be pressed together into a lump.

Firm.—When moist, crushes under moderate pressure between thumb and forefinger, but resistance is distinctly noticeable.

Plastic.—When wet, readily deformed by moderate pressure but can be pressed into a lump; will form a "wire" when rolled between thumb and forefinger.

Sticky.—When wet, adheres to other material, and tends to stretch somewhat and pull apart, rather than to pull free from other material.

Hard.—When dry, moderately resistant to pressure; can be broken with difficulty between thumb and forefinger.

Soft.—When dry, breaks into powder or individual grains under very slight pressure.

Cemented.—Hard and brittle; little affected by moistening.

Drift (geology). Material of any sort deposited by geologic 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 them. It includes glacial till, and glacial outwash, which is stratified.

Erosion. The wearing away of the land surface by wind, running water, and other geological agents.

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 the physical condition of the soil are favorable.

Ground moraine (geology). Glacial till accumulated beneath advancing ice and deposited from it during its dissolution, rather than aggregated in a thickened belt at the ice edge. The deposit is relatively thin and characteristically forms an undulating plain with gently sloping swells, sags, and closed depressions.

Horizon, soil. A layer of soil, approximately parallel to the surface, that has distinct characteristics produced by soil-forming processes. These are the major horizons:

O horizon.—The layer of organic matter on the surface of a mineral soil. This layer consists of decaying plant residues.

A horizon.—The mineral horizon at the surface or just below an O horizon. This horizon is the one in which living organisms are most active and therefore is marked by the accumulation of humus. The horizon may have lost one or more of soluble salts, clay, and sesquioxides, iron and aluminum oxides).

B horizon.—The mineral horizon below an A horizon. The B horizon is in part a layer of change from the overlying A to the underlying C horizon. The B horizon also has distinctive characteristics caused (1) by accumulation of clay, sesquioxides, humus, or some combination of these; (2) by prismatic or blocky structure; (3) by redder or stronger colors than the A horizon; or (4) by some combination of these. Combined A and B horizons are usually called the solum, or true soil. If a soil lacks a B horizon, the A horizon alone is the solum.

C horizon.—The weathered rock material immediately beneath the solum. In most soils this material is presumed to be like that from which the overlying horizons were formed. If the material is known to be different from that in the solum, a Roman numeral precedes the letter C.

Lacustrine deposit (geology). Material deposited in lake water and exposed by lowering of the water level or elevation of the land.

Leaching. The removal of soluble materials from soils or other material by percolating water.

Lime. Chemically, lime is calcium oxide (CaO), but its meaning has been extended to include all limestone-derived materials applied to neutralize acid soils. Agricultural lime can be obtained as ground limestone, hydrated lime, or burned lime, with or without magnesium minerals. Basic slag, oystershells, and marl also contain calcium.

Loess. A fine-grained, wind-laid deposit that consists dominantly of silt-sized particles.

Morphology, soil. The physical makeup of the soil, including the texture, structure, porosity, consistence, color, and other physical mineralogical, and biological properties of the various horizons, and their thickness and arrangement in the soil profile.

Mottling, soil. Irregularly marked with spots of different colors that vary in number and size. Mottling in soils usually indicates poor aeration and lack of drainage. Descriptive terms are as follows: Abundance—*few, common,* and *many;* size—*fine, medium,* and *coarse;* and contrast—*faint, distinct,* and *prominent.* The size measurements are these: *fine,* less than 5 millimeters (about 0.2 inch) in diameter along the greatest dimension; *medium,* ranging from 5 millimeters to 15 millimeters (about 0.2 to 0.6 inch) in diameter along the greatest dimension; and *coarse,* more than 15 millimeters (about 0.6 inch) in diameter along the greatest dimension.

Muck. An organic soil consisting of fairly well decomposed organic material that is relatively high in mineral content, finely divided, and dark in color.

Munsell notation. A system for designating color by degrees of the three simple variables—hue, value, and chroma. For example, a notation of 10YR 6/4 is a color with a hue of 10YR, a value of 6, and a chroma of 4.

Natural soil drainage. Refers to the conditions of frequency and duration of periods of saturation or partial saturation that existed during the development of the soil, as opposed to altered drainage, which is commonly the result of artificial drainage or irrigation but may be caused by the sudden deepening of channels or the blocking of drainage outlets. Seven different classes of natural soil drainage are recognized.

Excessively drained soils are commonly very porous and rapidly permeable and have a low water-holding capacity.

Somewhat excessively drained soils are also very permeable and are free from mottling throughout their profile.

Well-drained soils are nearly free from mottling and are commonly of intermediate texture.

Moderately well drained soils commonly have a slowly permeable layer in or immediately beneath the solum. They have uniform color in the A and upper B horizons and have mottling in the lower B and the C horizons.

Somewhat poorly drained soils are wet for significant periods but not all the time.

Poorly drained soils are wet for long periods and are light gray and generally mottled from the surface downward, although mottling may be absent or nearly so in some soils.

Very poorly drained soils are wet nearly all the time. They have a dark-gray or black surface layer and are gray or light gray, with or without mottling, in the deeper parts of the profile.

Outwash, glacial (geology). See Drift.

Parent material (soil). The horizon of weathered rock or partly weathered soil material from which soil has formed; horizon C in the soil profile.

Peat. Unconsolidated soil material, largely undecomposed organic matter, that has accumulated where there has been excessive moisture.

Ped. An individual natural soil aggregate, such as a crumb, a prism, or a block, in contrast to a clod.

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.*

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 to pH 7.0 is precisely neutral in reaction because it is neither acid nor alkaline. An acid, or "sour," soil is one that gives an acid reaction; an alkaline soil is one that is alkaline in reaction. In words, the degrees of acidity or alkalinity are expressed thus:

	pH		*pH*
Extremely acid	Below 4.5	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

Relief. The elevations or inequalities of a land surface, considered collectively.

Sand. Individual rock or mineral fragments in soils having diameters ranging from 0.05 to 2.0 millimeters. Most sand grains consist of quartz, but they may be of any mineral composition. The textural class name of any soil that contains 85 percent or more sand and not more than 10 percent clay.

Silt. Individual mineral particles in a soil that range in diameter from the upper limit of clay (0.002 millimeter) to the lower limit of very fine sand (0.05 millimeter). Soil of the silt textural class is 80 percent or more silt and less than 12 percent clay.

Soil. A natural, three-dimensional body on the earth's surface that supports plants and that has properties resulting from the integrated effect of climate and living matter acting on earthy parent material, as conditioned by relief over periods of time.

Solum. The upper part of a soil profile, above the parent material, in which the processes of soil formation are active. The solum in mature soil includes the A and B horizons. Generally, the characteristics of the material in these horizons are unlike those of the underlying material. The living roots and other plant and animal life characteristic of the soil are largely confined to the solum.

Structure, soil. The arrangement of primary soil particles into compound particles or clusters that are separated from adjoining aggregates and have properties unlike those of an equal mass of unaggregated primary soil particles. The principal forms of soil structure are—*platy* (laminated), *prismatic* (vertical axis of aggregates longer than horizontal), *columnar* (prisms with rounded tops), *blocky* (angular or subangular), and *granular*. *Structureless* soils are (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 solum below plow depth.

Substratum. Technically, the part of the soil below the solum.

Surface soil. The soil ordinarily moved in tillage, or its equivalent in uncultivated soil, about 5 to 8 inches in thickness. The plowed layer.

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. See Drift.

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.

Variant, soil. A soil that has properties sufficiently different from those of other known soils to justify a new series name, but of such limited geographic area that establishing a new series cannot 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.

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